Research Highlights in Technology and Teacher Education 2021

Foreward ...........................................................................................................................7

Preface.................................................................................................................................9

TEACHER EDUCATION

From Analogue to Digital Teaching and Learning in the Pandemic
Michael Dal(Iceland) ...........................................................................................................13

ICT-related Educational Competencies of Teacher Educators from an Intercultural Perspective. A Systematic Analysis of Competency Frameworks.
Kristina Förster (Germany) and Silke Grafe (Germany) ......................................................19

Crafting the Maker Educator Identity: Examining Teacher Identity Exploration Using Epistemic Networks
Mark Petrovich Jr. (USA), Amanda Barany (USA), Mamta Shah (USA), and Aroutis Foster (USA) .........................................................................................................................29

Investigating Adoption and Collaboration with Digital Clinical Simulations by Teacher Educators
Ritam Dutt (USA), Garron Hillaire (USA), Alison Fang (USA), Laura Larke (USA), Carolyn Rosé (USA), and Justin Reich (USA) ........................................................................................................39

The Education Influencer: New Possibilities and Challenges for Teachers in the Social Media World
Jeffrey P. Carpenter (USA), Catharyn C. Shelton (USA), Rachelle Curcio (USA), and Stephanie E. Schroeder (USA) ..........................................................................................................................49

TEACHING AND LEARNING WITH EMERGING TECHNOLOGIES

Tweeting Across the Pond: COVID-19 Emergency Learning Networks in the United Kingdom and the United States through Twitter #Edchat
K. Bret Staudt Willet (USA), Christine Greenhow (USA), and Cathy Lewin (UK) .................59

Instructor Social Presence in Remote Teaching: “Yes, we Can!”
Nicoletta Di Blas (Italy) ........................................................................................................69

Enhancing Student Engagement through a Web-Based Three-Dimensional Virtual Environment
William Sause (USA) .............................................................................................................77

We Need to Talk about the ISTE Students Standards: A Critical Analysis
Todd Cherner (USA), Alex Fegely (USA), and Cory Gleasman (USA) ................................85

A Comparison of Findings of Preservice Teachers’ Perceptions to Mobile Phone Integration from Three Studies—2013, 2015, & 2018
Kevin M. Thomas (USA), Michael Hylen (USA), and Beth Carter (USA) ..........................93
INSTRUCTIONAL DESIGN

Inclusive Instructional Technology Practices Implemented During COVID-19 to Reimagine Future Course Design
Michelle E. Bartlett (USA), Carrol Warren (USA), and Jordan Dolfi (USA) .......................................................... 101

Critical Success Factors of Distance Online Learning in Higher Education During COVID-19: Differences Among Students
Orit Ezra (Israel), Anat Cohen (Israel), Alla Bronshtein (Israel), Hagit Gabbay (Israel), and Orit Baruth (Israel) ........................................................................................................ 107

Designing Motivating Online Assignments and Telecollaborative Tasks in the Time of a Pandemic: Evidence from a Post-course Survey Study in Japan
Murod Ismailov (Japan) .............................................................................................................................................. 117

A Pilot Study of Using Online Collaborative Problem-Based Learning in an Undergraduate Translation Course
Qing Li (China) and Nanxi Meng (USA) .......................................................................................................................... 127

SCIENCE, TECHNOLOGY, ENGINEERING AND MATHEMATICS

Are We Making Progress? Gender Perceptions of Identity, Math, Teamwork and Social Support in Introductory Computer Science
Yolanda Reimer (USA) and Michael Coe (USA) ............................................................................................................... 135

AMTE’s 2021 NTLI Fellowship: Using a Framework to Teach Preservice Mathematics Teachers How to Professionally Notice within Technology-Mediated Learning Environments
Nina G. Bailey (USA), Demet Yalman Ozen (USA), Allison W. McCulloch (USA), Lara K. Dick (USA), Jennifer N. Lovett (USA), and Charity Cayton (USA) ................................................................. 143

GeoSTEM Hands-On: Creating and Testing Aerial Imagery Platforms in the Classroom and Outdoors
Christopher Baynard (USA), Terence Cavanaugh (USA), and Nicholas Eastham (USA) ............................................ 155

Integrating Mathematics in Science Instruction: Perceptions of In-service Middle School Science Teachers
Veena Paliwal (USA), Kim Huett (USA), Marian Buzon (USA), and Jonathan Corley (USA) ........................................... 165
FOREWARD

We are proud to bring you the papers that represent some of the finest research from our SITE 2021 annual conference in this year’s edition of Research Highlights in Technology and Teacher Education. Organized around teacher education, teaching and learning with emerging technologies, instructional design, and STEM, these papers exhibit the scope of our international researchers in the SITE community.

Of note here is how SITE members’ work is at the leading edge of research in the area of technology and teacher education; there are several manuscripts here that directly address the impacts of the COVID-19 pandemic. Central to SITE’s mission, this handbook is one way for us to disseminate our expertise and the knowledge generation in our field across a global context.

I expect that we will continue to see valuable research emerge from SITE related to the pandemic’s impact on education, both at SITE Interactive in October 2021, and at our annual conference in San Diego in 2022. With both in-person and online options for participation, we hope to see you in April to contribute to the body of research and our ongoing conversations around technology and teacher education.

Finally, many, many thanks to our senior book editors, David Gibson and Marilyn Ochoa, for making this volume come together through a lot of hard work! Enjoy reading this thirteenth edition of the Research Highlights in Technology and Teacher Education!

Elizabeth Langran
SITE President
Research Highlights in Technology and Teacher Education 2020

Preface

Research Highlights in Technology and Teacher Education is now in its twelfth year of publication. Collections in this book series present distinguished work by leading educators and researchers in the field, illustrating the broad-based impact of SITE and commitment to disseminating research to inform and improve the teacher education community as a whole. The research highlights contemporary trends and issues, theory and practice-based models, design-based research methods, innovative ideas, and effective use of research tools and approaches in the field of information technology and teacher education. This year, eighteen chapters are organized into four themes: (a) Teacher Education, (b) Teaching and Learning with Emerging Technology, (c) Instructional Design, and (d) Science, Technology, Engineering and Mathematics.

TEACHER EDUCATION

The first five chapters of this book focus on teacher education.

In “From Analogue to Digital Teaching and Learning in the Pandemic,” author Michael Dal contributes to the research on the transition to online teaching at the university level during the COVID-19 pandemic. To explore how online teaching can affect student learning, the study focused on graduate learning using both a quantitative survey and interviews to gain a deeper understanding of the survey results. Results showed that flexibility was needed to transition by both students and faculty. While general changes were made in the pedagogy as faculty became learners trying to manage new methods and technologies, students also needed to be more active during the lessons and in their preparation for classes.

Authors Kristina Förster and Silke Grafe, in “ITC-related Educational Competencies of Teacher Educators from an Inter-cultural Perspective. A Systematic Analysis of Competency Frameworks,” analyze ICT-related competence frameworks addressing teacher educators. They offer a strong starting point for further international discourse, in terms of both the diversification of underlying theoretical concepts and approaches to culturally responsive education. By analyzing four internationally recognized models—Teacher Educator Technology Competencies (TETCs), DigCompEdu, Jisc Digital Capabilities, and Media Didactica—the authors show that with the TETCs, important steps have been taken to integrate both discourses, while the other frameworks treat aspects related to culture as isolated phenomena.

In “Crafting the Maker Educator Identity: Examining Teacher Identity Exploration Using Epistemic Networks,” Mark Petrovich Jr., Amanda Barany, Mamta Shah, and Aroutis Foster report on their processes of exploring and enacting identities as maker educators in an environmental science context. Working with researchers in the Invent with Environment after school program in an environmental education center, these educators incorporated maker-based activities into their instruction. Researchers collaborated with them to encourage their active self-reflection as a part of identity exploration using the Projective Reflection theoretical framework. Teachers’ patterns of connection-making across facets of the self were visualized using Epistemic Network Analysis, to track and compare trajectories over time. Authors provide the implications for supporting teacher identity exploration, particularly as they enact maker education.

In “Investigating Adoption and Collaboration with Digital Clinical Simulations by Teacher Educators,” authors Ritam Dutt, Garron Hillaire, Alison Fang, Laura Larke, Carolyn Rosé, and Justin Reich examined the outcomes of implementation plans of 24 teacher educators (fellows) using the Digital Clinical Simulations platforms to center around issues of equity in K-12 computer science education. The fellows participated in a four-day workshop focused on using two tools - Teacher Moments (TM) and Eliciting Learner Knowledge (ELK). The authors examined the transition from authoring to implementing and research design as well as potential collaborations amongst them using social network analysis of the fellows, which spans major regions of the U.S. and generate a broad range of scenarios, as well as clusters of scenarios, enabling simulation-based research supported by collaboration. Technology adoption are operationalized through the notions of self-efficacy, help-seeking, and technology concerns.

Finally, the phenomenon of the education influencer is defined and contextualized in “The Education Influencer: New Possibilities and Challenges for Teachers in the Social Media World.” Authors Jeffrey P. Carpenter, Catharyn C. Shelton,
Rachelle Curcio, and Stephanie E. Schroeder illustrate the education influencer concept with empirical examples that they obtained through their own prior and on-going research. In this chapter, they situate the education influencer concept in relation to research and theory on teacher social media use, teacher identity, micro-celebrity, social media influencers, and teacherpreneurship. Education influencers have the potential to shape other educators’ beliefs, practices, education philosophies, and teacher identities, along with teacher education practices and policy making.

TEACHING AND LEARNING WITH EMERGING TECHNOLOGIES

Five chapters focus on teaching and learning with emerging technologies.

In “Tweeting Across the Pond: COVID-19 Emergency Learning Networks in the United Kingdom and the United States through Twitter #Edchat,” K. Bret Staudt Willet, Christine Greenhow, Cathy Lewin extend previous research by examining the educational response to COVID-19 within and across the United Kingdom and the United States, as documented in the Twitter #Edchat hashtag between February 1–May 31, 2020. In Spring 2020, schooling at all levels was halted or forced to switch to emergency remote teaching. Social media platforms, including Twitter, have been an avenue for educators to access professional learning from peers as part of broader professional learning networks (PLNs). Findings reveal topics of conversation by U.K. and U.S. tweeters were quite similar, but also highlight distinct discourse themes (e.g., #homelearning versus #remotelearning). These differences are discussed and connected to recent educational trends and emphases in the U.K. and U.S.

Nicoletta Di Blas, in her chapter, “Instructor Social Presence in Remote Teaching: “Yes, we Can!”” presents the results of a survey to more than 1000 Italian teachers who were forced to teach online that a “new form of relationship” with their students was one of the major positive aspects of the experience. Results of the study confirm that the Instructor Social Presence (ISP) can be achieved, even in a fully online environment; ISP seems to stem from a whole environment (composed of synchronous, asynchronous, collective and individual interactions) rather than on a single component of the remote teaching experience; eventually, high motivation and experience in pedagogy, over technical skill, seem to be a pre-requisite for instructors to be able to generate ISP.

William Sause explores the use of a 3D virtual classroom that integrates a 3DVE with web conferencing features to improve student engagement and resolve the technical issues in “Enhancing Student Engagement through a Web-Based Three-Dimensional Virtual Environment.” During the COVID-19 pandemic, a lack of student engagement with web conferencing tools has given rise to using three-dimensional virtual environments (3DVE). The purpose of this research is to investigate the use of a 3D virtual classroom that integrates a 3DVE with web conferencing features to improve student engagement and resolve the technical issues reported in previous studies. Results show that students had no technical issues accessing and running the 3D classroom and felt more engaged in the class than when using Blackboard Collaborate.

In “We Need to Talk about the ISTE Students Standards: A Critical Analysis,” authors Todd Cherner, Alex Fegely, and Cory Gleasman respond to the lack of peer-reviewed research or scholarly work specifically focused on the International Society for Technology in Education (ISTE) standards that have been published to be used in classrooms since 1988. This paper will introduce, describe, and contextualize the ISTE technology standards, that have been adopted by all 50 US states. The authors will then share their concerns about the standards before offering recommendations to teacher educators for addressing them.

The perceptions of preservice teachers to the integration of mobile phones in the classroom has been studied over time. In the chapter, “A Comparison of Findings of Preservice Teachers’ Perceptions to Mobile Phone Integration from Three Studies—2013, 2015, & 2018,” Kevin M. Thomas, Michael Hylen, and Beth Carter compare the findings from three studies of students enrolled in teacher preparation programs in Kentucky, Tennessee, and North Carolina. Benefits and barriers to the classroom use of mobile phones are provided; concerns about the use of mobile phones for cheating, cyberbullying, classroom disruptions, sexting, lack of access, and the negative impact of texting on writing are perceived as problems related to the presence of mobile phones in the classroom.
INSTRUCTIONAL DESIGN

Four chapters on instructional design consider the effects of the COVID-19 pandemic on online teaching and learning.

The first chapter in this section is “Inclusive Instructional Technology Practices Implemented During COVID-19 to Reimagine Future Course Design” by Michelle E. Bartlett, Carrol Warren, and Jordan Dolfi explore. COVID-19 prompted a shift for the need to seek the urgent adaptation of more inclusive online teaching and learning practices (Hodges, Moore, Lockee, Trust, & Bond., 2020). The need for practices to promote online learning for all prompted a project focused on the transition to Rapid Online Teaching and Learning (ROTL). Results of this study reveal that low bandwidth was experienced by students enrolled at community colleges as well as educators. For the faculty and students who experienced barriers to the ROTL transition forms of resolution included technology and institutional supports, but were primarily overcome by personal resources.

In the chapter, “Critical Success Factors of Distance Online Learning in Higher Education During COVID-19: Differences Among Students” Orit Ezra, Anat Cohen, Alla Bronshtein, Hagit Gabbay, and Orit Baruth sought to examine students’ perceptions in higher education at the end of the first semester after the transition to online learning. Based on a preliminary study focused on students’ difficulties and profits, five dimensions of Critical Success Factors (CFS) in online learning were found. The study examines CFS by defining its sub-dimensions in the new online learning conditions triggered by this period, and examines differences between students in perceived CFS sub-dimensions.

Murod Ismailov explores various factors influencing Japanese college freshmen’s motivation when completing graded online assignments as part of asynchronous English reading courses held during the COVID-19 pandemic. In “Designing motivating online assignments and telecollaborative tasks in the time of a pandemic: Evidence from a post-course survey study in Japan,” the qualitative study examines learner motivation by students from three separate classes. Results from an inductive content analysis of responses indicated that higher levels of motivation were strongly associated with assignments that facilitated learner autonomy, social interaction, personal interest, and practical utility of the task. Conversely, demotivation appears to be strongly associated with assignments reinforcing the perception of high difficulty, personal inefficacy, and cognitive overload.

Qing Li and Nanxi Meng’s “A Pilot Study of Using Online Collaborative Problem-Based Learning in an Undergraduate Translation Course Abstract: English-Chinese Translation” reports an online problem-based learning model designed and implemented for the first time in delivering an undergraduate English-Chinese translation course. With the development of machine translation technology and online translation collaboration platforms, the authors sought to familiarize students with the real-world work cycle of professional translation projects, enhance skills required as professional translators, and comprehensively cultivate students’ translation competence. Teaching advice and future research directions are also discussed.

SCIENCE, TECHNOLOGY, ENGINEERING AND MATHEMATICS

Four chapters in this book focus on science, technology, engineering, and mathematics.

Gender differences in perception and pursuit of computer science have been examined for many years and a wide variety of recommendations have been proposed to increase the number of women who engage in the field. Yolanda Reimer and Michael Coe analyzed the gender perceptions in four categories that heavily influence females’ pursuit of computer science: identity, math, teamwork and social support in “Are We Making Progress? Gender Perceptions of Identity, Math, Teamwork and Social Support in Introductory Computer Science.” Results show that females do not see math as a barrier into computer science and feel just as supported as males do by their social support system. However, females still need stronger identification with the field and teamwork opportunities should be more appealing to females.

The chapter, “AMTE’s 2021 NTLI Fellowship: Using a Framework to Teach Preservice Mathematics Teachers How to Professionally Notice within Technology-Mediated Learning Environments,” was written by Nina G. Bailey, Demet Yalman Ozen, Allison W. McCulloch, Lara K. Dick, Jennifer N. Lovett, and Charity Cayton. The authors report on their study of preservice secondary mathematics teachers professional noticing of students’ mathematical thinking in a technology-
mediated learning environment. Through pre- and post- video-based assessment, they examine how explicitly sharing a framework for professional noticing can support pre-service teachers’ development related to coordinating students written and spoken mathematical thinking with their technology engagement.

Christopher Baynard, and Terence Cavanaugh, and Nicholas Eastham discuss how faculty employed alternatives to the traditional geospatial education labs with hands-on approaches in “GeoSTEM Hands-On: Creating and Testing Aerial Imagery Platforms in the Classroom and Outdoors.” Using kite, balloon and pole aerial photography to capture low-elevation high-resolution data, the technologies were used in the classroom and outdoors in a constructivist, tinkering and discovery approach. Their research was a shift in approach from a computer-screen dominant model to a technology integrated, concrete method of learning that is driven by personal experiences and exploration.

The final chapter of the book is “Integrating Mathematics in Science Instruction: Perceptions of In-service Middle School Science Teachers” by Veena Paliwal, Kim Huett, Marian Buzon, and Jonathan Corley. The study explored sixth grade in-service Earth Science teachers’ attitudes and perceptions about integrating mathematics in science education, and to understand the usefulness, appropriateness, and feasibility of such an initiative. Using a qualitative approach, sixteen Earth Science teachers were interviewed about using math concepts in an Earth Science unit plan. This study has implications for researchers, policymakers, teacher educators, and practitioners interested in supporting efforts to integrate mathematics into science courses.

David Gibson
Marilyn N. Ochoa
Co-Editors
From Analogue to Digital Teaching and Learning in the Pandemic

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Abstract: The purpose of this paper is to contribute to the knowledge of how the pandemic has affected teaching and learning at the university level. The point of departure for this paper is the following research question: How has the change from teaching on campus to on-line teaching affected the students’ learning during the autumn term of 2020 and until present time? To answer this question a quantitative survey was conducted among 350 graduate students attending different courses. When the data had been analysed it was decided to interview 18 of the students, randomly chosen among the respondents. The purpose of the interviews was to get a deeper understanding of some of the results from the survey. The study shows among other things that the pandemic triggered unforeseen results regarding more general changes in the pedagogy used in the courses with a switch to a more flexible teaching approach, both in terms of adaptability to sudden changes and in terms of receptivity to the needs of students.

Keywords: Pandemic, Virtual learning, Distance teaching, Graduate students, Online activities, Collaboration tools

INTRODUCTION

The worldwide pandemic of COVID-19 has had an impact on teaching and learning in almost all the world. On January 27th, 2020, the Icelandic Government declared a state of uncertainty in the response to the outbreak of COVID-19 and a decision was made to apply immediate assembly restrictions to the whole country. One of the consequences of this assembly ban was that the Ministry of Education in Iceland recommended constraints and instructed the schools on all levels to make radical changes in schoolwork. During the last year or so schools at all levels have for some periods been closed. In shorter or longer periods students and teachers have exclusively been communicating virtually over the internet. In other periods, primary and secondary schools have been operating partly in school and partly on-line. In order words, the pandemic has had and still has quite an impact on teaching and learning in all the country.

At the university teaching and research activities also have been influenced by the pandemic. On March 11th, 2020, the University Emergency Response Board urged faculty heads, heads of departments and administrative officers to familiarize themselves with options for on-line learning and web conferencing to be prepared reorganising and redesigning teaching and communication activities. In fact, only a limited time was given to act and called for instant resolutions. On March 23rd, 2020, it was announced that arrangements for examinations and assessments would be done within a short time. On March 30th, two weeks after the assembly ban, all exams and assessments had been revised and almost all the examinations were to be done on-line. At this point students greatest concern was the upcoming final exams.

Though the pandemic seemed to have eased a bit in September 2020 after the summer vacation, it was decided that all teaching, conferencing, and meetings at the university should as much as possible be done on-line during the autumn term. On some faculties teachers and students expressed some concerns about the well-being of the new students starting at the university, the main question being that the virtual teaching and communication would stand in the way for integrating the new students into campus life. At most of the faculties it was therefore decided to organise on-campus teaching for the newly enrolled students. A prerequisite for this was that the teaching should be structured according to the general rules of assembly, for example that only 50 persons can be gathered in one and the same time. The teaching for students that already were enrolled was mostly organised as distance and on-line teaching, and the same precautions have been made for all the teaching, the meeting activities and conferencing here in the Spring term of 2021.
Parallel to the commotion caused by the pandemic, some studies have been conducted to capture the experiences of teachers and students. The first one was conducted in March on behalf of the Student Council at the university. The purpose was to get a better picture of the status and well-being of students during COVID-19. The results were striking, as 53% of students claimed that they experienced considerable stress and/or pressure which seemed to affect their learning progress (Student Council, 2020a).

Another survey focusing on job prospects and the well-being of students was conducted during May 2020 in cooperation with the Ministry of Education, Science and Culture (University of Iceland, n.d.a). The results revealed that the students’ mental state seems to be rather unhealthy as 47% of the respondents claimed that their mental health generally was in a rather bad state. Almost half of the participants rated their own mental health as low as 5 or lower on a 10-point scale where 10 was the best mental health (Student Council, 2020b).

Scholars at the School of Education carried out an institutional-wide survey of students’ experience (Björnsdóttir & Jóhannesdóttir, 2020). According to their findings, most students at the university express appreciation towards the teachers’ efforts to redesign courses and assessment methods. Also, many seems to be satisfied with the teachers’ use of technology and digital tools. On the negative side the students complained about the lack of coherence in the reorganisation of courses.

Only a few domestic studies have focused on the experiences of academic teachers despite the enormous task faced in restructuring their teaching, including curriculum and assessment. Gunnarsdóttir and Pálsdóttir (2020) studied the impact of COVID-19 on the working conditions of university staff in May 2020. The quantitative study had a response rate of 41%. The results indicated that academics felt less productive than normally in their research activities. Part of the reason was that due to the assembly ban staff members had their children at home and not all academics had access to a separate room to work in or proper tools to work from home. The results also revealed that 94% of the academic staff used digital solutions in their teaching. Only 23% had previous experience in online teaching. In addition, 47% felt added pressure during the assembly ban.

The abovementioned studies were conducted in the beginning of the pandemic in a time where teachers and students were upset on account of the sudden changes. Now the pandemic has been raging for about a year or so and students should have more experience with on-line teaching and virtual communication with peers. While the studies above provide an overview of the sudden impact of COVID-19 on students and staff, this study intends to examine how students succeed in including new technology and on-line teaching in their learning over a longer period. The aim of this study is thus to understand the way students have comprised on-line teaching in their own learning and to understand the challenges accompanying the shift from on campus to on-line teaching and learning. This paper addresses this issue by examining the following research question:

*How has the change from teaching on campus to on-line teaching affected the students’ learning during the autumn term of 2020 and until present time?*

To answer this question a survey with 20 questions was produced and presented for 450 students at the School of Education. Also, it was decided to make interviews with 15 – 20 students randomly chosen among the respondents in the survey. This was done to deepening the issue and getting more clear answers to some of the questions. The paper is organised in four main sections. In the next section the research design of the study is presented. In the third section some of the most important results will be presented and the final section discusses the findings.

**RESEARCH DESIGN**

The data for this study derives from a study conducted among 450 graduate students attending classes at the school of education at the University of Iceland In the January 2021. All the students were taught as distance learners even though almost half the students were enrolled as day students on campus. The study is constructed over a use of blended methods as both quantitative and qualitative research methods were used.

A qualitative survey was distributed among the student population. 352 students responded to the survey which means that the response rate was 78,2 %. In the end of January 2021 interviews were made with 18 randomly chosen respondents from the survey. The gender composition among the participating students was 99 (28%) males and 253 (72%) females.
The survey consisted of 20 questions about how the students perceive the on-line teaching during the pandemic. Six questions focused on the learning aspects, another five questions focused on study approaches – that is how students use the input provided online, and five questions focused on students’ likings on participating in online activities. The last four questions focused on personal information about the participants.

The interviews with the chosen respondents were made to get a better picture on how the students included the online activities into their own process of learning. Also, the students were asked to assess the effect of using on-line teaching. Finally, the students were asked about how they deal with technical matters.

**THE PARTICIPANTS AND THE TEACHING**

The students were enrolled in seven different courses (Table 1).

<table>
<thead>
<tr>
<th>Course number</th>
<th>Numbers of students</th>
<th>Students’ age range</th>
<th>Course level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Course 1</td>
<td>36</td>
<td>23 - 54</td>
<td>Graduate</td>
</tr>
<tr>
<td>Course 2</td>
<td>53</td>
<td>22 - 43</td>
<td>Graduate and undergraduate</td>
</tr>
<tr>
<td>Course 3</td>
<td>64</td>
<td>28 - 52</td>
<td>Graduate</td>
</tr>
<tr>
<td>Course 4</td>
<td>18</td>
<td>22 - 36</td>
<td>Graduate and undergraduate</td>
</tr>
<tr>
<td>Course 5</td>
<td>58</td>
<td>24 - 49</td>
<td>Graduate</td>
</tr>
<tr>
<td>Course 6</td>
<td>69</td>
<td>23 - 47</td>
<td>Graduate</td>
</tr>
<tr>
<td>Course 7</td>
<td>54</td>
<td>26 - 57</td>
<td>Graduate</td>
</tr>
</tbody>
</table>

The seven courses differed regarding numbers of participants. Most of the courses had over 50 students enrolled, and two courses had fewer students. The geographical location of the participants varied quite a bit. 162 or 46 % of the participants lived in the countryside, 10 lived outside Iceland (Denmark, the UK and Germany), and 180 or 51 % of the participant lived in Reykjavik and its suburbs. The oldest participant was 57 years of age and the youngest 22 years. The average age of the participants were 30,19 years which more or less corresponds with the average age of the students at the faculty.

In all classes the teachers use Moodle or Canvas as the digital teaching platform. In both platforms it is possible to manage the teaching and guide the students through the syllables. Also, different assignments and tests can be produced and used.

**RESULTS**

The survey

According to the results of the survey, most of the students or 95,5 % seems to have adopted to online teaching. A majority of the respondents or 96 % claimed that they due to the situation found it rewarding and interesting to participate in breakout rooms in Zoom or Teams. This activity gives the students a possibility to ‘meet’ and talk about both personal and professional issues. All the participants emphasise the necessity of having enough time for discussions and work in breakout rooms. Also, most of the respondents or 79 % call attention to the number of participants in the breakout rooms. They claim that the number of participants in breakout rooms should not be more than five, but the best number of participants is 3 or 4 participants.

Most of the respondents or 69 % find it especially satisfying if the preparation for an online class is followed-up by a short video presentation of the issue of the lesson. Such an introductory video of 5 – 15 minutes helps the students to focus on the subject of the lesson and is mostly a good summary that help them understand and get an overview of the enclosed reading material. Also, a video presentation can reduce the time of lectures in class and give more time to student
activities. Listening to long lectures in online classes can be challenging because the students find themselves tied up to the computer screen and the earphone, which can appear to be demotivating for the students.

It seems to be of rather big importance to activate students during online lessons. This can be done by arranging group work through breakout rooms or by letting students work together on Padlets or making their own presentations. A majority of the respondents or 65% claims that they learn better if the use Padlets together with other students during a class. The same number of respondents points out that they learn better if they are presenting material during class.

Most of the respondents or 85% find it rather boring to listen to lectures in online teaching. 45% of the respondents argue that it can be rather demotivating listening to lectures online because it is not that easy to ask the lecturer questions. It is often much easier in face2face teaching. Generally, the students seem rather to prefer short lectures in the form of videos.

The respondents find it necessary that the digital teaching platform is well organized and easy to use. Most of the teaching is done with help from Canvas and the students find the test tool very helpful for their learning. Also, 143 or around 40% of the participating students find the studio tool in Canvas very helpful. The studio tool makes it among other things possible for the students to submit assignments and comments orally or by video. The most used collaboration tool seems to be Google Docs, but also Dropbox and OneDrive are used as collaborative tools.

The interviews

All the 18 interviewed students explained that their notion on learning has changed quite a bit during their participation in online teaching. They claim that they are much more aware of the necessity of getting involved and being active during class. Also, they argue, their preparation for class has changed quite a bit. Online teaching seems to activate the students due to intensified interaction, for example by using breakout rooms. All 18 students agreed that it seems as if their learning is much more effective when taking part in online teaching.

Using the computer screen or Ipad is regarded as the students ‘normal’ and ‘daily’ form of communication. Therefore, many of the interviewed students (11) claimed that they in many ways preferred online-teaching, but of course they also miss meeting all their peer students face2face. However, in the future the students could imagine that online teaching once in a while could be a good option in a class. Statements like this indicate that many of the students hope that the experience from the COVID-period can lead to a future general modernisation of teaching and learning strategies.

Discussion and final remarks

The research question addressed the pedagogical and didactic challenges the students face while trying to adjust their studies to the conditions created by COVID-19. The findings reveals that their experiences were like the conclusions that Gudmundsdóttir and Hathaway (2020) put forward in the sense that neither students nor the teachers find it too difficult to deal with the technological aspect of online teaching.

Differently from the findings of Gudmundsdóttir and Hathaway (2020), however, this study highlights how, in the switch to online teaching, the students focus on pedagogical aspects and on the question of activity. From the pedagogical perspective, the changes were quite challenging and can best be described as attempts to quickly move on-campus designs to an online format, without the planning and development necessary to ensure the quality of a distant learning course (Sigurgeirsdóttir & Jóhannsdóttir, 2020). This kind of emergency remote teaching (Hodges, Moore, Lockee, Trust, & Bond, 2020) bears, thus, little resemblance to carefully planned course design in online teaching. The students seem to understand the teachers’ attempts to redesign teaching and assessment and in the process the students in many cases also changed their own attitude to teaching and learning.

The findings reveal that as the teachers became learners trying to manage new methods and technologies, the students also saw the need to be more active during the lessons and in their preparation for classes. This enhanced student participation and the understanding of teacher efforts increased (Björnsdóttir & Jóhannsdóttir, 2020). It also made students more sensitive to teachers’ work on redesigning and reorganising the classes.

Finally, there is the question of implications of COVID-19 for academic teaching in the near future. The challenges described above have to do, on the one hand, with the teachers’ struggle with technology and pedagogy in emergency situations, and on the other hand, with how that experience influenced their approaches to and perceptions of students.
There are some lessons to be learned from this situation that can be implemented into future teaching. Firstly, there are clear benefits from using technology to improve the quality of teaching and, thus, the students’ learning experience. However, if teachers are to continue this experimentation, as suggested by Gunnarsdóttir & Pálsdóttir (2020), institutions need to strategically support this endeavour in the long term. Secondly, COVID-19 triggered a further move toward a student-centred approach. It also appears as the appropriate lens through which academics should develop their future teaching practices, at least in reference to distant teaching and distant students. The study, thus, shows that the pandemic triggered unforeseen results regarding more general changes in the pedagogy used in the courses with a switch to a more flexible teaching approach, both in terms of adaptability to sudden changes and in terms of receptivity to the needs of students (Clegg & Rowland, 2010; Mann, 2008). This flexibility is likely to remain once the pandemic has been defeated.

REFERENCES


ICT-related Educational Competencies of Teacher Educators from an Intercultural Perspective. A Systematic Analysis of Competency Frameworks.

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Abstract: Both research and policy indicate the importance of considering ICT-related and intercultural competence development in education together. Teacher educators play a significant role in the development of these related competencies. The aim of this study is to analyze ICT-related competence frameworks addressing teacher educators, focusing on how they incorporate intercultural considerations. We analyze four internationally recognized models—Teacher Educator Technology Competencies (TETCs), DigCompEdu, Jisc Digital Capabilities, and Media Didactica—showing that with the TETCs important steps have been taken to integrate both discourses, while the other frameworks treat aspects related to culture as isolated phenomena. In TETC 8, the global dimension is represented by a specific competency, which is also differentiated into specific areas of competence. This offers a strong starting point for further international discourse, in terms of both the diversification of underlying theoretical concepts and approaches to culturally responsive education. Further research is needed to investigate how professional development can meet the needs of teacher educators in a global context.

Keywords: Global teacher competence, International comparative research, ICT-related educational competencies, Competency frameworks

INTRODUCTION

Policymakers and researchers across disciplines and educational contexts agree that teacher educators play a vital role in preparing preservice teachers for their future responsibilities. From a pedagogical perspective, teacher educators serve as role models for prospective teachers (Uerz et al., 2018) and their development of media-related educational competencies in a world increasingly characterized by digitalization and mediatization (Tondeur et al., 2019, Foulger et al., 2016, 2017). Similarly, from global citizenship education or intercultural competence-oriented perspectives, both policy and research stress the need for teacher educators to prepare preservice teachers for the challenges connected to teaching and learning in a world marked by globalization and diversity (Baroni et al., 2019, Mansilla & Jackson, 2011, Cochran-Smith et al., 2020). Therefore, teacher educators need to be both digitally and interculturally competent to prepare preservice teachers for contemporary and future education. Due to the significant intersection of these two requirements, it is valuable to consider media-related and intercultural competences for teacher educators together.

The aim of this paper is to analyze if and how frameworks related to teacher educators’ ICT-related competencies address issues about teaching and learning in a globally connected world. These frameworks will be deconstructed and discussed against the background of underlying concepts from intercultural research across disciplines and, where necessary, related fields. Our aim is to offer a starting point for discussions of media-related competence in the context of international and intercultural pedagogy.
LITERATURE REVIEW

Following Kim and Bhawuk’s definition of globalization as “a technologically driven process of change toward increased interconnectedness and functional interdependence among people across societies and nations” (Kim & Bhawuk 2008, p. 301), our literature review will explore how the emerging requirements for teacher educators in terms of ICT-related and intercultural competencies have been addressed in their respective research discourses.

Research around teacher educator competencies has been mapping demands for and modeling ICT-related competencies for about 30 years. A systematic comparative study on media-related competency frameworks by Tiede and Grafe (2020) indicated that a number of studies have been conducted to explore teacher educators’ ICT-related professional development, echoing similar recommendations by Krumsvik (2014), Borthwick and Hansen (2017), and Foulger and colleagues (2017). A systematic literature review by Uerz et al. (2018) found that there are significantly fewer studies on media-related educational competencies for teacher educators compared to corresponding studies focusing on preservice or inservice teachers. Tiede and Grafe’s category-based comparison of three ICT-related competency models for teacher educators—the Teacher Educator Technology Competencies (TETCs) model (Foulger et al., 2017), the Belgian Media Didactica Framework (Meeus et al., 2014), and the European DigCompEdu framework (Redecker, 2017)—showed that the three share central assumptions and overlap widely but also represent national singularities and research discourses (Tiede & Grafe, 2020). The TETCs, for instance, were developed in response to a call by the United States’ National Education Technology Plan (NETP) (Foulger et al., 2016, 2017), while the DigCompEdu framework evolved from the DigComp model, which was developed in 2012 as a framework for all citizens of the EU with the aim of meeting the “digital revolution” that encompasses all spheres of life (Caena & Redecker, 2019). Schröter and Grafe’s (2020) systematic analysis of frameworks addressing digital literacy and digital competence in university teachers concluded that more explication of underlying theoretical concepts would be helpful and that measuring digital literacy and competence among teacher educators remains a challenging task (Uerz et al., 2018).

The competency frameworks for teacher educators used for this study vary in their reach within the literature. The Media Didactica Framework (Meeus et al., 2014) is mentioned only sporadically in current media education research on teacher educators (Tiede & Grafe, 2020; Ripka et al., 2020). The two frameworks that do not exclusively refer to teacher educators, DigCompEdu and Digital Capabilities (Jisc), are widely referenced in the literature. Although studies on teacher educators are underrepresented, international examples can be found (Fulgence, 2020; Tiede & Grafe, 2020; Laudari, 2019). Especially with regard to the TETCs, it is clear that an international discourse focusing on teacher educators has developed, including different levels of action around media-related educational competencies. Studies by Carpenter et al. (2020), Luongo (2019), and Viberg et al. (2019), for example, explore teacher educators’ perspectives on TETCs. Other studies, such as Krutka et al. (2019) and the current paper, aim to contribute to the explication of individual competencies. A number of studies also describe the design and implementation of professional development based on TETCs (e.g., Foulger et al., 2020, Slykhuis et al., 2019). Until now, ICT-related teacher educator competency frameworks have not been analyzed in terms of their approach to intercultural aspects; in this paper, we seek to address this research gap.

In order to juxtapose ICT-related competency frameworks for teacher educators with aspects related to intercultural research, it is important to acknowledge the robust body of research within this complex multidisciplinary field, which spans six decades (Deardorff & Arasaratnam-Smith, 2017). These discourses vary significantly across national contexts and distinct cultural milieus (Spitzberg & Changnon, 2009, Arasaratnam-Smith 2017), although numerous reviews have been published on the concept of intercultural competence in an international perspective (Rathje, 2007; Spitzberg & Changnon 2009). Deardorff and Arasaratnam-Smith (2017) point out that, due to the wide interest in intercultural competence in multiple disciplines, nuanced and varied labels of this concept are used, which creates challenges for those seeking common ground. A literature review by Fantini (2020) reveals that more than 50 terms coexist in the literature to date to denote “abilities needed for intercultural interaction” (ibid.). However, some researchers do agree on the definition of intercultural competence as “a set of cognitive, affective and behavioural skills and characteristics” (Bennett, 2015, xxiii, as cited in Fantini, 2020).

The review by Fantini (2020) shows that the models that are frequently applied and referred to in education and research—namely Bennett’s Developmental Model of Intercultural Sensitivity (DMIS) (Bennett & Bennett, 1993), the model by Byram, Nichols and Stephens (Byram et al., 2001), and Deardorff’s model (Deardorff, 2006)—were developed
within monolingual and monocultural milieus and have therefore been the subject of critique in terms of Anglocentrism. Additionally, none of the models above address teacher educators specifically, but either focus on the student perspective or are intentionally generic so that they may be applied to various stakeholder groups. Dervin et al.’s (2020) critique takes this a step further by arguing that these intercultural competence models, and in fact any discourse about intercultural competence, are charged with political, sociological, personal, and glocal ideologies (ideologemes). With a particular focus on teacher education, they conclude that intercultural competence discourse in (teacher) education is currently in a state of crisis for the reasons mentioned above and call for “fairer ways of constructing intercultural competence” (Dervin et al., 2020, p. 6).

Since the 1990s, the interconnectedness between digital media and intercultural communication has been a subject of interest in research (Chen, 2012), as the compression of spatial and temporal relations through digital communication has changed people’s local, national, and global perceptions of space and, as a consequence, the nature of community or culture (ibid.). In this process, a new form of intercultural communication emerged (ibid.), characterized by new social networks, which has since become a major concern for intercultural scholars (for a more comprehensive review see Chen, 2012). A systematic literature review on intercultural competence development via digital technologies by Çiftçi (2016) revealed that previous studies mainly address undergraduate students and pointed to the need for interculturally competent educators to consciously guide participants (Çiftçi, 2016). One can conclude that there is a similar gap in intercultural research with regard to ICT-related competencies for teacher educators.

In this study, we focus on frameworks related to teacher educators’ ICT-related competencies and address the research question of how such frameworks reference teaching and learning in a globally connected world.

**METHODOLOGY**

In order to identify relevant frameworks, we combined the findings from previous literature reviews conducted by Tiede and Grafe (2020) and Schröter and Grafe (2020), who systematically analyzed ICT-related competence frameworks for teacher educators and teachers in higher education internationally. Tiede and Grafe (2020) used two sources of data. Firstly, they referred to an extensive literature review by the Joint Research Centre (Joint Research Centre, 2017). Secondly, they conducted an additional literature review using several established databases including ERIC and the Social Science Citation Index. This led to the identification of three frameworks: 1) TETCs (Foulger et al., 2017), which refers specifically to teacher educators; 2) Media Didactica (Meeus et al., 2014), which has a specific version for teacher educators; and 3) DigCompEdu (Redecker, 2017), which addresses educators at all stages, including teacher educators. Schröter & Grafe (2020) used the databases ERIC, Web of Science, ResearchGate, and Google Scholar, focusing on frameworks that explicitly address teacher educators, are internationally relevant, and are currently providing a basis for research. They identified the remaining models: 1) TETCs (Foulger et al., 2017); 2) DigCompEdu (Redecker, 2017); and 3) Jisc’s Digital Capabilities (Jisc, 2014). We decided to combine the results and use the literature from both studies. This resulted in the following competence models: TETCs, DigCompEdu, Digital Capabilities, and Media Didactica.

Tiede (2020) developed categories for the comparative analysis of ICT-related competency frameworks for teacher educators: 1) Model background; 2) Model genesis; 3) Model structure; and 4) Model contents. In accordance with our aim to identify and discuss aspects that can be linked to intercultural competence, our analysis will focus on the content of the frameworks and will only briefly refer to their respective backgrounds, geneses, and structures as needed for clarity. The selected frameworks will be evaluated for terms or concepts from the selection presented by Fantini (2020), including or relating to cross-cultural adaptation, cross-cultural awareness, cross-cultural communication, cultural competence, cultural or intercultural sensitivity, effective intergroup communication, ethnorelativity, global competence, global competitive intelligence, global mindedness, global mindset, intercultural competence, intercultural cooperation, intercultural effectiveness, intercultural interaction, international communication, international competence, metaphoric competence, multiculturalism, plurilingualism, and transcultural communication. Since this selection only represents a partial list (ibid, 33), we will be mindful to include other concepts that may be linked to digital interaction in an intercultural dimension.
ANALYSIS

TETCs

The Teacher Educators Technological Competencies (TETCs) model was developed in 2017 in response to the National Education Technology Plan (NETP) (Foulger et al., 2017). The process included a literature review supported by crowdsourcing, a six-round Delphi study, and a call for feedback from the research community (ibid.). Twelve competencies with three to five descriptors each were synthesized in a structured model. Among the 12 competencies, TETC 8 is relevant for our analysis because it addresses “abilities needed for intercultural interaction” (Fantini, 2020):

Teacher educators will use technology to connect globally with a variety of regions and cultures (Foulger et al., 2017, 433).

The competency is subdivided into three aspects representing different facets of the teacher educator’s role, as defined by TETC 8:

a) [Teacher Educators will] model global engagement using technologies to connect teacher candidates with other cultures and locations (Foulger et al., 2017).

This implies that a teacher educator must be able to act with intercultural competence in digital settings in order to be able to fulfill their normatively established role model function (cf. Tondeur et al., 2019, Foulger et al., 2016; 2017). Foulger et al. (2017) explicitly refer to the International Society for Technology in Education’s (ISTE) contributions as “standards and guidelines that influence our work” (Foulger et al. 422). The ISTE standards for educators state that teachers are required to “demonstrate cultural competency when communicating with students, parents and colleagues” (4d) and to “actively participate in local and global learning networks” (1a) (ISTE, n.d.-a). The example set by teacher educators through their teaching and mentoring activities enables preservice teachers to act with cultural competence in their (digital) classroom and professional community activities.

b) Teacher Educators will design instruction in which teacher candidates use technology to collaborate with learners from a variety of backgrounds and cultures (Foulger et al., 2017).

The second aspect of the competency relates to didactic design processes. Again, the experiential approach through which the preservice teachers learn to collaborate interculturally is emphasized. This competence aspect can be linked to the ISTE standard for educators to “[u]se collaborative tools to expand students’ authentic, real-world learning experience by engaging virtually with experts, teams and students, locally and globally” (ISTE, n.d.-a). Again, this corresponds with the ISTE standards for students, who are required to be “global collaborators” (ISTE, n.d.-b), and it may also be aligned with the standard for coaches, who are required to “partner with educators to identify digital learning content that is culturally relevant” (ISTE, n.d.-c).

c) [Teacher Educators will] address strategies needed for cultures and regions having different levels of technological connectivity (Foulger et al., 2017).

The third aspect of this competency addresses awareness of and capacity to deal with connectivity differences on a potentially global level. This has two important implications. First, teacher educators must themselves have an awareness of the interactions between connectivity and potential global opportunities for participation and resulting discourses of power, and they must also communicate this to their students. Second, teacher educators must be able to select and integrate technologies and tools flexibly, according to local requirements and objectives, and to communicate this knowledge to future teachers. However, it should not only be about knowing and being able to contextualize global differences in terms of ICT infrastructure and connectivity. In TETC 8.3, it is clearly stated that teacher educators should be able to deal constructively with these circumstances by integrating technologies and media that are available to all participants in transnational collaborations. This third aspect of the competency is analogous to TETC 1, which describes the sub-competency of being able to select relevant technologies for the learning content in question.
Regarding possible theoretical foundations behind the TETC constructs, appendix A of the article by Foulger et al. (2017) provides a useful entry point as it maps the results of the crowdsourced literature review. Of the 43 titles, two publications focus on the construct of global competence in relation to education (Mansilla & Jackson, 2011; Van Roekel, 2010). A policy brief by the NEA states that “global competence is a 21st century imperative.” Apart from awareness of global issues, appreciation of cultural diversity, and language proficiency to foster cross-cultural understanding, global competitiveness is also stated as an explicit goal of global competence education (Van Roekel 2010). Boix Mansilla and Jackson (2011) base the need for global competence education on flattened global economies and changing demands of work, as well as increasing cultural diversity due to migration and the need for global stewardship in light of climate change (p. 2f).

**DigCompEdu**

DigCompEdu does not exclusively address teacher educators; it was developed for “educators at all levels of education” (Redecker, 2017, p. 9) and is situated within the European Education Landscape. The framework comprises of six competency areas, namely “Professional Engagement,” “Digital Resources,” “Teaching and Learning,” “Assessment, Empowering Learners,” and “Facilitating Learners’ Digital Competence,” each including three to five competences. The framework also proposes six competence levels corresponding to the Common Framework of References for Languages (CFRL) (Redecker 2017, p. 9). On the macro level, DigCompEdu distinguishes between educators’ professional competencies, educators’ pedagogic competencies, and learners’ competencies.

Within “Facilitating Learners’ Digital Competence,” aspect 6.2 relates to digital communication and collaboration. The authors provide 12 examples, one of which explicitly addresses the aspect of culture. According to this example, competent teachers enable learners to “adapt communication strategies to the specific audience and cultural and generational diversity in digital environments” (Redecker, 2017, p. 80). In the following proficiency-level statements, a similar notion can be found on the third level (corresponding to B1, according to the CFRL):

> [...] guide learners in respecting behavioural norms, appropriately selecting communication strategies and channels, and being aware of cultural and social diversity in digital environments

(Redecker, 2017, p. 81)

This reference to culture is contextualized in terms of “21st century challenges” that educators can address by teaching “21st century skills” to “21st century learners” (cf. Redecker & Caena, 2019, p. 356). Redecker and Caena refer to the definition of 21st century skills proposed by Binkley et al. (2012), which they paraphrase as

> ...being able to communicate, share, and use information to solve complex problems, in being able to adapt and innovate in response to new demands and changing circumstances, in being able to marshal and expand the power of technology to create new knowledge, and in expanding human capacity and productivity

(Binkley et al., 2012, p. 17).

The authors distinguish between a total of 10 skills, each of which falls into one of the following categories: “Ways of Thinking,” “Ways of Working,” “Tools for Working,” and “Living in the World.” This last category includes the skills “8. citizenship - global and local,” “9. life and career,” and “10. personal and social responsibility - including cultural awareness and competence” (Binkley et al., 2012, 18-19).

**Digital Capabilities (Jisc)**

Developed in 2015 by the UK-based, government-funded organization Jisc, the Digital Capabilities framework addresses various groups in academia including students, researchers, librarians, and teachers in higher education and professional development. It is structured into six dimensions, with ICT proficiency at the core and digital identity and well-being framing the other four dimensions. In one of these four dimensions, namely “Digital communication, collaboration and participation”—which comprises the capabilities “Digital communication,” “Digital collaboration,” and “Digital participation”—two references relevant to intercultural discourse can be found. Digital collaboration is, among other aspects, described as
Capacity to work effectively across cultural, social and linguistic boundaries (Jisc, 2014, p. 6) which requires an understanding of the features of different digital tools for collaboration, and of the varieties of cultural and other norms for working together (ibid.).

In this framework, culture is addressed on the micro level and as a comparatively isolated phenomenon, as it is only relevant within one aspect of the competency.

**Media Didactica**

Media Didactica was developed by Belgian researchers in 2014. It consists of three interrelated strands focusing on students and preservice teachers, teachers, and teacher educators respectively. The framework strand for teacher educators distinguishes between three classes of competencies—“Media in teacher education,” “Media in the professionalization of the teacher educator,” and “Media in the training and education community” (Meeus et al., 2014). Each of these dimensions covers between one and three competence aspects, which are further specified through learning goals and examples (Meeus et al., 2014).

The Media Didactica framework for teacher educators contains one relevant example. In the communication aspect of the third competence dimension, “Media in the training and education community”, one of the two learning goals refers to teacher educators’ ability “to use media to build up and maintain an international network” (Meeus et al., 2014; Appendix, 55). However, the analyzed material does not contain any reference to a discourse in which intercultural interaction is theoretically grounded.

**DISCUSSION**

After comparing the frameworks studied, it is clear that the TETCs framework accentuates the aspect of culture most explicitly. Specifically, our analysis shows that the TETCs represent the only media pedagogical competency model for teacher educators that considers culture to be sufficiently important to be further diversified into multiple competence aspects. This framework’s comparatively prominent position in media pedagogical discourse offers optimum conditions for establishing links to intercultural competence research. In the case of Media Didactica and Jisc’s Digital Capabilities Framework, no theoretical foundation relating to intercultural research could be identified in the analyzed literature, whereas the TETCs and DigCompEdu are informed by the global competence and 21st century skills discourses respectively. In order to discuss the theoretical framing further, a multistage deconstruction process is required (Deardorff, 2006, Bolten, 2014). To this end, the underlying concept of culture must be determined and its situatedness examined in order to counteract a cultural bias or, in this case, an Anglo- or Eurocentric perspective (cf. Dervin et al., 2020).

We follow Bolten’s (2014) distinction between a closed (and structurally descriptive) and an open (and process-oriented) concept of culture. The closed concept is characterized by a close link between the constructs of nationality and culture, in which individual cultural identity is characterized by homogeneity and determined by culture. In many research and training contexts, however, structuring culture models still come into play, as they provide orientation, reduce complexity, and ensure measurability (cf. Bolten, 2014). The open concept of culture is characterized as a shared expectation of normality among members of a group (OECD, 2018, Rathje 2009). The national dimension is one of an infinite number of collective constellations that constitute themselves as subcultures or co-cultures (cf. UNESCO 2009). On the macro level, this can be linked to concepts such as global citizenship, which is based on the notion that the world has become a “global village” through globalization and digitalization (UNESCO, 2013), although much smaller communities and clusters (families, interest groups, etc.) can also be seen as cultures (cf. Bolten, 2014). Individuals always have multiple cultural affiliations and act in complex networks. Following an open concept of culture, these interactions between members of different groups may be called intercultural communication. This interaction may take place in a global or a local dimension. A prerequisite for intracultural communication, however, is that the individuals involved encounter difference and thus have to renegotiate their disturbed expectation of normality (cf. UNESCO, 2009, Bolten 2014, Rathje 2009).

Although the TETCs framework gives the most space to the aspect of culture among all the models examined, the construct of culture remains undefined within the framework. To understand this, we need to consider the genesis of the framework. The objectives of a Delphi process are to reach consensus, and the theoretical backgrounds of the participants may be diverse and remain implicit. We can conclude that the consensus reached by TETCs research provides valuable conditions for explicating the construct of culture and exploring possible meanings and underlying assumptions.
With the choice of an open or closed concept of culture, the meaning conveyed through TETC 8 changes significantly depending on whether “regions and cultures” is read as “regions and countries,” which would be the consequence of a closed concept of culture, or is taken to refer to complex clusters of meaning in virtual and physical environments, which would follow from an open and process-oriented conception of culture that emphasizes plurality and fluidity. Even though intercultural scholars stress that normative conceptions of culture are highly dependent on context (Bolten, 2014) and should therefore be neither limited nor fixed (UNESCO, 2009; 2013), research also shows that media shape new communities in which more fluid cultural identities emerge (Chen, 2012).

CONCLUSION AND OUTLOOK

There is plentiful evidence in research and policy on the importance of considering ICT-related and intercultural-global competence development in education together. It has also been shown that teacher educators play a significant role in this process. Looking at relevant teacher educator competence frameworks, we conclude that the TETCs best meet this newly emerging need to address ICT-related competence in a culturally sensitive and potentially global dimension, particularly through TETC 8. In addition, the theoretical foundation of TETC 8 can be clearly traced through the Global Competence Education Framework by Mansilla and Jackson (2011). In view of the highly heterogeneous intercultural research community in disciplinary, conceptual-theoretical, and empirical terms, and especially given the observed bias toward voices from the Global South (Dervin, 2020, Deardorff, 2009), a diverse and international discourse around the TETCs is needed. Designing internationally oriented ICT-enhanced professional development formats for teacher educators based on TETC 8 could make a significant contribution to pluralizing theoretical perspectives on digital intercultural interaction. Further research could thus make a valuable theoretical contribution, while at the same time contributing to the professionalization and internationalization of teacher educators. Recently published studies by Luongo (2019) and Carpenter et al. (2020) on teacher educators’ attitudes toward TETCs showed that respondents were significantly more ambivalent toward TETC 8 than toward other TETCs. The authors explain this gap in terms of conceptual uncertainty and a perceived discrepancy between the respondents’ own teaching and an international orientation. As a consequence, we conclude that training formats for the TETCs that focus on TETC 8 as a guiding principle and as a lens through which to view the other TETCs have potential for both the internationalization of teacher education as well as the ICT competence development of teacher educators.

REFERENCES


Tiede, J., & Grafe, S. (2020, April). International Perspectives on the Media-related Educational Competencies of Teacher Educators. A Systematic Category-Based Comparison of Competency Frameworks. In Society for Information Technology & Teacher Education International Conference (pp. 1251-1260). AACE.


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Crafting the Maker Educator Identity: Examining Teacher Identity Exploration Using Epistemic Networks

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Abstract: This work offers insights into three teachers’ processes of exploring and enacting identities as maker educators in an environmental science context. Invent with Environment was a maker-based after school program in an environmental education center where three educators worked with researchers to incorporate maker-based activities into their instruction. Researchers collaborated with the educators to encourage their active self-reflection as a part of identity exploration of maker educator roles. The teachers’ reflective data across three sessions of professional development and instructional sessions were collected and deductively coded for identity constructs defined by the Projective Reflection theoretical framework. Teachers’ patterns of connection-making across facets of the self were visualized using Epistemic Network Analysis, to track and compare trajectories over time. Networks revealed that all educators’ self-conceptualizations changed over time, but towards different facets of the self. The work concludes with implications for supporting teacher identity exploration, particularly as they enact maker education.

Keywords: Epistemic network analysis, Maker education, Identity exploration, Non-formal learning, STEM

INTRODUCTION

The Maker Movement is rooted in an evolving community of hobbyists, tinkerers, engineers, hackers, and artists committed to designing and building material objects for both entertainment and functional value (Martin, 2015). Though the traditional Maker Movement began in out-of-school spaces for mostly adult participants, a growing interest from the education community has sought to integrate making activities into K-12 education to provide learners the opportunity to develop science, technology, engineering, and mathematics (STEM) competencies. Beyond the physical maker “space”, the concept of learning by making (maker-based learning, maker-centered learning) has been lauded by educational researchers for its ability to facilitate new ways of understanding concepts, supporting identities and dispositions, and triggering future trajectories in academic domains and careers (Bevan, 2017). These potential learning outcomes are supported by the constructionist perspective of learning in which learners engage in the creation of mental models and physical objects. Papert and Harel (1991) add that the construction of these knowledge structures is best facilitated by learning
through play, hands-on building, and design. As a result, learners participating in maker activities are often presented the freedom to make choices, fail, and retry in both individual and collaborative settings. Subsequently, the activities presented by making asks learners to engage in open-ended problem solving that necessitates peer feedback and collaboration (Kurti, Kurti & Fleming, 2014; Maloy, Kommers, Malinowski & LaRoche, 2017). Though these interactions are necessary for the development of making from the constructionist perspective, they offer a new set of challenges for educators seeking to integrate maker-based learning into their instruction.

In a study of small group learning in makerspaces, Wallace and colleagues (2017) observed this emerging set of challenges from the educators’ perspective. Instructors struggled to balance the level of guidance required by learners while ensuring their instruction aligned with curricular goals and the experimental nature of making activities. This study illustrated the necessity of the continued development of educators as they seek to integrate making activities into their own instruction. Despite this, educational research is nascent in terms of how the introduction of interdisciplinary and interactive technological-pedagogical innovations such as making in formal and informal learning settings can stimulate dynamic shifts in teachers’ pedagogical roles in orchestrating student learning (Bevan, 2017; Brennan, 2014; Shaffer, Nash & Ruis, 2015). Even fewer studies have examined how we can educate teachers to reconstruct themselves in a time where the praxis of teaching is becoming increasingly decentralized and re-professionalized in digitally evolving learning ecologies (Brennan, 2014; Chee, Mehrtra & Ong, 2015; Cohen, 2017). Addressing this gap is inextricably tied to the dearth of empirical investigations that can support the democratization of making for K-12 aged students in formal and informal settings. Specifically, few investigations have revealed (a) which theoretical and pedagogical approaches can complement making activities and be instrumentally in supporting knowledge and skills in domains and disciplines that are valued in schools, (b) the interactions between self and learning and the resulting changes in learners’ interest and valuing of the content encountered through making, and (c) ways to understand, develop, and assess the processes students engage in and the artefacts they create through making (Halverson & Sheridan, 2014; Petrich, Wilkinson & Bevan, 2013; Quinn & Bell, 2013).

In this study, we adopt theoretical approaches that focus on motivating teachers’ actions in a specific role identity (learning by making, in this study) by elucidating the harmony (or lack of it) between the cognitive, social and affective aspects that impact teachers’ adoption of the role identity (Kaplan & Garner, 2018; Shah & Foster, 2018). Thus, in this paper, we answer the following research question: What is the nature of environmental educators’ identity exploration over time as a result of iterative design, development, and instruction of a maker-based course for environmental science?

THEORETICAL FRAMEWORK

Projective Reflection (PR) is a theory and methodology of learning which frames learning in the 21st century as a continual process of change in an individual’s identity, or a process known as identity exploration (Foster, 2014). This process follows an individual’s identity within situated contexts which afford the repeated and intentional exploration of role possible selves within specific domains or career roles. Learners can be supported in the process of Projective Reflection using designed environments (e.g., maker-based learning, game-based learning) and by using role possible selves as theoretical supports. Projective Reflection is comprised of four theoretical constructs which support the exploration of identities across specific domains or career roles: (a) Knowledge (foundational, meta, and humanistic) and digital/technical literacy skills (Kereluik, Mishra, Fahnoe & Terry 2013), (b) Interests (situated/perceptual, epistemic/personal) / Valuing (global/personal) (Wigfield & Eccles, 2000), (c) patterns of Self-organization/Self-control (co-regulation, socially-shared regulation, and self-regulation) (Vygotsky, 1934/1986), and (d) Self-perceptions/Self-definitions (self-concept, self-efficacy) (Kaplan & Flum, 2012).

Additionally, PR provides six questions through which identity exploration can be examined as it is changed repeatedly over time: (1) What do learners know? (2) What do learners care about?; (3) How do learners think?; (4) How do learners see themselves?; (5) What do learners want to be in the future?; and (6) What do learners expect to be in the future? The four constructs, partnered with the six guiding questions, can be utilized to aid in tracking changes across an individual’s (a) initial current self (Starting Self) prior to the beginning of an intervention, (b) exploration of multiple role-possible selves (Exploration of Possible Selves), and (c) desired possible self (New Self) following the completion of a designed environment (See Figure 1). Table 1 provides a brief overview of the four constructs as well as specific examples as reported by the participants of this study.
In focusing specifically on the process of identity exploration of environmental educators, this study utilized Kaplan and Garner’s (2018) Dynamic Systems Model of Role Identity (DSMRI) which conceptualizes a teacher’s professional role identity and motivation as a dynamic system comprised of four components that repeatedly emerge to inform motivated action. The DSMRI focuses on four interdependent constructs that underlie teacher action: (a) ontological and epistemological beliefs; (b) purpose and goals; (c) self-perceptions and self-definitions; and (d) perceived action possibilities. This framework is crucial in facilitating teacher education programs to promote teacher identity development and resulting changes in instructional practices that are aligned with educators’ role identity (Kaplan & Garner, 2018). In this study, the integration of maker technology and the designed experience of learning by making was a novel instructional practice for all three educator-participants. As such, the DSRMI was instrumental in supporting educators’ self-reflection as instructors who facilitate maker-centered learning.

Table 1

<table>
<thead>
<tr>
<th>PR Constructs</th>
<th>Identity exploration processes</th>
<th>Case examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Knowledge</td>
<td>Describing changes in understand</td>
<td>“To be successful in this role, one would have to have a basic knowledge of learning by making and then a passion for exposing students to the environmental science field.”</td>
</tr>
<tr>
<td>Interests and Valuing</td>
<td>Affirming personal interest, valuing or relevance of a topic or behavior</td>
<td>“A central characteristic of mine that would influence my role as an educator would be my passion for the environmental field/desire to make younger generations aware of the environmental problems our world faces.”</td>
</tr>
<tr>
<td>Self-organization and self-control</td>
<td>Modifying behavior based on feedback</td>
<td>“Encourage the students to ask questions and comments to develop ideas. This way we can be more creative.”</td>
</tr>
<tr>
<td>Self-perceptions and self-definitions</td>
<td>Reflections on how teachers see themselves in past, present, or future</td>
<td>“Yes, yes. That I can incorporate more activities based on my previous experiences.”</td>
</tr>
</tbody>
</table>
METHODS

This research was conducted as part of a grant awarded to advance theory and research on promoting identity exploration and change maker-centered learning opportunities. Building on this broader agenda, Invent with Environment (IwE), a play-based after-school workshop, was designed and implemented from Fall 2018 to Spring 2019 to help high school and middle school students to engage in the exploration of identities related to environmental science. Across 14 weeks of workshop activities, three environmental educators partnered with researchers to implement IwE activities and were asked to repeatedly and explicitly reflect on emerging (a) construct knowledge of land stewardship and invasive species management which were aligned with the Next Generation Science Standards (NGSS) for high school and middle school environmental science, (b) generate and sustain interest and valuing in land stewardship and invasive species management, (c) encourage goal-setting, self-monitoring and the overall regulation of role-specific activities, and (d) explore multiple identities (role-possible selves) related to their teaching in this context.

Participants and Settings

All activities relating to the IwE program were conducted at an environmental education center in a northeastern US city. The center is one of the first urban environmental education centers in the country and focuses on four key program areas: environmental education, environmental art, land stewardship, and wildlife rehabilitation. The center offers programs which focus broadly on STEM in addition to a specific focus on environmental science. These programs are offered to all school-aged students (K-12) through partnerships with local schools and community centers. Participants throughout the IwE program included three in-service environmental educators (2 male and 1 female) who work at the environmental center. These participants were recruited purposively as they were available for the duration of the intervention and expressed interest in adopting maker-centered learning into their instruction. Participants included Ashley, Austin, and Edmund (pseudonyms).

Ashley identified herself as Caucasian. Ashley joined the center in 2017 as a public program manager. The programs she manages seek to develop an appreciation for the outdoors in those that take part in them. Most of these public programs are geared towards families. Ashley also manages the summer camps for ages 6-9, and each week in camp focuses on a different environmental topic. As a result, her role also involves working with the counselors on how to teach those topics. Ashley participated in the study because she hopes to learn more about play-based approaches when it comes to supporting interest/knowledge in environmental science and art. Ashley believed that there are many ways of learning, and that she would be very supporting of any new way of learning that could potentially serve to further a students’ interest in this field.

Austin identified himself as Caucasian. Austin joined the center in 2016 as a land stewardship manager. Austin leads groups of students in volunteer activities around the property. He also works with Kindergarten students on ecological subjects like soil, trees, and wildflowers. Austin’s motivation to participate in this study was to align the educational process to stewardship practice that can enhance the landscape of the center.

Edmund identified himself as multiracial. Edmund joined the center in 2016 as the lead environmental educator. He leads visitors and groups through the center’s property while facilitating lessons. Edmund’s role also involves working with after school and outreach programs. Edmund participated in this study because he aspired to learn new ways to engage the students with environmental science, the other students, and their community.

Data Collection and Procedures

The IwE program included a teacher professional development (3 weeks – Fall 2018), an initial course (4 weeks – Winter 2019), and a revised course implementation (7 weeks – Spring 2019). The researchers and participants worked collaboratively throughout the professional development (PD) to design and develop a curriculum which aligned with the environmental center’s goals while introducing maker-based learning. The PD resulted in a four-week curriculum centered around environmental science which was offered to 18 high school students over a period of four weeks. Following the completion of this initial session, the researchers and educators reflected on course feedback and their own experiences with the designed curriculum. As a result, a modified and expanded curriculum was offered to 14 middle school students over a period of seven weeks.
At the beginning of the professional development, participants were asked to provide background information regarding their roles in the environmental center, what they enjoyed about their role in supporting students’ knowledge and interest in environmental science, and what they expected as a result of participating in the IwE program. Additional qualitative data was collected using a 7-item DSMRI [14] trigger activity which prompted participants to reflect on their ontological epistemological beliefs, actions possibilities, purpose and goals, and self-perceptions and definitions in their roles as educators at the environmental center. Sample items included, “What is one major goal you have in your role of an environmental science educator?” and “What major behavior do you do in your role of an environmental science educator?” Participants completed this survey prior to the beginning of each PD session, pre-post the IwE initial course, and pre-post the IwE revised course. As such, participants were prompted to intentionally reflect on their role as environmental educators as a continual process of change over the course of the IwE program.

Data Analysis

Quantitative Ethnography (Shaffer, 2017) was used to guide data analysis procedures and answer the research question. Researchers engaged in a deductive coding process for each teacher’s chronological reflective data (short-answer question responses), in which each response was coded for the presence (1) or absence (0) of change or reflection on the self in terms of the four Projective Reflection constructs. For example, a teacher describing her ability to “listen well” as valuable to her environmental science educator role would be coded for both Interest and Valuing and Self-perceptions and Self-definitions. Each line of data was independently coded by one or more graduate-level coders and one faculty-level researcher, who then compared codes and addressed line-by-line discrepancies until agreement was reached.

Coded datasets were then uploaded into the Epistemic Network Analysis (ENA) web tool to generate network visualizations of the associations that teachers drew between identity constructs over time. Units of analysis consisted of all lines of data associated with each educator (the variable Participant) subset by the first and second half of each teacher’s chronological posts (the variable ParticipantHalves). Time 1 for each teacher consisted of reflection data from weeks 1-4 and Time 2 consisted of reflection data from weeks 5-7 as this was the midpoint of activity. Lines of Conversation were drawn between each teacher’s data (Participant), and subset by each Session of reflective data; it was deemed unlikely that a teacher would explicitly reference back to reflections from prior sessions, which were separated by several months.

Codes in epistemic networks are the constructs whose associations to other constructs are modeled over time. In this case, the four Projective Reflection constructs served as the deductive codes applied to each line of forum data whose longitudinal associations were modeled over time. To calculate these longitudinal associations, the ENA algorithm uses a moving window to construct a network model for each line in the data, showing how codes in the current line are connected to codes that occur within the recent temporal context (Siebert-Evenstone et al., 2017), defined as 3 lines (each line plus the 2 previous lines) within a given conversation. An in-depth examination of the nature of teachers’ discourse revealed that the teachers rarely connected one response to more than the one or two responses prior, suggesting that a stanza window of size three was appropriate for this study. From an identity perspective, this longitudinal assessment of associations over time is appropriate, particularly when considered from a developmental understanding of identity that conceptualizes the current and future self as necessarily influenced by the past self.

The ENA model normalized the networks for all units of analysis before they were subjected to a dimensional reduction, which accounts for the fact that different units of analysis may have different amounts of coded lines in the data (i.e., different number of posts). For the dimensional reduction, we used a singular value decomposition, which produces orthogonal dimensions that maximize the variance explained by each dimension. (See Shaffer, Collier & Ruis (2016) for a more detailed explanation of the mathematics; see Arastoopour, Swiecki, Chesler & Shaffer (2015) for examples of this kind of analysis.) To help close the interpretive loop, in-depth qualitative examinations of each teacher case (Yin, 2017) were conducted to contextualize teacher changes in the networks over time.

RESULTS

Nonparametric Mann-Whitney tests showed that differences between Time 1 and Time 2 associations for each teacher were not statistically significantly different at the alpha=0.05 level. This is likely due to the relatively small dataset of reflective teacher data. While tests of statistically significant change in student data can help to illustrate the degree of
change enacted by each teacher, a lack of statistical significance does not necessarily indicate that they did not change over time. Processes of identity exploration as defined by Projective Reflection are most valuable when participants can enact them in an integrated fashion; that is, when reflection can regularly connect Knowledge gains, emerging personal Interests and Values, the enactment of Self-organization and Self-control strategies, and specific Self-perceptions and Self-definitions in a domain. As such, an examination of the epistemic networks for each time period can help to illustrate what aspects of identity exploration teachers may have emphasized from the beginning to the end of their participation.

**Ashley’s Identity Exploration**

An examination of Ashley’s epistemic network indicated generally balanced connections between all four PR constructs, though Ashley demonstrated the strongest connections between knowledge and her perceptions and definitions of self and her self-organization and self-control (See Figure 2). Overall, Ashley demonstrated much stronger connections to knowledge over the first half of the IwE program as all her connections to knowledge are stronger in Time 1 (green). Prior to the first professional development, Ashley highlighted connections between knowledge of environmental science, technical literacy with making technologies, and facilitating student interest in environmental science, “To be successful in this role, one would have to have a basic knowledge of learning by making and then a passion for exposing students to the environmental science field.” As the program progressed, Ashley illustrated stronger connection between self-organization and self-control and the constructs of self-perception and self-definition and interests and valuing. Ashley exemplified particularly strong connections between her perceptions and definitions of self and her self-organization and self-control over this time period. This shift from strong connections to knowledge towards connections to self-organization and self-control could indicate that Ashley began to develop an emerging sense of self in her role as an instructor who sought to integrate making activities into her instruction. In the second half of the IwE program, Ashley reflected on her own role as an educator and how that might impact her students, “One major practice that I do is to allow for student-led exploration. I would want them to work on projects that are of most interest to them.” This ultimately led to her identification of her final “goal” of the program, “One major goal that I have in my role is for students to feel connected to the natural world and feel as though they have stake in solving environmental problems.” Through these qualitative exemplars, Ashley’s shift from knowledge orientation to orientation towards her own self-organization and self-control is detailed.

**Figure 2.** Difference model for Ashley in which associations from Time 1 (green) are subtracted from Time 2 (red). Connections that were stronger in Time 2 are marked in red.
Edmund’s Identity Exploration

Comparatively, an examination of Edmund’s epistemic network illustrated distinct differences from Ashley’s trajectory. Once again, there were also distinct differences between Edmund’s identity exploration trajectory from time 1 to time 2 (See Figure 3). Edmund began the first half of the program demonstrating relatively strong connections between his self-perceptions and self-definitions and the other three PR con- structs. This is unusual for PR data as individuals generally require extended periods of time to elucidate their specific roles. Edmund, however, began the intervention with a relatively strong sense of his role as an educator despite the added integration of the maker curriculum: “First understand that all the kids must be treated the same way disregarding their origin, background etc. Give them time to analyze. It’s ok to ask questions, and it’s ok if they don’t know the answer. Make them feel welcome.”

Additionally, Edmund’s connection between his perceptions and definitions of self and his interests and values was consistently strong throughout the entire program. As the strength of association in this relationship did not change from time 1 to time 2, it was cancelled out in the difference model visualization. Edmund’s early manifestation of this relationship was captured in his background survey, “I hope to learn new ways to engage the students with environmental science, the other students and their community.” In addressing his goal at the onset of the program, Edmund made explicit connections between his personal interest and perceptions of self by identifying his role in creating connections between the content (environmental science), the students, and their communities. In the second half of the program, Edmund demonstrated stronger overall connections to his interests and values: “Be open to listen to the concerns of the students and be very flexible. Flexibility is very important to be able to transmit to the students that it is ok to not know everything.” Throughout the program, Edmund demonstrated distinct interests in his role as a mentor to students even going so far as to offer insight on how to apply for internships and camp counselor roles for interested students. His epistemic networks and shifts from time 1 to time 2 indicate a more specific and more explicitly and repeatedly affirmed development of his interests and values over time.

Figure 3. Difference model for Edmund in which associations from Time 1 (green) are subtracted from Time 2 (red). Connections that were stronger in Time 2 are marked in red.
Austin’s Identity Exploration

Austin’s epistemic networks indicate that he began the first half of the IwE program with relatively varied connections. Strongest among these connections were the relationship between his knowledge and self-organization and self-control and between his interests and values and self-organization and self-control. Specifically, Austin demonstrated interest in developing an understanding of how maker activities integrate with environmental science: “Understand the process of how learning by making can be combined with environmental science. Understand the possibilities of what can be achieved.” In the second half of the program, Austin demonstrated stronger connections to self-perceptions and self-definitions comparatively. Despite this, Austin tended to enact a more balanced process of identity exploration across both time 1 and time 2. This balanced trajectory is best illustrated by the relatively central location of the centroid which illustrates the summative effect of Austin’s identity exploration throughout the duration of the IwE program (See Fig. 4). Austin’s reflection on his experience in the first iteration of the IwE curriculum demonstrates his balanced connection between content knowledge, perceptions of self, and regulated actions: “I need to do better adaptive response in delivering the subject matter. Round 1 was challenging.”

Figure 4. Difference model for Austin in which associations from Time 1 (green) are subtracted from Time 2 (red). Connections that were stronger in Time 2 are marked in red.

DISCUSSION

Findings from the Invent with Environment program revealed that while the environmental educators may not have enacted statistically significant changes in their process of identity exploration, distinct and notable changes from each instructor’s Starting Self to New Self were identified through Projective Reflection as a result of their participation in the intervention.

Figure 5 illustrates the summative epistemic networks for all three participants. This model shows the centroids for each teachers’ data overall (squares) and for their centroids in times 1 and 2 (circles). Ashley (red), Austin (blue) and Edmund (purple) show different trajectories of associating different constructs to a greater or lesser degree over time, despite being asked to reflect on the exact same questions over time. In general, Ashley followed a more “traditional” identity exploration trajectory as defined by Projective Reflection. While she began by demonstrating stronger connections to knowledge, her trajectory shifted to be more focused on self-organization and self-control by the end of IwE. As
evidenced previously, Ashley discussed her encouragement of student-led exploration. This suggests that as Ashley’s own identity as an environmental educator shifted to integrate making activities into her instruction, her approach also shifted to integrate a more constructionist perspective in support of learning by making (Papert & Harel, 1991).

![Figure 5. Centroid movements from Time 1 to Time 2 with shifts labelled.](image)

While Austin (shifting from interests and values to self-organization and self-control) and Edmund (shifting from self-perceptions and self-definitions to interests and values) experienced less traditional trajectories in terms of identity exploration as defined by Projective Reflection, their experiences reveal potential pathways of similar educators attempting to integrate making activities into their instruction. Specifically, these non-traditional identity exploration pathways require additional investigation in order to aid in understanding and interpreting the various trajectories educators undergo as they seek out ways to integrate making into their instruction. This outcome suggests that additional supports (e.g., longer and/or more targeted professional development, additional curricular development time) may be required to facilitate a more balanced identity exploration trajectory. This balanced trajectory necessitates not only stronger connections between individual constructs in an educator’s New Self, but also an overall integration of the four constructions which is exemplified by stronger relationships across and between all constructs as defined by Projective Reflection.

**REFERENCES**


Quinn, H., & Bell, P.: How designing, making, and playing relate to the learning goals of K-12 science education. In M. Honey & D. Kanter (Eds.), *Design, make, play: Growing the next generation of STEM innovators* (pp. 17-33). New York: Routledge.


Investigating Adoption and Collaboration with Digital Clinical Simulations by Teacher Educators

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Abstract: In this study, we examine the outcome of a four-day workshop with 24 Teacher Educators (fellows) who were supported in using two tools - Teacher Moments (TM) and Eliciting Learner Knowledge (ELK). The tools are designed for authoring, implementing, and research Digital Clinical Simulations in education. The simulations centered around issues of equity in K-12 computer science education to provide in-/pre-service teachers with opportunities to practice high-stakes interactions in low-stakes settings. We operationalize the technology adoption of the fellows through the notions of self-efficacy, help-seeking, and technology concerns to recognize the potential barriers they faced in transitioning from authoring to implementing and research design. Finally, we note the fellows’ implementation plans in the ensuing academic year and examine potential collaborations amongst them using social network analysis. Our results reveal how a small group of fellows, spanning major regions of the U.S., generate a broad range of scenarios, as well as clusters of scenarios, enabling simulation-based research supported by collaboration.

Keywords: Digital clinical simulations, Collaborative technology adoption, K-12 computer science education

INTRODUCTION

In this paper, we tackle issues of equity in computer science for U.S. K-12 classrooms. Equity issues in K-12 classrooms in the U.S. are frequently multi-faceted and contextual and arise from various scenarios (Gretter et al., 2019; Ryoo et al., 2019). Each classroom not only has different distributions of student demographics (e.g., race/ethnicity, socioeco-
nomic status, English language learners) but are also subjected to different regulations based on the State and school district. For example, a classroom in Texas is very different from a classroom in Arkansas. Moreover, mandatory classroom policies aimed at broadening participation places the challenges of equitable access to Computer Science education on the schools and subsequently on the teachers, most of whom lack the means to do so in terms of resource or skills (Cao et al., 2020; Mark et al., 2020; Sauppé et al., 2019). To address issues of equity, we need to find ways to deal with these networks of challenges (Hillaire et al., 2020).

A viable solution to tackle the diverse challenges lies in how we prepare teachers. While there are a wide variety of K-12 schools, there are substantially smaller teacher education programs (Kawas et al., 2019; Yadav et al., 2016). It would be beneficial to work alongside Teacher Educators since they are likely familiar with the diverse range of equity issues in K-12 CS Ed arising from different contexts. However, such a distributed approach may be inefficient since it could potentially yield several disparate and disconnected efforts. Another key challenge specific in preparing teachers is a lack of opportunities to practice high stakes interactions in low stakes settings. Grossman et al. (2009) found that other professions in social sciences provided ample opportunities to practice high-stakes interactions in low-stakes settings. In contrast, Teacher Educators have historically had access to practicums where they practice teaching with actual students. These are high stakes interactions and not an ideal place to learn how to handle issues of equity.

To address these challenges, we leverage Digital Clinical Simulations (DCS) platforms, designed to support teacher educators to author, implement, and research via simulations in the classroom (Hillaire et al., 2021). In previous work, the relatively simple format of simulations in Teacher Moments, a DCS tool, was conducive for authoring simulations pertaining to issues of equity (Hillaire et al., 2020). Related work also examined the help-seeking behavior of teacher educators when using Teacher Moments for authoring, implementing, and researching digital clinical simulations (Hillaire et al., 2021). We extend this work by examining new functionality in Teacher Moments as well as the additional DCS tool ELK (Eliciting Learning Knowledge) which facilitates role-play. We examine the technological adoption of the DCS authoring tools by the fellows through the quantitative metrics of self-efficacy, help-seeking, and technological concerns replicating the measurement and analysis previously reported for the first cohort of fellows (Hillaire et al., 2021). Additionally, we perform thematic analysis of their feedback experience to understand the best possible ways to provide support. We examine the results of a planning session in the second year of the INSPIRE CS-AI project, where 12 fellows returned for the second year of the fellowship and 12 additional fellows were recruited to begin scaling up the use of the platform.

Help-seeking is an important dimension to consider for technology adoption because technology can only be effectively implemented when teachers understand the entire process and are aware of the whole cycle of the technology they use in the classroom (P. A. Ertmer & Ottenbreit-Leftwich, 2010). It was observed that “peer-feedback” was the only theme of help-seeking that spanned the three aspects of authoring, implementation, and research. Consequently, collaboration with peers, could facilitate technology adoption by Teacher Educators.

In our current study, we examine the factors that are beneficial to supporting peer-collaboration amongst teacher educators. To encourage collaboration between fellows, the additional 12 fellows were recruited using the recommendations of previous cohorts. In addition to this recruitment strategy, we had various workshop activities that assigned pairs of teacher educators to work together. We also established affinity groups where fellows expressed common topics of interest. Finally, with the recruitment strategy and workshop activities designed to foster collaboration, we examine the resulting implementation planning at the end of the workshop to see which of these elements of recruitment and workshop design resulted in collaborative implementation plans. Social network analysis over the implementation plans reveals a high degree of mutual collaboration. Furthermore, collaboration appears to be related to affinity groups formed during the workshop more than any other factors analyzed.

**RELATED WORK**

**Simulation Based Research:** Many studies have used simulations in education, some of which have been informed by clinical simulation work in medical training. (Dotger and Ashby, 2010; Dotger, 2013). In clinical simulation work, there has been a transition from questions focused on the efficacy of simulations in medical education to considering new research opportunities made possible by using simulations - referred to as simulation-based research (SBR) (Lamé and Dixon-Woods, 2020). Such simulation-based research has been employed in several avenues of K-12 CS Ed, like computational thinking (Adler and Kim, 2018; Reich et al., 2018), critical incidents (Pieper et al., 2020), and even problems of practice (Borneman et al., 2020; Robinson et al., 2018).
In this study, we focus on SBR for multi-center studies, which are studies where clinical simulations are replicated across multiple sites as a means to examine the extent to which simulations can be generalized across contexts. We apply this approach to the use of simulations in Teacher Education. To connect the use of clinical simulation to the concept of multi-centered research, we next describe digital clinical simulations, which provide tools for distributed authorship (Hillaire et al., 2020).

**Digital Clinical Simulations (DCS):** DCS approximates the real-life interactions of a participant (say a teacher) by making them interact with an agent through scripted conversational prompts (Hillaire et al., 2020). The agent is considered unintelligent since the scripted prompt is static and does not depend on the participant’s response. DCS derive their inspiration from clinical simulations in medical education to create authentic patient interactions between a medical student and a mannequin or a paid actor (Dotger, 2013; Hamstra et al., 2014). In addition to providing a platform to play-test the scenarios, DCS should also enable the participants to revisit their play-testing to observe their choices and reflect upon what they could have done instead. This ensures individual reflection on their own responses. Finally, DCS should also include support for group reflections by providing features that enable authors (Teacher Educators) to collectively examine participant responses and compare and contrast different play-testing strategies. Thus, the system should facilitate authors to broadcast and share their experiences and findings with other pre-service teachers, Teacher Educators, and researchers. Teacher Educators can help facilitate discussions based on their depth of knowledge around issues of equity for which the simulation was designed (Sullivan et al., 2020).

**DIGITAL CLINICAL SIMULATION TOOLS**

**The Entire Cycle of Digital Clinical Simulations**

As observed in (Hillaire et al., 2020), Teacher Educators exhibit curricular expertise, i.e., the ability to contextualize content-appropriate material to the learner (Ennis et al., 1994). Moreover, by supporting Teacher Educators as authors, it situates the simulation around topics for which the Teacher Educator has expertise. This, in turn, supports discussing pre-service teachers’ behavior within the simulation (Sullivan et al., 2020). Teacher Educators have skills suited for authoring and, in doing so, could create simulations for which they could effectively facilitate implementations. However, previous work found that they needed support, particularly in the form of peer-feedback, throughout all phases of authoring, implementing, and researching the use of DCS (Hillaire et al., 2021). While support for technology adoption is a potential barrier, the desire for peer-feedback promotes generating a network of Teacher Educators. To consider the technology adoption of DCS for simulations, we first detail two tools and then consider how to support technology adoption. We illustrate the four phases of DCS in Figure 1. In this work, we focus on two such platforms that act as DCS authoring tools, namely, (i) Teacher Moments for single user simulations with unintelligent conversational agents (Hillaire et al., 2020) and (ii) ELK for two user simulations. (Reich et al., 2018). In this study, we examine how workshop recruitment and workshop activities influence collaborative implementation planning.

![Figure 1. An info- graphic illustrating the four phases of adopting DCS.](image-url)
In Figure 1, Phase 1 refers to authoring scenarios, while Phase 2 refers to prospective plans of designing implementation and research plans with DCS. Phase 3 refers to facilitating the implementation/research plans and finally Phase 4 talks about analyzing their implementation/research to reflect and refine their beliefs on equity. In this work, we focus on Phase 1 and Phase 2.

**Teacher Moments (TM):** TM is an open-source, online authoring platform for DCS and provides opportunities for improvisational interaction with scripted character(s). Previous work with TM supported authoring simulations that follow a simple linear path meaning all participants go through the same set of interactions in the same sequential order. While this positions the simulation’s story as lower in terms of complexity, it makes authoring the simulation similarly straightforward (Hillaire et al., 2020).

In this paper, we explore the capacity for Teacher Educators to author branched scenarios (hereby referred to as Branched) using the new branching functionality in the TM platform. Branching increases the story’s complexity and opens up new opportunities by considering improvisational responses to dynamic narratives (Smeda et al., 2012). While the increased complexity in the simulation narrative opens up new avenues as a DCS authoring tool, we consider how the increased complexity in narrative impacts Teacher Educators’ ability to author branched scenarios.

**Eliciting Learner Knowledge (ELK):** ELK is an online simulation game between two participants (Reich et al., 2018). One assumes the role of a teacher, and the other assumes the role of a student. The platform supports chat/discussions between players through a text-based interface. At the beginning of each simulation, ELK provides each player with their corresponding background details and an overview of the scenario; the teacher receives a learning objective. The student receives a learning profile with a list of the said student’s conceptions and misconceptions. The players then engage in a synchronous 7-minute conversation and take the same true/false quiz at the end of the simulation, which scores whether the participant role-playing the student could portray themselves accurately and whether the teacher was able to estimate the student’s understanding.

Although primarily designed to help pre-service and in-service teachers understand questioning strategies and learn about possible student misconceptions (Reich et al., 2018; Wang et al., 2020), ELK can also be used in role-play scenarios to facilitate discussions on problems of practice. Since the design of such scenarios, including the crafting of the questions, require curricular expertise, we observe that the ELK satisfies the first criteria of DCS.
Finally, ELK provides Teacher Educators with functionalities to analyze conversation exchanges in bulk, enabling them to compare and contrast different strategies about a scenario or strategies across different scenarios. It provides a platform for Teacher Educators to identify the most successful simulations and the reason behind them. It presents them with the opportunity to share their findings with the community and lead to collective reflections.

**Technology Adoption of DCS**

We consider Teacher Educators’ technology adoption of DCS by examining three aspects: 1) self-efficacy, 2) help-seeking, and 3) concerns. Self-efficacy is essential because one can only effectively integrate technology if they understand the overall process (Ertmer and Ottenbreit-Leftwich, 2010), which is authoring, implementing, and researching the use of DCS for teacher education. Similarly, help-seeking is vital because teachers require help when adopting technologies that innovate pedagogical practice (Ertmer and Ottenbreit-Leftwich, 2010). The Concerns Based Adoption Model (CBAM) suggests evaluating concerns to evaluate technology adoption (Hord et al., 1987).

**METHODOLOGY**

**Participants:** 24 Teacher Educators participated in a four-day workshop on authoring digital clinical simulations using Teacher Moments and ELK. 12 fellows had previously participated in a year-long fellowship (INSPIRE CS-AI) wherein they used Teacher Moments by authoring, implementing, and researching the use of DCS for Teacher Education. The 12 first-year fellows were responsible for recruiting second-year fellows to foster collaboration, so the 12 second-year fellows were all recommended by first-year fellows. None of the 24 fellows had previous experience with ELK.

**Workshop Schedule:** The workshop took place over four days in July 2020. The first day focused on authoring simple linear Teacher Moments simulations. The second day focused on authoring branched Teacher Moments simulations. The third day focused on authoring ELK scenarios, and the fourth day discussed plans for implementation and research using DCS for Teacher Education. At the end of each day, we administered a survey that examined self-efficacy, help-seeking, and technology concerns focused on the authoring activity of the day: Teacher Moments, Teacher Moments (branched), and ELK.

**Table 1**

Questions asked in the exit-tickets to document the authoring experience of the fellows.

<table>
<thead>
<tr>
<th>Question</th>
<th>Mode</th>
</tr>
</thead>
<tbody>
<tr>
<td>I am capable of authoring scenarios for DCS</td>
<td>Likert scale</td>
</tr>
<tr>
<td>I require supports to author scenarios in DCS</td>
<td>Yes/No</td>
</tr>
<tr>
<td>If yes, what supports can help you author scenarios</td>
<td>Text-box</td>
</tr>
<tr>
<td>I think DCS could benefit from additional supports</td>
<td>Yes/No</td>
</tr>
<tr>
<td>If yes, the supports I would like to see added to DCS are</td>
<td>Text-box</td>
</tr>
</tbody>
</table>

**Table 2**

Questions in Day 4 exit tickets to document the implementation and research plans of fellows.

<table>
<thead>
<tr>
<th>Question</th>
<th>Mode</th>
</tr>
</thead>
<tbody>
<tr>
<td>I am capable of planning a [lesson/research study] that implements DCS in my class</td>
<td>Likert scale</td>
</tr>
<tr>
<td>I require supports for [implementation plans/research] using DCS</td>
<td>Yes/No</td>
</tr>
<tr>
<td>If yes, the supports that I need to help me [implement/research] scenarios in my class and/or professional sessions</td>
<td>Text-box</td>
</tr>
<tr>
<td>I think [ELK/TM] could benefit from additional supports for [implementation/research]</td>
<td>Yes/No</td>
</tr>
<tr>
<td>If yes, the [implementation/research] supports that should be added to [ELK/TM]</td>
<td>Text-box</td>
</tr>
</tbody>
</table>
Materials

**Day 1, 2, & 3 fire-hose slides:** We document the scenarios the fellows have authored for a particular DCS in their corresponding fire-hose slides. For each scenario, we ask the fellows to provide a summary/description and the problems of practice associated with it.

**Day 1, 2, & 3 exit tickets:** We also document the fellows’ feedback on the first three days of the workshop on authoring different DCS in the corresponding exit tickets. The questions in the exit tickets are provided in Table 1 and were framed as either a Likert-scale, a binary Yes/No question, or a Text-box to record general textual response.

**Day 4 Implementation Plan:** We formalize an implementation plan, spanning the next 12 months, for the fellows to implement and research the scenarios they had authored during the workshop. We created affinity groups wherein fellows could identify common themes of interest to facilitate collaboration among peers. The implementation plan outlines all the scenarios that a fellow is interested in implementing and its tentative schedule.

**Day 4 exit ticket:** The exit ticket on Day 4 outlined the fellow’s future endeavors in using different DCS tools for lesson implementation and/or research. The questions posed in the exit ticket are shown in Table 2. We show the same questions for both implementation and research design but for the sake of brevity, we refer to them as [implementation/research] in Table 2.

Research Questions

(RQ1) How do Teacher Educators describe the experience of authoring, implementing, and researching DCS in terms of self-efficacy, help-seeking, and technology concerns?

(RQ2) How do Teacher Educators project collaborating on their implementations?

RESULTS

RQ1. How do Teacher Educators describe the experience of authoring, implementing, and researching DCS?

During the workshop, the fellows authored 46 Digital Clinical Simulations spanning both ELK and Teacher Moments. Out of the 46 simulations, the fellows authored 17 ELK scenarios, 19 Linear TM scenarios, and 10 branched TM scenarios. We report the participant’s adoption of Teacher Moments and ELK along the dimensions of self-efficacy, Help-Seeking, and Technology concerns for authoring in Table 3 and those concerning implementation and research in Table 4.

Of the 66 responses to exit surveys from each of the four days of the workshop, 22 mentioned seeking help, and 44 indicated technology concerns. 11 of the help-seeking responses were for authoring, 3 for implementation, and 8 for research. The breakdown across phases for the technology concerns responses was 21, 11, and 12, respectively. Three raters coded these responses, and in a consensus rating, the four themes of peer-feedback, ideas/examples, feature requests, and tech support emerged. These themes were prevalent in both help-seeking and technology concerns across the phases of authoring, implementation, and research design.

Peer-feedback refers to responses in which participants expressed a desire to discuss their ideas or have their work reviewed by others during the authoring, implementation, and/or research process. One participant stated, “It would be great to have someone discuss my ideas and have feedback on what may or may not work.” This aligns with findings from the first year of the fellowship (Hillaire et al., 2021). Participants who asked for ideas/examples felt that they needed more time to form ideas, that they wanted help in brainstorming ideas, or that they would have benefited from examples of scenarios, implementation methods, or past research to use as a starting point. For instance, a participant was “not sure how best to facilitate this online and would love ideas for thinking about reflection.” Tech support encompasses responses from participants who did not have specific questions or requests at the time but would like for help to be available if they run into difficulties in the future. One such response was, “just check-ins when I encounter challenges - no specific support needed at this time.” Finally, feature requests included descriptions of new features for DCS, which participants would find helpful in any of the three phases, such as “more open-ended questions along with the true-false/yes-no responses” in ELK.
Table 3
Technology adoption for authoring

<table>
<thead>
<tr>
<th>Authoring</th>
<th>Self-efficacy</th>
<th>Help-seeking</th>
<th>Concerns</th>
<th>#Scenarios</th>
</tr>
</thead>
<tbody>
<tr>
<td>ELK</td>
<td>6.46</td>
<td>15.38%</td>
<td>61.54%</td>
<td>17</td>
</tr>
<tr>
<td>TM (Linear)</td>
<td>6.27</td>
<td>42.85%</td>
<td>46.67%</td>
<td>19</td>
</tr>
<tr>
<td>TM (Branched)</td>
<td>5.71</td>
<td>21.42%</td>
<td>42.85%</td>
<td>10</td>
</tr>
</tbody>
</table>

Table 4
Technology adoption for implementation and research

<table>
<thead>
<tr>
<th>Authoring</th>
<th>Self-efficacy</th>
<th>Help-seeking</th>
<th>TM-Concerns</th>
<th>ELK-Concerns</th>
</tr>
</thead>
<tbody>
<tr>
<td>Implementation</td>
<td>6.33</td>
<td>25.00%</td>
<td>25.00%</td>
<td>75.00%</td>
</tr>
<tr>
<td>Research</td>
<td>5.58</td>
<td>75.00%</td>
<td>45.45%</td>
<td>63.63%</td>
</tr>
</tbody>
</table>

Table 5
Codes for help-seeking and technology concerns

<table>
<thead>
<tr>
<th>Phase</th>
<th>Help-Codes (counts)</th>
<th>Tech-Codes (counts)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Authoring</td>
<td>Tech support (6), Peer feedback (4), Ideas/examples (2)</td>
<td>Feature requests (5), Documentation/tutorials (4), Tech support (3), Workshop clarification (2), Ideas/examples (1), Peer feedback (1)</td>
</tr>
<tr>
<td>Implementation</td>
<td>Peer Feedback (1), Tech Support (1), Ideas/examples (1)</td>
<td>Feature Requests (4), Tech Support (4), Feature Requests (4), Data collection (2), Documentation/tutorials (1), Workshop clarification (1)</td>
</tr>
<tr>
<td>Research</td>
<td>Tech Support (4), Peer feedback (2), Data collection (1), Feature requests (1), Ideas/examples (1), Workshop clarification(1)</td>
<td>Feature Requests (3), Peer feedback (3), Tech Support (3), Workshop clarification (3), Ideas/examples (1), Data collection(1)</td>
</tr>
</tbody>
</table>

RQ2. How do Teacher Educators project collaboration on their implementations?

To foster collaboration, we requested that each fellow implement four simulations per semester in the coming academic year (4 per semester). If all 24 fellows implemented 8 simulations, this would result in 192 implementations in the coming year. During implementation planning, fellows scheduled a total of 102 implementations, with more implementations scheduled for the fall (71) than for the spring (31).

For the 102 planned implementations, 17 were cases where the fellow indicated they would implement a simulation without specifying which simulation they would use, 29 were cases where fellows planned to implement their individual simulation, most notably for this study 56 indicated they would implement a simulation authored by a peer comprised of 44 unique pairs of author and implementer. 32 times the implementer plans to use one simulation from the same peer author, while 12 times the implementer plans to use two simulations from a peer author.

We formalize the authors’ potential collaborations with other fellows in the implementation plan by constructing a social collaboration network, as illustrated in Figure 3. The nodes represent fellows as specified by their numeric id, and the directed edge from one node (say 14) to another (say 12) indicates that ‘14’ wants to work with ‘12’. The directed edge weight denotes the number of scenarios of ‘12’ that ‘14’ wishes to implement.

Global analysis: The collaboration network comprises 24 fellows and 44 edges, out of which only five fellows have no incoming or outgoing edges, i.e. they do not wish to collaborate with anyone else. The network has a high global clustering coefficient score (Wasserman et al., 1994) of 0.275. A high gcc implies the existence of triads (links between one’s neighbors) and thus hints at increased collaboration between one’s neighbors. 17 out of 24 fellows comprise 12 unique triads, implying that 17 fellows are willing to collaborate on at least two other scenarios. The network exhibits a high reciprocity score of 0.273, implying that if a fellow A is willing to author a fellow B’s scenario, there is a 27.3% probability that B will also author A’s scenario. This score indicates high levels of mutual interest.

Year-wise analysis: We also distinguish between returning and new fellows and observe the network characteristics of these two sub-groups. We observe that both the mean in-degree and out-degree new fellows (1.33 and 1.5 respec-
tively) are lower than those of the returning fellows (2.33 and 2.17 respectively). We posit that although the new fellows are unsurprisingly, more hesitant to collaborate, the differences are not statistically significant. In fact, the new fellows displayed a greater interest in collaborating with existing fellows (12 edges vs 6 edges), which highlights their inclination to collaborate with experienced fellows.

Potential Reasons for collaboration: We further investigate the potential reasons for collaboration amongst the fellows along the lines of previous recommendations, workshop activities, and affinity groups. In the recruitment strategy, we investigated if recommendations from previous fellows led to improved collaboration efforts. We observe a moderate effect along these lines with, 5 out of 12 new fellows planning implementations with the fellows that recruited them. Thus, there is a reason to adopt a similar recruitment strategy to foster collaborative implementations when supporting Teacher Educators to adopt novel pedagogical approaches. In a comparative analysis, we examined if the paired workshop activities where fellows were assigned into pairs to try out the technology led to better collaborative implementation plans than the affinity group activity. 14 out of 44 collaborative implementation plans consisted of participants that were assigned as pairs during the workshop. However, affinity groups relate to 35 out of 44 collaborative implementation plans. An affinity group caters to a specific research theme put forward by the fellows and broadly aligns with the problems of practice they wish to implement and research. It resulted in 12 distinct affinity groups, as shown in Table 6, along with the corresponding number of fellows who wanted to participate in that affinity group. This suggests that when designing a workshop to support technology adoption, affinity groups appear more productive in implementation planning for collaborative technology adoption. From these results, we would suggest that during workshops to support technology adoption, affinity group activities promote more collaborative planning than assigned paired activities. While both have some influence, if workshop planners need to choose between the two, then affinity groups would be a better use of time.

<table>
<thead>
<tr>
<th>Affinity Groups</th>
<th>Fellows</th>
<th>Affinity Groups</th>
<th>Fellows</th>
</tr>
</thead>
<tbody>
<tr>
<td>Culturally responsive pedagogy</td>
<td>10</td>
<td>Engaging preservice teachers with equitable online teaching</td>
<td>5</td>
</tr>
<tr>
<td>Equity/Social Justice</td>
<td>9</td>
<td>Digital Citizenship</td>
<td>4</td>
</tr>
<tr>
<td>Elementary CS</td>
<td>8</td>
<td>Queering the CS curriculum</td>
<td>3</td>
</tr>
<tr>
<td>Elementary Teacher Education</td>
<td>7</td>
<td>Bi/Multilingual learners in the CS classroom</td>
<td>3</td>
</tr>
<tr>
<td>Cyber Security</td>
<td>6</td>
<td>Engaging Students with impairments in classroom</td>
<td>3</td>
</tr>
<tr>
<td>Artificial Intelligence in K-12</td>
<td>6</td>
<td>Neurodiversity / UDI</td>
<td>2</td>
</tr>
</tbody>
</table>

CONCLUSION AND FUTURE WORK

In this work, we examine the adoption of Digital Clinical Simulation authoring tools by 24 Teacher Educators across the USA. We perform quantitative and qualitative analysis to identify the capabilities of fellows to adopt DCS for authoring, implementing, and researching and potential collaboration among the fellows.

A quantitative analysis highlighted high self-efficacy scores in authoring, implementing, and researching DCS. A subsequent thematic analysis on the fellows’ feedback and social network analysis revealed high inclinations for collaboration, thereby making this an ideal scenario for multi-center studies. These results from the first two phases of adopting DCS demonstrate the generation of a network of solutions that may help address the network of equity problems in K-12 computer science education. Future work will address the last two phases of DCS adoption, namely facilitation of the said implementations and equipping fellows with the skills to research and reflect on problems of practice and issues of equity.

Acknowledgements

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REFERENCES


Hillaire, G., Larke, L., Reich, J., & Fang, A. (2021, April 9). Technology Adoption Concerns and Help-Seeking from Teacher Educators Authoring, Implementing, and Researching Equity Focused Simulations. [In Mouza, C. (Chair), Critical Perspectives on using Simulations to Broaden Participation in Computer Science through K-12 Teacher Education]. Symposium conducted at the meeting of the American Educational Research Association, Online.


The Education Influencer:
New Possibilities and Challenges for Teachers in the Social Media World

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Abstract: In this primarily conceptual paper, we define and contextualize the phenomenon of the education influencer. We situate the education influencer concept in relation to research and theory on teacher social media use, teacher identity, micro-celebrity, social media influencers, and teacherpreneurship. While educator use of social media for professional learning and networking has received substantial prior attention in the literature, educator engagement with the entrepreneurial, commercial, and for-profit aspects of social media has received limited scrutiny. Some P-12 educators have used social media platforms to cultivate large audiences of followers, and, as has been seen in other industries, have looked for ways to develop personal brands and monetize their influence with their audiences. We illustrate the education influencer concept with empirical examples from our prior and on-going research. Next, we discuss the implications of the rise of education influencers for teachers and policymakers, and identify areas for future research. Given that education influencers have the potential to shape other educators’ beliefs, practices, education philosophies, and teacher identities, we also consider implications for teacher education.

Keywords: social media influencer, entrepreneurship, teacherpreneurship, teacher moonlighting, microcelebrity

INTRODUCTION

Social media influencers have taken up important roles in popular culture and in the world of marketing (Enke & Borchers, 2019). Influencers are compensated for recommending or providing testimonials for products and services. Recently, influencer culture and behaviors have also arrived in education; however, education presents a unique context where influencer experiences, dynamics, and impacts are likely to differ from those in other settings (see Ho et al., 2021). In the United States, the vast majority of teachers work in public school systems, and are therefore state employees, an atypical role for influencers in other sectors. The teaching profession in the U.S. has historically been characterized by relatively flat hierarchies; for example, U.S. teacher pay has typically been based on years of experience and attainment of advanced degrees, rather than performance measures that might contribute to larger discrepancies in how different teachers are compensated (Ladd, 2007). So while influencers may be a relatively natural extension of trends in entrepre-
neurship, endorsements, and advertising in some fields, their place within the professional culture and practices in education is complicated and controversial.

Nonetheless, in recent years, the “influencer” term has become part of the parlance of education circles (e.g., Collins, 2019). For instance, the 2020 International Society for Technology in Education Annual Conference required presenters to complete an influencer disclosure form declaring any commercial relationships, which were then noted in the conference program. Despite this influencer presence in education, at the time of writing, the education influencer label has been utilized in only one empirical study (Shelton, Schroeder, & Curcio, 2020) which did not have conceptualization of the term as a primary goal. In this paper, our purpose is therefore to define and contextualize the concept of the education influencer. Clear conceptualizations are important instruments for framing what researchers observe and how they make sense of those observations (Caws, 1959).

The rise of influencers is entangled with the popularity of social media. Many educators employ social media for professional purposes, and there are various ways to use these media (Galvin & Greenhow, 2020; Robson, 2018). Although social media companies’ commercial imperatives affect what transpires on these platforms (Friesen & Lowe, 2012), some users also benefit from the platforms’ commercial aspects. Education influencers who build audiences of thousands of followers use social media to reap direct profits and also to develop their personal brands. To contextualize the educator influencer concept, in the following sections we first provide background on educator social media use and address literature on teacher identity and social media. Second, we zoom out to synthesize prior scholarship and theorizing on the concepts of micro-celebrity and social media influencers. Third, we narrow our focus back to education to consider the extant literature on teacherpreneurship and teacher micro-celebrity. We then situate the education influencer concept in relation to these various literatures and subsequently illustrate aspects of education influencer behaviors, identities, and impacts with empirical examples from several of our recent and on-going research projects. We discuss new possibilities and tensions associated with education influencers, for both the influencers themselves and for education cultures, online educator spaces, and the education profession. Finally, we conclude by considering implications for practice, policy, teacher education, and future research.

**Educator Social Media Use and Teacher Identity**

Social media platforms such as Facebook, Instagram, Pinterest, Reddit, and Twitter have in recent years become sites of substantial educator professional activity (Carpenter et al., 2020a; Greenhow & Galvin, 2020; Lantz-Andersson, Lundin, & Selwyn, 2018; Shelton et al., 2020; Staudt Willet & Carpenter, 2021). Through the access these platforms provide to colleagues beyond their schools, many educators build and maintain relationships, networks, and communities on social media, as well as finding, sharing, and discussing education ideas, practices, and resources (Carpenter et al., 2019, 2020a; Carpenter & Krutka, 2015; Hashim & Carpenter, 2019; Rosenberg et al., 2020). However, some education-related social media content is of questionable quality (Sawyer et al., 2019) and the lack of traditional content regulation and vetting also has been cause for concern (Carpenter & Harvey, 2019, 2020). The quantity of social media content can prove overwhelming (Staudt Willet, 2019), and spam can clutter popular education-focused social media spaces (Carpenter et al., 2020b). To date, research has attended primarily to educators’ intrinsically motivated social media use for professional learning and networking, but some educators also appear to bring extrinsic and commercial motivations to their social media use.

In addition to considerations related to educators’ purposes and motivations, social media use can be linked to professional identity. Professional identity is an important factor in teacher development, attrition, and job satisfaction (Buchanan, 2015; Hong, Day, & Greene, 2018). For example, professional identities influence educators’ motivations to teach and their ability to sustain commitment to their work (Day, Stobart, Sammons, & Kington, 2006). Teacher identity is continuously constructed, refined, and negotiated in relation to institutions, education policies, communities, and cultural scripts (Buchanan, 2015; Danielewicz, 2001). To date, the literature on teacher identity has not engaged extensively with the impacts of social media on identity development and expression. There are indications social media platforms allow for performative expression of identity and various kinds of identity work (Lundin et al., 2017; Robson, 2018). For example, teachers without formal leadership roles in their schools can use social media to engage in informal leadership and mentoring activities. However, because of risks associated with context collapse, some educators may avoid including essential elements of their identities in their social media activities (Kimmons & Veletsianos, 2014).

Social media thus appears to feature both the hegemony of existing ideals and the subversion or reinterpretations of such ideals (Robson, 2018). In other words, social media can provide new spaces for identity expression but various fac-

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tors may constrain what is expressed in those spaces. Aspiring or novice teachers could be misled or discouraged by the idealized and curated nature of some educators’ social media posts. It therefore appears that social media platforms present some barriers and benefits, but the prior research has focused on teacher identity in relation to social media use for professional learning and networking. How education influencers’ use of social media relates to teacher identity has not received attention in the extant literature.

Micro-celebrity and Social Media Influencers: New Identities on Social Media

The education influencer phenomenon is related to two larger phenomena that developed outside of the education context: micro-celebrity and social media influencers. Senft (2008) and Marwick and boyd (2011) described how individuals who were not previously celebrities in offline contexts have been able to leverage social media to draw attention to themselves, build audiences, and enhance their reputations; in the process, they achieve a degree of micro-celebrity. Micro-celebrity involves “ordinary” or “every day” people engaging in strategic self-presentation practices and interactions with followers on social media that result in increased online status (Abidin, 2015). For example, a number of individuals with interests in beauty products have leveraged vlogs and other social media to establish themselves as beauty gurus whose YouTube channels have large followings (Hou, 2019). By using social media to share their perspectives and elements of their personal lives, micro-celebrities create a sense of intimacy, authenticity, and familiarity with followers, and as such are seen by many to be more relatable and approachable than traditional celebrities (Raun, 2018). For some followers, there may even be a perception that they relate to micro-celebrities on a peer-to-peer or friendship basis, in contrast to the distance that is presumed to exist between traditional celebrities and their fans (Abidin, 2015; Senft, 2008). However, the often highly performative, idealized, and curated nature of social media behaviors and self-presentation can cast doubt upon micro-celebrities perceived authenticity and relatability (Khamis et al., 2017; Marwick & boyd, 2011).

More recently, the evolution of some micro-celebrities’ social media use has led to the development of the related concept of the social media influencer (SMI; Abidin, 2015). Some micro-celebrities do not monetize their roles, while the SMI concept is associated with influencers directly financially benefiting from their capacity to influence (Enke & Borchers, 2019). Like micro-celebrities, SMIs use social media to create social capital, cultivate attention for themselves, and develop a persona and personal brand. Many followers may feel that an SMI is someone they know and trust. However, once they have a sufficiently established audience, SMIs can then seek compensation for endorsing or marketing different products, services, and people, or otherwise commodifying themselves and their audiences (Khamis et al., 2017). For example, in the tourism industry, some travel companies will pay or provide free travel experiences to SMIs in return for different kinds of endorsements of their destinations, products, or services (Xu & Pratt, 2018). SMIs are adept at content production, content distribution, interaction, and relationship building. For many SMIs, much of the content they produce does not include endorsements or direct advertising; promotional posts might constitute a small minority of their content. SMIs are typically known for their perceived authenticity and accessibility, and are seen by their followers to be inspirational, credible experts and opinion leaders.

Micro-celebrity, Entrepreneurship, and Influencers in Education

Education processes, products, and contexts are different in many ways from the commercial and cultural realms in which the micro-celebrity and SMI concepts were originally developed and researched. Educators’ work can be considered a public good and is seen to have intellectual and social value, not just economic value (see Ho et al., 2021). Micro-celebrity and SMI are therefore likely to be enacted and interpreted in education differently than in other contexts. We therefore consider that the micro-celebrity and SMI concepts are manifested in education in particular ways and deserve the distinct labels of education micro-celebrity and education influencer.

As previously noted, substantial numbers of educators have taken up use of social media for professional purposes. Through their social media activities, many of these individuals end up broadening their professional networks and interacting with educators from beyond their schools or districts (Carpenter & Green, 2017). Some teachers have developed quite large followings on social media, such that they can be considered education micro-celebrities. Although the concept of the education micro-celebrity has received scant scholarly attention (Shelton et al., 2020), it is a well-established
enough phenomenon to garner some coverage in popular press articles (e.g., Reinstein, 2018; Hartung et al., 2020) and has even spawned a popular satire Twitter account, @EduCelebrity. Because of their large audiences, education micro-celebrities can potentially create connections between different networks and stakeholders. Education micro-celebrities can contribute to the teaching profession by acting as knowledge creators, curators, and brokers. Education micro-celebrities who are classroom teachers also potentially give voice to teacher perspectives that are often left out of education policy decisions. However, some education micro-celebrities may have influence that is disproportionate with their expertise, share content that is unreliable, and contribute to unhealthy notions of what is a “good enough teacher” (Pittard, 2017). Also, micro-celebrity can to some extent be purchased or manipulated through practices such as buying followers and “comment pods” in which groups of users agree to comment on each other’s posts to manufacture the appearance of interesting content or engaged, enthusiastic audiences (Carpenter et al., 2020a).

For some time, a subset of education micro-celebrities has been able to parlay their social media influence into compensation for offline activities, such as paid speaking opportunities at professional conferences. Nonetheless, in many cases, education micro-celebrities have not necessarily engaged in the overt endorsement or sales of particular products or services. The rise of social media, however, has been entangled with commercial imperatives and neoliberal individualism (Friesen & Lowe, 2012; Khamis et al., 2017), and it is therefore unsurprising that education micro-celebrities often seek to monetize their knowledge, skills, and audience. Thus we have the emergence of the education influencer. Importantly, many educators are not adequately compensated for their work relative to professionals in other fields with similar levels of expertise and experience (Allegretto & Mishel, 2020), and education influencing can be seen as an extension of a long history of teachers taking second jobs on weekends or summers to supplement their incomes. In all likelihood, many education influencers may want to make positive contributions to teaching, learning, and their profession, while also having strong and sometimes conflicting motivations to develop their personal brands and their profitability.

Before further illustrating the education influencer phenomenon, we also connect it to the online teacherpreneur concept (Shelton & Archambault, 2018). In contrast to influencers, who typically endorse or market products and services created by others, online teacherpreneurs are educators who sell their own original classroom resources, often within online educational marketplaces such as TeachersPayTeachers.com (TpT). While a small number of elite sellers in such marketplaces do achieve a level of micro-celebrity and wealth, the vast majority of sellers make much more humble sums (Koehler et al., 2020), and such small scale sales of one’s own goods do not reflect the SMI concept. In other words, not all teacherpreneurs are education influencers. Similarly, not all education influencers try to directly sell their own original education resources. It is, however, not uncommon for influencers to engage in some direct sales of their own products. For example, one New York City teacher who is a popular education influencer with over 100k Instagram followers also offers curricular resources she has created via TpT. Past research has shown that teachers and teacherpreneurs use social media spaces like Instagram, Pinterest, and Facebook in tandem with online educational marketplaces (Pittard, 2017; Shelton & Archambault, 2019, 2020). It is common for an education influencer to showcase their resources on social media, often by posting stylized images and/or videos of the materials they sell and explaining how they can be used in a classroom. These social media posts direct followers to the marketplace where they can then purchase said materials.

ILLUSTRATING THE EDUCATION INFLUENCER CONCEPT

Although the influencer term has been used for some time in other fields (e.g., Gillin, 2007), the education literature has only begun to engage with the influencer concept. To illustrate characteristics of education influencers and education influencing, we draw upon empirical examples from our on-going and recent research projects (Author et al., 2019b, 2020, 2020a, in preparation). To protect influencer’s anonymity, we have opted to present some synthetic examples below that represent the spirit of their Instagram posts, but not the exact language (Bruckman, 2002). We divide our examples into three related categories: education influencer behaviors, education influencer identity, and the impacts of education influencers.
Education Influencer Social Media Behaviors

Educational influencers engage in a broad range of activities that aim to turn their influence into profits. For example, some teachers work as brand ambassadors for educational technology companies, receiving compensation such as free software or hardware, or paid-for professional development experiences in exchange for promoting the company’s product(s) (Saldaña et al., 2019). In some cases, education influencers may be paid to directly promote or market educational goods or services, or even for promotion of goods or services that are not directly related to education (Authors, 2020). For example, we recently observed an education influencer on Instagram endorsing an online yoga program and sharing a link to a discounted membership in the program.

In prior work, Authors (2020) analyzed posts \(N = 310\) and stories \(N = 115\) from 18 purposefully selected P-12 educators with large social media followings who operate as education influencers on Instagram. We identified four primary types of content posted by these individuals: promotional content, solicitations for engagement, motivational content, and advocating for classroom approaches. In terms of promotional content, these education influencers promoted themselves, other influencers, and products. At times, they shared content that promoted both people and products, such as the influencer who shared a product created by another teacher and the craft store that was the source for her back to school paper. She shared, “I love the way these fonts combine and I also love the quick “About Me” section. I love all of it! I bought this a while back from [user, redacted], and I cut off the corners and added some adorable #backtoschool paper from [store, redacted]!” Indeed, we have observed how education influencers engage in various forms of promoting each other. This can include signal boosting or amplification where influencers draw attention to other influencers in overt or more subtle ways (e.g., see comment pods; Author et al., 2020a).

Related to promotional content, influencers also solicited engagement by asking questions or encouraging followers to comment to win a giveaway. For instance, one posted,

**HELP VOTE!** These are the 6 finalists for the Super September Bulletin Board Challenge✨ This time I challenged you to post a pic using [hashtag, redacted] for a chance to win a $25 Sbux gift card!! Tomorrow I will announce the winner, but I need your help voting on your favorite board! Comment below, including the letter of your favorite board!

Education influencers also shared motivational messages, some of which could be criticized as lacking substance. For instance, one influencer posted, “Excited that Day 1 of 180 Days of Amazing starts TODAY!! Brand new school, Brand new staff, Brand new classes, Same amazing experiences!!” Finally, and less prominently, education influencers advocated for certain classroom approaches, such as the influencer who wrote, “The debut whiteboard for the school year is ready to go for the big day tomorrow! … When students enter, if they see a prompt on the whiteboard, they’ll answer it during our morning routine. It’s an awesome way to learn about everyone, and provide a space for students to reflect and build each other up.” A criticism of the postings analyzed from this group of education influencers was that messaging often lacked a connection to critical social issues. However, in subsequent research (Authors, in preparation) specifically focused on anti-bias, anti-racist (ABAR) education influencers, we found a concern for critical social issues was prominent.

Other evidence points to the notion that education influencers are strategic in how and what they post. For example, in an interview conducted for a study on educator Instagram use (Author et al., 2020a), an influencer described some of the careful calculation that affected when he posted content: “You wanna get the highest engagement that you can so looking at like the analytics and the posting times and when’s gonna be the peak engagement hours and what can you do to increase, you know, the visibility of your posts and who can see it.” Education influencers also will sometimes not state their affiliations with their school district or school. One education influencer from Author et al. (2020a) mentioned that in his early social media use, he commonly shared examples from his classroom and his students’ work, but when his audience grew and he moved to a school district that was less supportive of teacher social media use, he stopped posting such content. He explained, “With the exposure that my account gets and … the messages and the comments that I get, I just don’t want them [my students] associated with that.” Social media platforms make users’ content visible to unanticipated audiences, and that persistent visibility can limit freedom of communication and interaction for educators (Author et al., 2019c). For education influencers, their heightened visibility means they must manage risks with their online actions falling afoul of community members’ expectations for educators.
Education Influencer Identity

Education influencers must navigate a variety of identity related tensions. Research has noted how personal-professional boundaries can be difficult to manage on social media (Carpenter et al., 2019), and to be seen as relatable and accessible, most education influencers share from their personal lives. While mainstream celebrity often assumes a certain distance between celebrities and fans, micro-celebrity is based on engaging with audiences and some degree of personal disclosure (Abidin, 2015; Senft, 2008). An education influencer from Carpenter et al. (2020a) explained, “I do share things just from my regular life as well ... people just kind of take an interest in you as a person as well even though I think it’s weird.” In addition to this blending of personal and professional identities, education influencers’ identities may relate to the visual nature of platforms such as Instagram and TikTok, which seem to focus attention on “conventionally good-looking” users (Marwick, 2015, p. 139).

Some education influencers find themselves managing tensions between different professional roles, such as being both an education influencer and an educator trying to engage in professional learning. A participant in Carpenter and Harvey’s (2019) research described struggling to negotiate multiple motives for using social media: “I’m always struggling with that balance of, OK, I’m a person, I’m a teacher, and I’m also a businessman and how do I work all of those 3 things together. Am I on here as a businessman, am I on here as a leader, am I on here as somebody to learn? So I’m always trying to balance that, and that’s a challenge for me.” Additionally, because many SMI followers value influencers in part for their perceived intrinsic motivations and noncommercial interests, SMI-brand collaborations can result in tensions for influencers’ authenticity management (Audrezet, De Kerviler, & Moulard, 2018). An Instagram education influencer in Carpenter et al. (2020a) discussed trying to be perceived as someone who endorses products, but in an authentic way:

You don’t wanna come across as somebody who’s just, you know, promoting sponsored things just for the sake of a paycheck ... when you are promoting like certain apps and certain ... programs, books, anything like that, just making it very transparent that it’s something that you believe in and that you agree with.

While education influencers—by definition—influence their audience, their identities are also to some degree inevitably shaped by their audience. One education influencer interviewed for Carpenter et al.’s (2020a) study explained that among his followers, “people feel very invested in you and what you’re doing and they feel like they have kind of a right to say whatever they can or they want to.” In order to maintain and potentially grow their audiences, education influencers must present and maintain personas that attract interest and interaction from their followers. Education influencers may find, for example, that they sometimes have to make trade-offs between what they value and what generates attention and expands their follower numbers. Some education influencers may have few qualms about presenting themselves in strategic ways on social media, while others may find it more problematic, disconcerting, or difficult to manage (cf. Kimmons & Veletsianos, 2014).

Education Influencer Impacts

In addition to their earning capacity, SMIs by definition can influence and therefore have been conceptualized as having the power to make changes in communities and encourage action within a group with a shared interest (Hudders, et al., 2020). While prior research and businesses’ willingness to compensate SMIs suggests they have the capacity to influence purchasing behaviors, it is less clear to what extent education influencers might be able to motivate their followers to participate in educational and social movements. Facebook and Twitter have, after all, been used in recent years in the organization of teacher protests and activism (Brickner, 2016; Will, 2018). Additionally, some education influencers may have valuable expertise to share with the field. Education influencers’ experience and knowledge were a point of conversation with a teacher in Shelton et al. (in preparation) research. Specifically, this first-year teacher shared that she looked to influencers on Instagram to gain knowledge on the application of ideas learned during teacher preparation, and to engage in a “level of collaboration” with experienced teachers working in similar contexts. The teacher described an influencer who taught the same grade level as follows: “She’s this third grade teacher and we follow the same sequence. And she specifically, when she was doing multiplication... We struggled with multiplication. And so whenever she posts something I’d be like, ‘Okay, doing that tomorrow. Let’s go.’ ...So it’s like I was using her as a model almost.”
Besides providing general pedagogical support, some education influencers may support engagement with more critical topics such as anti-bias education. For the largely White female U.S. teacher workforce, the perspectives ABAR education influencers offer into social issues may be quite valuable. They may inform specific classroom practices that are culturally responsive, and equity-focused, while also more broadly expanding teachers’ world views, opinions on social issues, and activism. For example, in an Instagram post from an ABAR influencer (Shelton et al., 2021), followers were challenged to disrupt the status quo in education and “unpack the common tropes we’ve held to that support structural inequity.” Additionally, this influencer encouraged followers to, “Please read and cite the work of the BIPOC authors you are reading when sharing your learning in community. If you’re looking to amplify folx of the global majority? Read them, listen to them, cite them, and pay them.”

Promotional and commercial content can arguably be relevant to and welcomed by some users. For example, a teacher who works for a school district that uses Google Apps for Education (GAFE) may consider some GAFE-related content to be useful, even if it is also implicitly or explicitly serving to advertise GAFEs products. Indeed, in one study (Carpenter et al., under review) the likelihood of a tweet being retweeted was actually increased when it came from a for-profit account or was self-promotional in nature. This could signal that at least some users welcomed the presence of for-profit actors and promotional content.

Education influencers also, however, potentially have negative impacts in online spaces. Research has suggested that at least some teachers find the presence of promotional content in educator social media spaces to be distracting or a source of frustration (Carpenter & Harvey, 2019; Carpenter et al., 2020a). For instance, a P.E. teacher interviewee from Carpenter and Harvey’s (2019) research commented, “I get a little bit frustrated with the physical education and health professionals that are out there that are selling various things … It’s just my own personal feeling that I have gained so much from so many people at no cost, now it’s my turn to start giving back to the profession.”

Given how social media can expand access to colleagues beyond one’s own school, it may provide teachers with a broader set of educators to consider as models of possible teacher identities. New facets of teacher identity are created by the existence of the education influencer phenomenon, and likely impact some educators’ sense of what it means to be a “good enough teacher” (Pittard, 2017). Education influencers’ presence will therefore potentially impact on the professional identity development of some educators who themselves have no intention of becoming influencers or even interacting with them. For example, the presence of education influencers likely moves online spaces towards individualistic, consumerist, capitalist cultures (see Attick, 2017) rather than towards spaces of collective activism (Thapliyal, 2018). It may be that the presence of teacherpreneurs, education micro-celebrities, and education influencers is “relegating traditional versions of professionalism to the margins” (Keddie, 2018, p. 197). Spaces that attempt to accommodate both influencers and political activism may see resulting tensions given such distinct motivations. Education influencer culture may lead to unhealthy forms of competition among growing numbers of aspiring education influencers.

**IMPLICATIONS FOR PRACTICE, POLICY, AND FUTURE RESEARCH**

The education influencer phenomenon has various implications for education practice. Regarding P-12 education practice, teachers and administrators must be aware that some of the endorsements of education products and services they see or hear may in effect be paid advertisements, rather than fully honest testimonials based purely on educational merits. Educators should also know that education influencers can manipulate their social media profiles to inflate their popularity. Educators would also be wise to reflect upon how their consumption of content from education influencers could result in unhealthy social comparisons.

Traditional models of mentorship within teacher education programs pair pre-service teachers (PSTs) with in-service teacher mentors as part of their coursework. Today’s aspiring teachers, however, potentially have access to various virtual, informal mentors. Some virtual mentors may simply want to altruistically give back to the profession and help PSTs navigate the transition to being a teacher. And some education influencers may offer helpful advice, perspectives, and resources for PSTs. Nonetheless, PSTs should be aware of how influencers’ motivations and content are entangled with commercial ends. Education influencers may be well intentioned, but their messaging is unvetted and can at times be trite, inaccurate, or uninformed (Shelton et al., 2020). PSTs would benefit from understanding the for-profit nature and user surveillance in which social media platforms engage. They should also develop as critical consumers of the content they encounter, learning how to critique content that influencers share (Sawyer et al., 2020).

Influencers operating in the domain of education also have a particular responsibility to behave ethically. In November 2019, the U.S. Federal Trade Commission published guidance for influencers regarding the disclosure of their
relationships with brands. Education influencers and the schools that employ them must be aware of such guidance and the potential conflicts-of-interest associated with influencing. School districts and states should review and update current codes of ethics and conflict-of-interest policies so that educators and other school stakeholders have clear guidelines regarding the ethical considerations surrounding education influencers (Saldana et al., 2019).

Finally, the ground is fertile for future research on education influencers and related concepts. Although teacherpreneurs who sell education resources on sites such as TpT have been the subject of self-report research (Shelton & Archambault, 2019, 2020), surveys or interviews with education influencers could yield insights into the particular motivations and experiences of this population. Given how cyberviolence can disproportionately affect individuals from marginalized groups (Nagle, 2018) and concerns regarding the large percentage of education influencers who seem to be white (Collins, 2019), the experiences of education influencers of color merit study. There is also a need to build upon Shelton et al.’s (2020) analysis of influencer content. Future studies could analyze the nature of educational influencer content in terms of the philosophies, ideas, or practices with which it is related. In addition to studying influencers and influencer content, research is needed on their audiences. Such work might ask how educators evaluate education influencer content. For example, what strategies do educators use to determine which content is and is not a paid advertisement or endorsement? To what extent do users simply treat promotional content as a necessary annoyance? Content from education influencers may well be interpreted in distinct ways by different users. Research could also explore how the presence of influencers shapes the nature of online spaces and educators’ experiences of those spaces.

CONCLUSION

School and district-level administrators, professional associations, publishing houses, and education professors have typically played some degree of a gatekeeping role in determining which teachers have influence beyond their classroom and schools. Social media platforms, however, have presented opportunities for teachers to publicly share their learning and practice (Lieberman & Mace, 2010) and potentially impact their profession beyond their school or district. Although some educators who have taken up these opportunities to share have decided to share freely, others have looked to earn money from their social media activities and audiences. In this paper, we have explored one approach to profiting from social media activities, that of acting as an education influencer. Although many of the dynamics present for influencers in other sectors are likely relevant in the specific context of education, we have described how there are also unique opportunities and challenges for education influencers given the nature of the teaching profession, the work of teaching, and norms around teacher identity. Teachers have faced long histories of arguably inadequate compensation. While there are serious challenges and concerns surrounding education influencers, it is also problematic to blame teachers for seeking to make up for insufficient salaries. When more teachers receive appropriate compensation for their work, we may see fewer teachers who feel compelled to invest their time in teacherpreneurial activities or to try to develop themselves into education influencers.

REFERENCES


Tweeting Across the Pond: COVID-19 Emergency Learning Networks in the United Kingdom and the United States through Twitter #Edchat

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**Abstract:** The global COVID-19 pandemic produced economic and social disruptions of unprecedented scale. In Spring 2020, schooling at all levels was halted or forced to switch to emergency remote teaching. Social media platforms, including Twitter, have been an avenue for educators to access professional learning from peers as part of broader professional learning networks (PLNs). This paper extends previous research by examining the educational response to COVID-19 within and across two countries, the United Kingdom and the United States, as documented in the Twitter #Edchat hashtag between February 1–May 31, 2020. Findings reveal topics of conversation by U.K. and U.S. tweeters were quite similar, but also highlight distinct discourse themes (e.g., #homelearning versus #remotelearning). These differences are discussed and connected to recent educational trends and emphases in the U.K. and U.S.

**Keywords:** social media, Twitter, COVID-19, PLNs, emergency remote teaching, emergency response networks

**INTRODUCTION**

The COVID-19 pandemic has produced economic and social disruptions of unprecedented proportions across the world. Although global trends have fluctuated, the United Kingdom (U.K.) and the United States (U.S.) have consistently been two of the most affected countries, as both were regularly among the top 20 most infected nations and the top five in highest cumulative death totals (World Health Organization, 2020).

In Spring 2020, the field of education saw massive upheaval and changes as schooling at all levels was halted or forced to switch to *emergency remote teaching* (Hodges et al., 2020). In the United States, 93% of teachers shifted to teaching online (Kurtz & Herold, 2020), starting on March 10, 2020. U.S. teachers were not necessarily prepared for this rapid pivot; fewer than 50% had been trained to use educational technology in innovative ways prior to the pandemic and only 20% perceived that they were allocated sufficient time to experiment with technology (Kurtz et al., 2019). Similarly, in the United Kingdom, as all schools closed on March 20, 2020, teachers were forced to support their students remotely and many reported a steep learning curve (Williams, 2020). Prior to the pandemic, most schools in the U.K. had not prioritized investment in educational technology (Ofsted, 2021a), with concerns raised at the time that two-thirds did not have sufficient infrastructure (Gibbons, 2020) and approximately one-third (35%) of school staff lacked confidence in teaching remotely (Ofsted, 2021b). Teaching communities in both the U.S. and the U.K. found themselves in a challenging position, and educators reached out for support in various ways. Social media has been an avenue for accessing
professional support from peers (Greenhow, Galvin, et al., 2020), with Twitter being one common platform used by educators during the pandemic (Trust et al., 2020).

In a prior study (Greenhow, Lewin, & Staudt Willet, 2020), we examined the educational response to the global public health crisis by comparing the U.K.’s and U.S.’s educational responses to COVID-19. To accomplish this, we collected news media articles and Twitter data in relation to how schools, teachers, students, and their families responded to the shift to emergency remote teaching during the Spring 2020 semester as a result of the COVID-19 pandemic. We focused on news media articles to explore systemic changes in relation to teachers’ digital pedagogy, digital equity, parents-as-educators, and educational policy (Greenhow, Lewin, & Staudt Willet, 2020). In the following paragraphs, we briefly report an overview of findings from that earlier study. Specifically, we compare the educational response to COVID-19 in the U.K. and the U.S., including both overlapping and divergent themes in the two countries’ approaches to digital pedagogy adoption.

In the U.K., the four nations (i.e., England, Northern Ireland, Scotland, and Wales) had devolved responsibility for education, with their own policies for educational technology focusing on measures of impact such as learning outcomes and equitable access. In addition, the four nations had developed different support systems, such as national learning platforms. Schools in all four U.K. nations closed on March 20, 2020, remaining so until early June when, for example, primary schools in England began to reopen. U.K. news media articles reflected considerable discourse related to teachers’ professional development needs, with an existing initiative designed to support classroom use re-purposed to support teachers trying to deliver learning online (Greenhow, Lewin, & Staudt Willet, 2020). Initially, there was resistance to synchronous lesson delivery from some stakeholders, mainly due to safety concerns but also related to digital equity concerns. Pre-recording lessons was promoted, although such asynchronous modes had the limitation of no student interaction. Limited opportunities for interaction frustrated both staff and students.

In the U.S., responsibility for education occurs primarily at state and local levels. A National Education Technology Plan (U.S. Department of Education, 2017) presented a vision of anytime learning and equitable access, but it did not address remote learning. Pandemic-induced school closures in the U.S. began at state levels on March 10, 2020, with many states then announcing by the end of April that schools would remain closed until the end of the academic year. Interestingly, there was little discussion in U.S. news media about how prepared teachers were for the pivot to emergency remote teaching and their professional development needs during the first few months of the pandemic (Greenhow, Lewin, & Staudt Willet, 2020). Teachers’ initial responses were to put resources online for their students and interact asynchronously, with some engaging in synchronous teaching through videoconferencing. Concerns voiced in the U.S. news media included debates over whether to teach new material or assess the learning that took place during this period. Student-teacher interaction was reduced and requirements for school attendance changed, with around 20% of students not in attendance. Teacher workload shifted to supporting parents and technology troubleshooting.

In both U.K. and U.S. contexts, schools were given autonomy in choosing how to respond to the emergency. This autonomy filtered down to teachers, who were often left to figure out their own way forward. Levels of student-student or student-teacher interaction were low initially in both the U.K. and the U.S., with live teaching more popular in the U.S. than in the U.K. due to different views of safety and privacy issues. Attendance and digital equity were issues in both countries. U.S. news media articles included discussion of summative assessment and remote-learning accountability, but this topic was relatively absent in the U.K (Greenhow, Lewin, & Staudt Willet, 2020). U.S. articles also highlighted changes to teachers’ workloads, with a greater emphasis on troubleshooting and parent communication; this again was not reflected in U.K. articles. Importantly, and a concern for this paper, U.K. news media articles highlighted the lack of teachers’ digital skills as a challenge, whereas in U.S. news media, this issue was barely mentioned (Greenhow, Lewin, & Staudt Willet, 2020).

Current digital-pedagogy guidance in the U.K. advocates building in feedback, assessment and peer interactions (Ofsted, 2021b). In addition, recommendations suggested that teachers need professional development and support for “both the use of the technology solution planned and adapting the curriculum and their teaching approaches for a remote education environment” (Ofsted, 2021a, p. 27). Similar guidance circulated in the U.S., where teachers have reported urgent needs for supporting remote education for vulnerable populations, helping students catch up to grade level, and assessment (Diliberti & Kaufman, 2020). Supporting the development of digital pedagogy is more important than ever, and opportunities to provide this help should be highlighted.

This current paper extends our previous work (Greenhow, Lewin, & Staudt Willet, 2020) by critically examining the educational response to COVID-19 within and across two countries, as documented in the Twitter #Edchat hashtag between February 1–May 31, 2020. Our investigation seeks to answer the question: What was the educational response to COVID-19 in the U.K. and U.S. as evident in social media and, specifically, Twitter #Edchat?
Perspectives

We frame this investigation of Twitter #Edchat activity during COVID-19 with the professional learning network (PLN) concept. Although definitions vary, PLNs can be conceived of as interactive systems of people, spaces, tools, and resources (Trust et al., 2016; 2017). The PLN concept is grounded in situated learning theories that view learning as occurring within social contexts and distributed among participants (Lave & Wenger, 1991). Trust et al. (2016) described PLNs as dynamic systems that shift and expand based on an individual’s needs, interests, and goals. PLNs exist with or without formal learning objectives and are broad “multifaceted systems, that often incorporate multiple communities, networks of practice, and sites that support both on- and off-line learning” (Trust et al, 2016, p. 17).

A PLN framing is especially apt for this current study of the educational response to COVID-19 where dynamic and flexible online discourse seems critical in an emergency like a pandemic. PLNs are flexible and adaptable. For instance, because PLNs support personalized learning, the range and types of people in educators’ PLNs can vary to suit their needs and preferences (Krutka et al., 2017). In addition, PLNs are accessed through multiple spaces where educators interact and learn, from face-to-face (e.g., conferences) to online spaces like social media. Indeed, social media growth has prompted more opportunities for educators to cultivate PLNs that “span across traditional spatial, temporal, and institutional boundaries” (Trust et al., 2017, p. 2). Finally, through their PLNs, educators seek tools and resources (e.g., ideas, curricular materials, teaching and learning perspectives, encouragement, technological tools) that can help them evolve their pedagogy (Trust et al., 2016, 2017).

LITERATURE REVIEW

Although much has been written in the past decade about educators’ use of social media for professional purposes (Greenhow, Galvin, et al., 2020), our review of relevant literature addresses how educators develop and adapt social media to supplement their PLNs. Prior to the COVID-19 pandemic, research on educators’ learning via social media suggested its potential for adapting to disruptions like the global pivot to emergency remote teaching in Spring 2020. For instance, Trust and colleagues’ (2016) study of K-12 teachers’ PLNs (n = 732), found that the flexible, multifaceted nature of PLNs fostered personalized professional activities and growth across cognitive, social, affective, and identity domains, with most participants reporting changes in their teaching—which they believed affected students’ learning. Similarly, Gao et al.’s (2012) literature review reported educational affordances of Twitter such as immediate participation, sustained interaction and communication, informal learning, and just-in-time reflection. Greenhalgh and Koehler (2017) studied the sudden introduction of a Twitter hashtag amongst French educators as a way to respond to, process, and adjust pedagogy following terrorist attacks in Paris on November 13, 2015. This study demonstrated how social media can facilitate just-in-time learning. Smith Risser (2013) studied how one new teacher developed an informal mentoring network through Twitter to support their transition from learning to teach in a teacher preparation program to practicing teaching as a professional.

The ability to filter and organize information by using hashtags is an especially important and valued feature of Twitter. Prior research has shown the Twitter educational hashtag #Edchat provides benefits for teachers’ professional learning and is one of the most widely subscribed teacher networks on Twitter (Carpenter & Krutka, 2014; Staudt Willet, 2019; Xing & Gao, 2018). Although much existing research relies on educators’ perceptions of their PLN at a single point in time (Carpenter et al., 2021), Xing and Gao (2018) studied 643,347 #Edchat tweets composed during one-hour synchronous sessions spanning six years, using machine learning techniques to categorize tweets by discourse type. They found that most #Edchat tweets exhibited either cognitive discourse (i.e., stating personal ideas or opinions, sharing experiences, and initiating new conversations by asking a question) or interactive discourse—expressing agreement or responding to an earlier tweet (Xing & Gao, 2018). Our study contributes to the accumulation of insights on continuity and change in educators’ PLNs (Carpenter et al., 2021) during the pivot to emergency remote teaching in two countries.

METHOD

We focused data collection on Twitter #Edchat because it is a well-established (i.e., ongoing since 2009), consistently high-volume, and largely on-topic conversation about broad education themes (Staudt Willet, 2019). As a result, #Edchat has also been the subject of much educational research (Greenhow, Galvin, et al., 2020).
For this study, we collected 331,538 #Edchat tweets from February 1 to May 31, 2020 through a series of Twitter Archiving Google Sheets (Hawksey, 2014). We used the statistical programming software R (R Core Team, 2020) to shape and analyze the data. First, we collected additional tweet metadata (e.g., tweeter information) using the tidytags R package (Staudt Willet & Rosenberg, 2020). We then classified tweets by type (e.g., original tweets, retweets). Of the 331,538 #Edchat tweets in our dataset, 118,163 (35.64%) were original tweets (i.e., retweets were removed). We used the mapsapi R package (Dorman et al., 2020) to retrieve country information for all tweeters and then filtered the original tweets to keep those composed by tweeters explicitly self-identifying in their Twitter profiles as located in the U.K. or U.S. Our subsequent, final dataset included 8,111 tweets from 360 U.K. tweeters and 73,859 tweets from 2,821 U.S. tweeters.

To computationally understand communication patterns and topics, we compared #Edchat tweets from U.K. and U.S. tweeters using several natural language processing (NLP) techniques. NLP is an approach to quantitatively analyzing large amounts of data and is used to describe and predict the nature of conversations. NLP has been employed for various educational applications, such as the design of chatbots for teaching (Smutny & Schreiberova, 2020) and the development of automated feedback systems (Zhu et al., 2020). In addition, NLP techniques have been used in education research to differentiate between the learning spaces defined by synchronous Twitter chats and general, asynchronous hashtag use (Greenhalgh et al., 2020).

In the present study, we applied NLP in several ways. First, we calculated the daily count of #Edchat original tweets from U.K. and U.S. users. Second, we calculated the likelihood of other hashtags appearing alongside #Edchat in tweets, as well as log odds ratios to describe the difference in likelihood of hashtags being used by U.K. versus U.S. tweeters. An odds ratio quantifies the strength of association between hashtag inclusion from U.K. and U.S. tweeters; the logarithm tempers sensitivity to relative positions that can often occur in odds ratios. Third, we created topic models using latent Dirichlet allocation (LDA), a statistical method of grouping words together using frequency and likeness. These topic models allowed us to identify the most common conversation topics by U.K. and U.S. #Edchat tweeters. We report the results of these analyses in the next section.

RESULTS

To answer our research question, What was the educational response to COVID-19 in the U.K. and U.S. as evident in social media and, specifically, Twitter #Edchat?, we considered tweet activity in #Edchat as indicated by several measures. First, we measured the volume of daily activity in Twitter #Edchat by the number of original tweets containing the #Edchat hashtag each day from February 1 to May 31, 2020, taking into consideration whether the tweeters self-identified as being located in the U.K. or the U.S. Second, we compared the most common hashtags to appear in #Edchat tweets from U.K. and U.S. tweeters. Third, we created topic models to infer the most common conversational subjects in tweets from U.K. and U.S. tweeters.

We found that the number of daily original tweets from U.K. #Edchat tweeters remained relatively constant from February 1 to May 31, 2020 (Figure 1). However, the number of daily original tweets from U.S. sources spiked in mid-March 2020, around the time that COVID-19 news suddenly disrupted regular education modes. This suggests that U.S. tweeters used #Edchat for COVID-19 response disproportionately more than U.K. tweeters, who may have used hashtags like #UKedchat and #edutwitter more often to supplement their PLNs.
Figure 1. Daily #Edchat Original Tweets from U.K. and U.S. Tweeters.

We then created a plot of the hashtags occurring alongside #Edchat in tweets from U.K. and U.S. users (Figure 2). The dots are shaded according to the log odds ratio, which shows the strength of association between hashtag inclusion from U.K. and U.S. tweeters. The dark purple and blue dots represent smaller differences between countries, whereas the bright green and yellow dots show greater differences.

Figure 2. Top Hashtags in #Edchat Tweets by U.K. and U.S. Tweeters.
From calculating the log odds ratios of hashtags occurring alongside #Edchat, we found that U.K. tweeters were far more likely to use #UKedchat (one of the most commonly used hashtags in the U.K.), #SLTchat (Senior Leadership Team chat, explicitly intended for administrators in the U.K.), #metacognition, and #pedagogy, as well as somewhat more likely to include #edutwitter, #leadership (likely connected to #SLTchat), and #teacher. U.K. tweeters were also much more likely to include #homeschooling, #homelearning, and #homelearninguk, although these hashtags appeared infrequently, present in fewer than 3% of tweets even for U.K. users. In contrast, U.S. tweeters were more likely to use #tlap (a chat based on the book *Teach Like a Pirate*), #sel (social and emotional learning), #remotelearning, and #distancelearning and slightly more likely to include #k12, #covid19, and #edtech. U.K. and U.S. tweeters included #education, #teachers, #teaching, and #learning at similar rates.

Finally, we used topic models to identify five distinct topics in #Edchat tweets from U.K. users and five from U.S. users (Figure 3). The shading depicts *topic-word density*—that is, the likelihood that a term appears in a topic. Dark purple means that a term is absent from the topic, green shows that the term appears a moderate amount, and yellow means the term appears in the topic with high frequency.

![Figure 3. Terms and Topics in #Edchat Tweets by U.K. and U.S. Tweeters.](image)

In the computationally generated Topic 1 amongst U.K. #Edchat tweeters, the terms “teachers” and “edutwitter” appeared often, “edtech,” “UKedchat,” and “new” appeared a moderate amount, and “SLTchat” and “help” appeared less often but are worth noting because these two terms rarely showed up in other topics. It can also be instructive to identify which terms do not appear in a topic. It is noteworthy that “teaching” and “classroom” do not appear in Topic 1. Thus, in sum, we interpret U.K. Topic 1 to be about school administrators (Senior Leadership Team implied by “SLTchat”) appealing to U.K. educators broadly (“edutwitter”) for help with new educational technology (“edtech”) solutions (“help”) for teachers, although not necessarily teaching tools or classroom materials. We applied a similar interpretive process to all 10 topics.
U.K. Topics 2 and 5 are also related to administrators (SLTchat), although Topic 2 is distinguished by the terms “get,” “school,” and “students,” seemingly describing tweets from administrators focused on obtaining resources for their schools and students. Topic 5 seems to be administrators looking to support teachers and teaching, marked by terms such as “use,” “pedagogy,” and “metacognition.” U.K. Topic 3 is focused on finding new teaching materials, and Topic 4 is about teachers looking for classroom help. Terms like “UKedchat,” “SLTchat,” “edutwitter,” “pedagogy,” and “metacognition” appeared across the five U.K. topics, but did not show up at all in the top-five U.S. topics.

U.S. Topics 1, 2, and 5 were related to the distinctly COVID-19-related term “remotellearning” (which did not appear in any of the U.K. topics). Topic 1 combined “remotellearning” with “k12,” “help,” and “now.” Topic 2 connected “remotellearning” to the terms “students,” “teacher,” “use,” “join,” and “check,” whereas Topic 5 connected “school(s),” “students,” “learn,” “learning,” “teachers,” and “teaching.” In other words, although remote learning was a common theme across several topics, this subject was approached in a variety of ways: searching with urgency (“now”) for resources that would help with remote learning in a K-12 context (Topic 1), finding resources usable by a teacher to check students’ attendance during remote learning (Topic 2), and identifying more general resources for remote teaching and learning (Topic 5). In addition, U.S Topics 3 and 4 combine teaching and learning with distinct terms such as “time” (Topic 3) and “online,” “free,” “new,” and “classroom” (Topic 4). In other words, U.S. Topic 3 seems to be connected to educators’ concerns about time-sensitive issues related to emergency remote teaching, and Topic 4 is likely connected to educators’ search for teaching resources in an educational context newly disrupted by the COVID-19 pandemic.

DISCUSSION AND CONCLUSION

Our findings show that the topics of conversation by U.K. and U.S. #Edchat tweeters were quite similar, despite using different terminology (e.g., metacognition, remote learning). Overall, tweeters from both countries either sought specific help (e.g., advice on educational technology or teaching resources) or offered support. They were responding to personal or perceived needs through the social media portion of their PLN, which offered them immediacy and rapid access to professional learning and advice (Gao et al., 2012). Carpenter et al. (2021) argued that shifts in PLNs over time are influenced by a confluence of factors. They identified two major factors: first, changes in educators’ professional roles, responsibilities, goals, and interests; and second, changes in the make-up of the people comprising the PLN. Teachers likely experienced all of these changes during the COVID-19 pandemic. In this time of emergency and urgency, many educators quickly adapted their PLNs to address changing professional needs by reaching beyond their local contexts in ways that traditional, predetermined professional development programs would be slow to or unable to address.

Therefore, educators’ reliance on social media to expand their PLNs is likely to increase during rapidly unfolding educational emergencies. Social media platforms offer opportunities for expansive professional learning during times of crisis by (a) widening the context for learning beyond formal teacher professional development opportunities to larger networked publics; (b) introducing a hybridization of expertise (e.g., educators further along in the shift to emergency remote teaching coming alongside experts outside the discipline); and (c) mixing different types of information and resources (Manca & Ranieri, 2016). Tapping a wide, diverse network of people and resources—what has been called bridging social capital (Lin, 1999)—is especially critical in times of crisis when locally available support and information are insufficient to inform decision-making.

In addition to these common themes, U.K. and U.S. tweeters also demonstrated differences in their #Edchat tweeting. Past research has demonstrated that tweeters use the same hashtag for different purposes (Greenhalgh et al., 2020). In this case, U.K. and U.S. participants came from educational contexts and COVID-19 responses tied to their respective countries; the ways they used #Edchat differently are likely connected to these distinct backgrounds. For instance, some differences in terminology may be related to how the pandemic was discussed in the news media in the U.K. and the U.S., respectively. The use of the #homeschooling, #homelearning, and #homelearningUK hashtags by U.K. tweeters may reflect discourses presented in the U.K. news media during the first several months of COVID-19’s impact (Greenhow, Lewin, & Staudt Willet, 2020). In the U.K., school closures were presented as a shift to home schooling despite the fact that schools, and not parents, retained responsibility for their students’ education. In contrast, the use of #remotellearning and #distantlearning by U.S. tweeters corresponds to the initial educational response presented in the U.S. news media, which was to move academic content online (Greenhow, Lewin, & Staudt Willet, 2020). The #distantlearning hashtag connects to a long-standing upward trend toward various forms of online and blended learning in U.S. education. However, scholars have argued that the emergency forms of “distance learning” that emerged during the ini-
tial months COVID-19-related disruptions to education systems in Spring 2020—and were reflected in tweets and news media during this time period—were far from the best practices touted in education research, where various types of interaction are paramount (Hodges et al., 2020).

Other distinctions between U.K. and U.S. tweeters may be related to various recent educational trends and emphases. For instance, the use of the #metacognition hashtag by U.K. tweeters reflects a growing interest in metacognition and self-regulated learning; guidance for teachers published in 2018 offered seven recommendations to promote its use in U.K. classrooms (Education Endowment Foundation, 2018). Arguably, the shift to emergency remote teaching as a result of school closures foregrounds the importance of metacognitive strategies as students take on more responsibility for self-managing their learning in such circumstances. Similarly, the use of the #sel hashtag by U.S. tweeters reflects recent interest in students’ social and emotional learning (SEL). One way for educators to support SEL during the COVID-19 pandemic was by using video to provide affective communication and feedback (Kaplan-Rakowski, 2020). However, at the outset of emergency remote teaching, synchronous and asynchronous video strategies were likely novel topics not considered by many teachers who struggled to rapidly adjust their curricula to fit online modalities. That is, thoughtful implementation of video assessment probably seemed like an impossible luxury while trying to shift to emergency remote teaching in a matter of days. Instead, Twitter may have seemed like an appealing place to increase educators’ expertise through the #Edchat and #sel hashtags.

In addition to discussing the insights added by this study, it is important to acknowledge limitations. Although #Edchat tweets represent a large and general dataset of education-related content, there were nearly eight times as many self-identified #Edchat tweeters from the U.S. as from the U.K. This means that overall, #Edchat is likely more U.S.-centric in its topics of conversation. Furthermore, we were likely unable to examine the full breadth U.K. tweeters’ emergency response to COVID-19 because we only evaluated U.K.-centric hashtags (e.g., #UKedchat, #edutwitter) when they appeared alongside #Edchat in tweets. One likely implication of this limitation is that we did not see a spike in U.K. tweeting around mid-March 2020 when schools closed due to COVID-19 concerns, as was evident in U.S. tweeters (Figure 1). Future research should address this limitation by collecting tweet data related to hashtags known to be associated with the U.S. (e.g., State Educational Twitter Hashtags like #michED for the U.S. state of Michigan [Rosenberg et al., 2016]) or the U.K. (e.g., #UKedchat).

This study has examined the educational response to COVID-19 within and across the U.K. and the U.S., as documented in the Twitter #Edchat hashtag between February 1 and May 31, 2020. Relatively little is known about the nature of continuity and change in PLNs across temporal, spatial, institutional, and country contexts (Carpenter et al., 2021), and even less about PLNs as flexible, just-in-time emergency response networks. This present research contributes to the knowledge base by offering initial understanding that could help generate a transnational strategy for supporting educators’ just-in-time professional learning during global disaster situations.

REFERENCES


Dorman, M., Buckley, T., Dannenberg, A., & Bhaskar, M. (2020). mapsapi: ‘sf’-Compatible Interface to ‘Google Maps’ APIs (Version 0.4.5) [R package]. https://CRAN.R-project.org/package=mapsapi


Staudt Willet, K. B., & Rosenberg, J. M. (2020). tidytags: Simple collection and powerful analysis of Twitter data (Version 0.1.0) [R package]. https://github.com/bretsw/tidytags


Instructor Social Presence in Remote Teaching: “Yes, we Can!”

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Abstract: One of the major objections raised against remote teaching is that it hampers “social presence”, one of the key components of a learning experience (according to the Community of Inquiry model of teaching; Garrison et al., 2000). In this paper, we present the results of a survey to more than 1000 Italian teachers who were forced to teach online during the COVID-19 pandemic (March-June 2020) and – quite surprisingly – identified the discovery of a “new form of relationship” with their students as one of the major positive aspects of the experience. Results of the study confirm that the Instructor Social Presence can be achieved, even in a fully online environment; ISP seems to stem from a whole environment (composed of synchronous, asynchronous, collective and individual interactions) rather than on a single component of the remote teaching experience; eventually, high motivation and experience in pedagogy, over technical skill, seems to be a pre-requisite for instructors to be able to generate ISP.

Keywords: Community of Inquiry, Social presence, Instructor social presence, Online learning, Distance education, COVID-19, Teacher-student relationship

INTRODUCTION

In 2001, discussing what then used to be called “Computer-Mediated Communication” (CMC) Motteram wrote: “There is continuing debate in the world of education about the roles that CMC can usefully play in supporting learning. This debate is related to a strongly held view that without physical meetings, it is not possible to establish an effective community of learners and as a result learning will be impoverished.” This debate is, today, more relevant than ever, in the aftermath of an almost world-wide lockdown caused by the COVID-19 pandemic and the forever-changed scenario of education. It deals with what the Community of Inquiry, or “CoI” model (Garrison et al., 2000, 2001, 2010) calls “social presence” and Berge calls “social interaction” (Berge, 1995). This component, in both models, is considered as key in a teaching/learning process. Social presence deals with the human relationships that are created in the process of teaching/learning, both among the students and between the instructors and the students, and that are responsible for making it smooth, pleasurable and rewarding.

The research presented in this paper addresses the issue of whether social presence can be achieved in remote teaching. The relevance of this question can hardly be underestimated: since the time of Plato (Plato, Phaedrus, 276a), a personal relationship between the student and the teacher has been identified as the key to successful learning, to the point that the Athenian philosopher declared that he would not confide the most relevant elements of his doctrine to any book but he would write them “with intelligence in the mind of the learner”, in a face-to-face relationship (Di Blas, 2020). With the current emergency situation, which as far as we can forecast is not about to finish, but also in view of a “new normal” in which all the positive lessons learnt during the pandemic will likely give vent to ever more hybrid learning environments, investigating if and under what conditions social presence in remote teaching can be achieved is becoming unavoidable. The paper is based on data from a survey administered to 1001 Italian teachers (of all school grades) in the midst of the pandemic, in May 2020, about the way they were coping with the situation and the positive/critical aspects they were facing. It is organized as follows: first of all the CoI framework is introduced, with a specific focus on the “Instructor’s Social Presence”, which is the aspect that we detected through our survey; then, the method of the study is explained; all the data relevant to the paper’s argument are presented in the following paragraph (profile of the respondents,
their confidence with technology, the way they taught during the pandemic and their motivations). Eventually, the last paragraph recaps the main lessons learned and highlights further developments for the research.

BACKGROUND

What is social presence in education and why is it so important? Social presence is defined as “the ability of participants in a Community of Inquiry to project their personal characteristics into the community, thereby presenting themselves to the other participants as ‘real people’ [...] The primary importance of this element is its function as a support for cognitive presence, indirectly facilitating the process of critical thinking carried on by the community of learners”. The Community of Inquiry framework is rooted in John Dewey’s view of practical inquiry: in fact, according to Dewey, “inquiry was [...] an essentially social activity. Dewey believed that through collaboration that respected the individual, students would assume responsibility to actively construct and confirm meaning.” (Swan et al., 2009).

Social presence is part of the Community of Inquiry model together with other two elements: cognitive presence, i.e. “the extent to which participants [...] are able to construct meaning through sustained communication”, and teaching presence, i.e. the design and facilitation of the learning experience (Garrison et al., 2000).

![Community of Inquiry](image)

**Figure 1.** The Community of Inquiry model (Garrison et al., 2000).

Due to the emergence of distance teaching, similar views had been proposed even before the CoI model was defined. For example, Berge (1995) had underlined how “Social interaction” needed to be preserved in distance teaching: “regarding social interaction, it is my assumption that a goal of distance teaching is to create an environment that both fosters trust among the learner and the instructor and also seeks to promote a cooperative and collaborative environment, allowing students to learn from course materials, the instructor, and each other.” While in CoI the emphasis seems to lie mostly on the community building among the students, other scholars who picked up the trail shed light on the bonds between the students (as a group or as individuals) create with the instructor. Bray et al. (2008) identify “Ease of Teacher Interaction” as a facilitating factor in online courses; Pollard et al. (2014), for example, speak about “Instructor Social Presence” (ISP), and claim this should be considered an addition to the original model at all effects, since “Instructor social presence reflects a significant impact on community and the learning environment” and therefore deserves to be studied per se. ISP is defined as social presence that “involves instructors establishing their presence as being there in terms of frequency of communication and interaction with students as well as supporting students throughout the learning process”
The ISP does not seem to be confined to synchronous lessons as may be expected: studies show it can be achieved through asynchronous means as well, for example through feedback to students on their assignments and performances via asynchronous video (Borup et al., 2014; Thomas et al., 2017). Richardson, et al. (2016) discuss some strategies instructors may put into place in order to foster the establishment of a relation with their students (which the participants to their study acknowledge as “impactful” into their students’ success); quite interestingly, they highlight the sharing of personal information as one possible strategy, recommending at the same time to keep a balance between professionalism and “personalism”. Fiock (2020) lists a useful set of recommendations to design an online course according to the CoI framework and the tips on how to enhance social presence do include sharing personal stories and information, as well as incorporating audios and videos into the course’s content and conducting one-on-few coaching and mentoring sessions. For a comprehensive description of the additions to the CoI model, ISP included, the reader may refer to Kozan & Caskurlu (2018), Mykota (2018) and Peacock and Cowan (2016). In this paper, we will deal with the ISP, finding further confirmation that it can be achieved in remote teaching and evidences about the strategies highlighted above.

METHOD

In Italy, school closures due to COVID-19 began on February 21 in the 12 towns first hit by the virus. In the following weeks, these and other restrictions were extended to a significant portion of Northern Italy. On March 9 the government mandated the closure of all Italian schools and on March 10 the entire country went on lockdown. Citizens were not allowed to leave the house except for essential reasons. Starting March 2020, Politecnico di Milano made available free of charge a MOOC on remote teaching (taken from one of its master programs, on how to infuse technology into education) to help face the Coronavirus emergency. The MOOC was marketed through the author’s laboratory mailing list of direct contacts (7,000 circa) and official mailing to the regional branches of the ministry; it experienced an immediate and huge success, gathering in the end more than 3,660 members.

In May 2020, a survey was proposed to all the participants: 1001 answers were collected. It investigated various aspects of the “over-night moving into online mode”; most of the questions required a five-points Likert scale answer. In what follows, the main results connected to the paper’s focus on the Instructor’s Social Presence will be presented, but before plunging in to the results section, the reader must be warned that a bias affects the sample. All the teachers enrolled to the MOOC, and probably even more the ones that were willing to answer the survey in order to “support our research”, are quite motivated teachers who showed a clear willingness to do more, in a time of crisis. None had compelled them to join the MOOC, nor were they under obligation to train themselves: they had gotten the news that the MOOC existed and had decided to enroll, in their wish to be equipped to better face the situation. In other words, a voice is not heard, in our data: that of the “teachers left behind”, those who were not up to the task and basically gave up teaching during the schools’ closure (Di Blas, 2020). As it will be recollected in the final discussion, the results and subsequent considerations must be considered through this lens.

RESULTS

Of the 1001 teachers who answered to the questionnaire, most were women (79.2%), in line with the average composition of the Italian school system teaching staff. All school levels were represented, with upper secondary schools as majority (53.95%; fig. 2). Most of the respondents were “âgéée”: 73.13% were aged more than 45 (60.84% between 45 and 60; 12.29% more than 60; fig. 2).
Figures 2 and 3. School levels of the respondents and age-range.

This figure may, at first glance, seem surprising. Contrary to what one might expect, in fact, it appears that it is the older teachers who want to commit themselves to tackle the pandemic, first of all by enrolling in a training course such as the MOOC was, and then carrying out activities of various kinds to manage remote teaching, as we came to know by reading their comments and their posts. How is it possible? One would instead expect young teachers, belonging to a generation that is more familiar with technologies, to be at the forefront at a time when technologies are the only way to keep in touch with students and teach. The point is that, as other projects have shown, it is above all pedagogical knowledge that matters, far more than technology knowledge (see for example Di Blas and Paolini, 2016). That is why we find teachers of a certain age and consequently more experienced from a pedagogical point of view engaged in innovative actions to ensure that “the school does not stop” (as went the popular motto in the lockdown’s days).

Data about confidence with technology and its use in the classroom come as a confirmation: 11.79% only of the respondents rated herself/himself as “quite confident” in the use of technologies for education, before the pandemic (on a scale from 1 to 5, where 5 was the most positive answer). 16.43%, on the contrary, declared they had none or almost no confidence (fig. 4). Data about the actual usage of technology in the classroom show a similar trend, though with higher figures for those who did not make use of them at all – made little use, and subsequently lower figures at the other end of the stick, for the highest scores (fig. 5).

Figures 4 and 5. Confidence in the use of educational technologies and their actual use in the classroom before the pandemic.

The next set of questions relevant to the focus of this research concerns the educational “activities” and modes of teaching teachers adopted during the pandemic (Figures 6, 7, 8 and 9). 62.77% of the teachers taught synchronous lessons extensively, “much and very much”; they also made large use of asynchronous strategies, e.g. sharing of educational videos, either shot by themselves or found on the internet, sharing of documents, collaborative use of cloud spaces, etc. (73.03% “much and very much”).
Figures 6 and 7. Activities by the teachers during the pandemic, synchronous lessons and asynchronous teaching (sharing of videos, of cloud collaborative spaces, of resources…).

A good number of teachers held online Q/A sessions (50.87% “much and very much”) with the whole group of students and eventually, a reasonable but significant number held individual sessions, mostly in the afternoon, with struggling students: one of the discoveries of the lockdown period, in terms of pedagogical affordances by the digital platforms being used (26.2% “much and very much”).

Figures 8 and 9. Data concerning the use of Q/A sessions and individual online sessions.

Let us now focus on the question where the issue of “Instructor Social Presence” emerged. In consideration of the fact that it is always possible to find a “silver lining” in every situation, teachers were asked to pinpoint positive aspects they had acknowledged in their remote teaching experience during the pandemic. The list of options was the following and teachers were asked to select three out of them:

- enhanced interaction with the pupils
- new way of “perceiving” the pupils; opportunity to discover them through the new medium
- improved discipline (it is more difficult to mis-behave online)
- greater cooperation with colleagues and the school principal
- satisfaction in seeing my skills put to use (management of distance learning)
- greater organizational flexibility
- greater visibility of the teacher’s work and effort with the families
- enthusiasm to discover that “yes, we can”
- learning of new methods and tools

The list had been distilled from the free comments and posts the teachers enrolled to the MOOC had been making (which explains its being a-systematic) and was meant to feel the pulse of the situation as it was unfolding. The three
most voted options were, in order (fig. 10): learning of new methods and tools (71.18%); greater organizational flexibility (37.99%) and eventually, and quite surprisingly, “new way of “perceiving” the pupils; opportunity to discover them through the new medium”, almost on a par with the second option (36.46%).

After this discovery was made, all the survey’s questions were filtered to see whether the sub-group of teachers who had made this selection differed under some respect from the sample. It turned out that they did not: in all questions, the values of this sub-group (the teachers who had opted for “new way of perceiving the pupils” as a positive aspect) were in line with the whole set, with negligible differences, amounting to maximum 1-point percentage. There was just one exception. To the question about the time devoted to individual interaction, off school hours, this sub-group scored a bit higher: 30% said “much and very much” as opposed to the 26.2% of the whole set. The difference is not huge, but significant with respect to the focus of this research, since holding individual online meetings can easily be seen as a way to facilitate the creation of bonds between the instructor and the students.

The last data relevant for this research are about the motivation for learning new methods/tools and “staying on the front line”: “passion for teaching” and “love for my students” were the ones that scored the most (86.35% and 82.64% respectively, “much” and “very much”), as opposed to “sense of duty” and “obligation” (Fig. 11).

The free comments to the questions, by the teachers, complete the picture: “Our habits, schedules, spaces, programs and methods have been upset. We had the opportunity to reinvent our work, focusing on pupils’ needs, desires and desire to learn. This creative process has been, many times, fun and engaging! We brought out the skills and knowledge we had acquired but didn’t usually use. In addition to teaching, in this particular and historical period, the most important thing concerned human relationships, the closeness that the teachers showed to the students made everything easier! The affection and enthusiasm have crossed the devices’ screens, and I am sure that all the positivity has reached the students and their families. Full speed ahead!”

“With one of my classes I started, almost as a joke, an evening game... challenging the students with questions or puns, to keep in touch. After a month, I can say that this very small thing has created greater cohesion among the kids and also a less formal relationship, albeit always very respectful of the role, with me. Last night it was my turn to ask the question .... I had an unexpected event and I forgot. The kids, worried, wrote in the chat: ‘Teacher, what’s up? Aren’t you asking the question tonight?’. To my reply, which arrived late, they replied: ‘Don’t worry, you can recover tomorrow!’. It was awesome!”

“You discover a lot about yourself and your pupils; they share passions and emotions that are often silenced or revealed only to a few. Here is my anecdote: level 6, group of kids, video lesson. One pupil who does not have much self-esteem, was and is afraid to show up because he is overweight; he notices that in the study where I teach there are many books, but what attracts him is the poster (Stormtrooper from Star Wars) and, for the first time, he makes his voice heard; since then, he has continuously intervened in the lesson, revealing skills and competences that otherwise would have remained hidden.”

Figures 9 and 10. Main positive aspects of teaching remotely during the pandemic and the reasons why to keep improving/training and staying in the front-line.
“Most of the kids add small messages to their homework, asking how I and my boyfriend (a doctor) are doing; some ask to speak with me, telling me little anecdotes about them and their families. I have not received any defections during my hours, even by kids other colleagues complain about as ‘missing’. Once a very shy boy connected before the lesson, on purpose, to introduce me to his little sister and his cat. Two siblings attended my lessons and greeted me…”

CONCLUSIONS

Let us recap here the main observations that the survey’s results offer. Note that the sample is biased at its roots, since it involves teachers who were proactive enough to enroll in the MOOC. This is further confirmed by the data on the motivations that kept them on the front line, where we find “passion for teaching” and “love for my students” as the most selected ones. We can therefore say that the sample is a group of aged teachers, not necessarily confident with technology (a significant 16.43% started off with quite limited/no knowledge at all about technologies for education and 26.52% made no/little use of technologies in the classroom) but with years of experience in teaching (strong “pedagogy knowledge”) and highly motivated. These teachers faced the pandemic putting into place a number of actions, synchronous and asynchronous (sharing of videos, shot by themselves or found on the internet, documents, collaborative working spaces…) plus Q/A sessions and individual sessions with struggling students, off the regular school hours. The sub-group that identified “the new relation with the students” as a positive aspect is in line with the description above but shows even more willingness than the whole set to hold individual sessions, often crossing the boundaries of the instructor’s private space. Though further research is surely needed to dig deeper into this issue, there are some lessons that we can draw from these data.

First and foremost, in answer to the question this research stem from, we can confirm that the Instructor Social Presence can be achieved, even in a fully online environment. This lesson is in line with previous research and is quite reassuring, in view of the months that await us, in which quite likely most of our teaching will still be online with devices’ screens between us and the students.

The second observation is that this feeling of “presence” does not seem to be confined to specific moments but to span the whole experience, in a sort of “extended school mode” in which teachers are available far beyond the usual school hours. While it is more evident in synchronous moments, it (probably) depends on the whole effort done by the teachers to reach out to the students (e.g. the sharing of materials to be used in an asynchronous way – e.g. videos by the teacher herself). Again, this observation is in line with previous findings (as highlighted in the state-of-the-art section) and needs further exploration to elicit how much different dimensions like for example synchronous vs. asynchronous, individual vs. collective, professional vs. personal attitude, affect the instructor’s social presence. The specific strategies being put into place would also be quite interesting to investigate (e.g. small games).

The third lesson, again in need of further investigation, is that motivation and experience in teaching (over technological skills) seem to be pre-conditions in order to foster social presence. One of our teachers commented: “scholars say that the only real schooling is face-to-face. But I know teachers that, even if they were sitting at the same desk with their students, would not be able to establish a relationship with them”. The data shown in this paper tell us that motivated teachers can “cross the devices’ screens” and reach out to their pupils, no matter what, even without being particularly skilled in technology.

Negation of the relevance of social presence in teaching is something we must be quite alert about. It would paradoxically lead to the conclusion that learning can be achieved “right the same” through reading documents, watching some videos and using some tools, without ever interacting with an instructor, some way or another, and/or our peers. Under this respect, we foresee a potential gap possibly more serious than the technological gap currently affecting part of the learners world-wide: that one day, some privileged learners will have access to quality education where the difference will be made by the possibility of interacting with an instructor (which, as Plato taught us, is probably the only way to develop and refine critical thinking) while others (the less affluent ones) will be fed with pre-packed, ready-made online learning programs that, again using Plato’s words, cannot but repeat the same answer ever again, even if questioned. Garrison warns us that “Social presence marks a qualitative difference between a collaborative community of inquiry and a simple process of downloading information” (Garrison, 1999): let’s ensure that all can benefit from it.

In May 2020, we published an eBook with quotes and stories by the teachers during the lockdown: “Voices from Italian schools in the time of Covid-19”, which is freely available, also in English, on Google and Apple stores.
REFERENCES


Pollard, H., Minor, M., & Swanson, A. (2014). Instructor social presence within the community of inquiry framework and its impact on classroom community and the learning environment. Online Journal of Distance Learning Administration, 17(2).


Enhancing Student Engagement through a Web-Based Three-Dimensional Virtual Environment

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Abstract: The rise of online courses due to the COVID-19 pandemic has led to the use of web conferencing tools such as Zoom, Microsoft Teams, and Blackboard Collaborate to conduct lectures. Research has found that classes that utilize these tools suffer from lack of student engagement. Prior studies have attempted to address this issue using three-dimensional virtual environments (3DVE) which have resulted in technical problems experienced by their participants. The purpose of this research is to provide and investigate the use of a 3D virtual classroom that integrates a 3DVE with web conferencing features to improve student engagement and resolve the technical issues reported in previous studies. Results show that students had no technical issues accessing and running the 3D classroom and felt more engaged in the class than when using Blackboard Collaborate. Furthermore, assessment scores of students that attended the class in the 3D classroom were on average over twice that of those that used Blackboard Collaborate.

Keywords: Web conferencing, Three-dimensional virtual environment (3DVE), Education, COVID-19

INTRODUCTION

As a result of the COVID-19 pandemic, many colleges and universities have transitioned their classes from a traditional face-to-face (F2F) format to a synchronous online learning environment. This transition has prompted educators to adopt web conferencing tools (e.g., Zoom, Microsoft Teams, and Blackboard Collaborate) to hold their classes remotely. With features such as audio, video, chat, and screen sharing, educators can communicate with their students in real-time and conduct their classes as they would in a F2F environment. However, studies have found that students tend to be less engaged in synchronous online learning environments than in a F2F setting. For instance, Kohnke and Moorhouse (2020) have found that, during Zoom meetings, students tend to be less willing to nominate themselves to respond to questions or provide opinions due to the lack of paralinguistic cues. According to Lowenthal et al. (2020), synchronous online class sessions encourage multitasking and distraction, and are difficult to participate in depending on situational factors. Basko and Hartman (2017) reported that the attendance rate for their zoom video conferences was only 18% of students enrolled in the classes. Due to this lack of engagement, researchers have looked to three-dimensional virtual environments (3DVE) to improve the remote learning experience. When applied to online education, 3DVEs provide new levels of teaching presence, spatial awareness, engagement, and interactivity, while offering established online collaborative and communication tools such as virtual whiteboards, audio, video, text, messaging, and web pages (Bentz, 2016). However, technical difficulties as well as steep learning curves associated with 3DVEs can cause students to experience high levels of frustration, thus interfering with their abilities to reap the educational benefits of the virtual environment (Hartley, Ludlow, & Duff, 2015). This present research offers a 3D classroom environment that integrates a 3DVE with web conferencing features to improve student engagement. In addition, the technical issues reported in previous studies are addressed by applying technology that renders 3D graphics directly in a web browser, without the need to download software or plugins (Dirksen, 2015).
LITERATURE REVIEW

Researchers have applied 3DVEs to education for the past two decades (Kostarikas, Varlamis, & Giannakoulopoulos, 2011). The 3D virtual world application Active Worlds introduced “Active Worlds University” in the early 2000’s which provided online courses in 3D technology. Dickey (2005) used this platform for a case study to gain insight into the types of learning experiences 3D virtual worlds afford spatially distanced learners in both asynchronous and synchronous learning environments. It was found that this form of learning led to a more immersive experience allowing the learner to become situated and embodied in the environment (Dickey, 2005). However, interactions between students and the instructor were hindered due to the absence of audio chat which few tools offered at that time. Therefore, interaction was text-based and dependent upon typing speed and skills (Dickey, 2005).

The online virtual world Second Life improved interaction capabilities and, through the open source project Sloodle, integrated with the learning management system Moodle thereby allowing students to link the 3DVE from their online learning environment. In addition to audio chat, Second Life provides the ability to project presentation slides, videos, and images, or to display an interactive web browser (Kostarikas et al., 2011). Kostarikas et al. (2011) used Second Life in their research to investigate if the existence of a 3DVE could combine smoothly and productively with presently established online learning tools. Through a pedagogical evaluation, it was found that most students were excited to participate in the 3DVE and assessed the course to be more interesting and helpful in understanding the material. Nevertheless, students had difficulties in activating voice chat due to limited technical experience and insufficient equipment (Kostarikas et al., 2011). Domingo and Bradley (2018) used Second Life to ascertain student perceptions of the use and value of the 3D virtual space. While 52% of students reported a positive experience, 76% of those with a negative experience suffered from technical problems caused by audio and account issues, difficulties downloading the software, and inadequate computer technology.

Despite its drawbacks, Second Life has remained a popular virtual world platform in the area of online education. Reiso lu, Topu, Yılmaz, Yılmaz, and Gökta (2017) examined a total of 167 studies that involved the use of 3D virtual worlds in education and found that Second Life was used in 99 of those studies. To avoid the issues reported by Kostarikas et al. (2011) and Domingo and Bradley (2018), however, the 3D classroom developed for this present research is designed to run in a web browser and does not require any downloads. Moreover, the minimum requirements to run the 3D classroom are quite low and are effectively supported by all systems (“WebGL Best Practices,” 2020). The subsequent section discusses the implementation of the 3D classroom in full detail.

IMPLEMENTATION

The 3D classroom was implemented using several technologies and was built on an existing web-based multiplayer gaming architecture (Lever, 2019). The solution uses Node.js for the server, Socket.IO for client-server communications, and Three.js to create and display the 3DVE. In addition, WebRCT was used for audio chat and real-time screen sharing between peers. Each of these technologies is discussed below.

Three.js

To overcome the technical limitations caused by Second Life as reported in previous studies, one of the goals of this present research was to develop a 3DVE that would not need to be installed and could run inside of the web browser. To achieve this goal, the Three.js JavaScript library was used. Three.js is an application programming interface (API) that encapsulates WebGL, a very low-level system that draws points, lines, and triangles (“Three.js Fundamentals,” n.d.). Three.js provides functions that can be used to create cameras, lighting, materials, and objects (Wang, Li, Zhang, & Zheng, 2016).

Node.js

The server application was implemented using Node.js. Node.js is a server-side event-driven platform that can instantaneously respond to a large number of client requests. It achieves this through the use of callbacks (i.e., code that is
triggered by an event). Callbacks are typically used in client-side JavaScript applications, such as when a user clicks a button on a webpage. Consequently, Node.js server applications are also written in JavaScript. Node.js also supports the use of third-party modules. One such module used in this research is Express, which acts as a web server that listens for HTTP requests and responds with the starting page that launches the 3D Classroom.

Socket.IO

All communication between the client and server within the 3D classroom was accomplished via websockets. The websocket module that is used in this research is Socket.IO. Through Socket.IO, the client sends the server all user activity including the updated position, orientation, and applied animation, as well as any chat messages the user would like to send to the class. The server then broadcasts this data to all clients and the client in turn applies the appropriate updates to the 3D classroom. The transmission of more complex data, such as audio chat and screen sharing, is handled by the WebRTC framework.

WebRTC

Within the 3D classroom, all users have the ability to use audio chat and share their screen in real time. Screen sharing enables the instructor to present his or her material such as PowerPoint slides as he or she lectures. Students can also share their screen when they are struggling with a particular assignment or activity, or if they are presenting their work to classmates. The WebRTC framework was used to implement both the audio chat and screen sharing features. WebRTC is an open-source framework that provides plugin-free real-time communication capabilities to browser-based applications (Petrangeli et al., 2019). For multi-user audio chat, this research uses an open source example that utilizes WebRTC for peer-to-peer voice chatting between two or more people (Noek, 2017). For this present research, this code was modified to support screen sharing and the ability to mute one’s microphone when not speaking.

METHODOLOGY

The 3D classroom developed for this research was applied to a collegiate level online course focusing on databases and big data. There are 16 undergraduate students enrolled in the course, and classes are normally conducted synchronously using Blackboard Collaborate. The first 8 volunteers (group A) were selected to attend a lecture on the topic of “big data” in the 3DVE, while the other 7 students (group B) attended the same lecture using Blackboard Collaborate (one student was absent). The students from group A were provided a link in Blackboard, our learning management system, that brought them to the start page of the 3D classroom, as shown in figure 1. From the start page, the student entered their chosen username, selected an avatar, and clicked the button to enter the 3DVE. Within the 3D classroom (as illustrated in figure 2), the students were able to explore the classroom environment by clicking and dragging their mouse to move the avatar to their desired location. They could also sit by selecting and clicking on any chair within the environment. In addition, the interface provides an overlay that contains a chat area that students could use to type messages to their classmates and instructor. Also included in the interface is a button panel comprised of three buttons: mute, share screen, and raise hand. The mute button mutes the student’s microphone when not speaking. The share screen button allows the student to share his or her screen which becomes enabled if no other user is sharing their screen (i.e., only one user can share their screen at a time). Lastly, the raise hand button animates the avatar and plays a notification sound so the instructor is aware that the student has a question. Both the chat area and button panel appear semi-transparent as to not obstruct the view of the 3DVE.
To evaluate the 3D classroom, both qualitative and quantitative measures were used. For qualitative evaluation, students from group A were provided a questionnaire after class asking their opinion of the tool. The quantitative evaluation was done via a short five-question quiz related to the lecture. The quiz was given to both group A and group B.

Data Collection

After attending the class, students from group A were asked to complete an anonymous survey based on their in-class experience and opinion of the 3D classroom. Questions were focused on presence and engagement, interest in further use of the tool, and ease of use. Students answered each question using a Likert scale from 1 (strongly disagree) to 5 (strongly agree). The questions posed in the questionnaire were as follows:

1. I felt a greater sense of presence in this class than when using Blackboard Collaborate.
2. I found this class more engaging than when using Blackboard Collaborate.
3. I would be more likely to attend an online class if using this tool.
4. I would be more likely to participate during an online class if using this tool.
5. I would take more online courses if this tool was used to conduct lectures.
6. The 3D classroom was easy to access.
7. The 3D classroom interface was intuitive and easy to use.
Students from both groups were given a short five-question quiz at the end of class based on the topic covered during the lecture. Questions were high-level and could be easily answered by paying attention to the presented material. The class results served as a quantitative measure of the overall level of engagement of the class from both groups.

RESULTS

The survey results illustrated in figure 3 show that students overall thought the 3D classroom was more engaging than Blackboard Collaborate, the web conferencing software that is typically used to conduct lectures in the online course. When asked if they felt a greater sense of presence in the 3D classroom, approximately 63% of the students agreed or strongly agreed. An even greater percentage (75%) agreed or strongly agreed that the 3D classroom was more engaging than when using Blackboard Collaborate. While only 50% of the students agreed or strongly agreed that they would be more likely to attend an online class if using the 3D classroom, approximately 63% said they would be more likely to participate during an online class that uses the tool. Only 13% agreed that they would take more online courses if the 3D classroom was used, suggesting that a F2F environment is still the preferred modality among students.

The two survey questions that addressed accessibility and ease-of-use showed that students overwhelmingly thought the 3D classroom was easy to access with all students either agreeing or strongly agreeing. However, half of the students said the interface was intuitive and easy to use.

The quantitative results, which were measured using a five-question multiple choice quiz related to the lecture, revealed that students were more attentive in the 3D classroom than in Blackboard Collaborate. As shown in figure 4, the eight students that attended class in the 3D classroom (i.e., group A) scored an average of 70% on the quiz, while the students that attended the class using Blackboard Collaborate (i.e., group B) scored an average of 34.3%. The course average of group A before attending the class was 87.3%, and the course average of group B was 86.8%.

![Student Survey Results](image)


**DISCUSSION**

This research investigated if a three-dimensional classroom environment enhances student engagement in an online course. Although this question has been addressed by previous researchers (Domingo and Bradley, 2018; Kostarikas et al., 2011), their studies have been limited due to technical issues experienced by their students when using current 3DVE solutions such as Active Worlds and Second Life. This present research therefore applied state-of-the-art 3D web-based technologies to build an environment that is easy to access and use from any web browser. Results from a student survey given after the class lecture indicated that all students were able to easily access the 3D classroom and attend the class. Although some were dissatisfied with the user interface, this did not interfere with their ability to focus on the class lecture. Most students reported that they felt more engaged and present in the 3D classroom than when using Blackboard Collaborate and, although they prefer F2F classes, would be more likely to participate in an online course using the 3D classroom. A quiz given at the end of class on the presented material further supported this sentiment as the quiz average of those that attended the class using the 3D classroom was over twice that of the students that used the standard web conferencing tool.

The results of this research reflect student performance and opinion of the tool after only one class session. Future work includes an entire semester of use in order to perform a full analysis of the 3D classroom. Before the tool could be applied in this capacity, however, the user interface issues reported by the student participants must be addressed. Some students further elaborated on this point using an open-ended optional question at the end of the survey stating “the click to walk is a little weird” and that student name labels “were large and distracting” making it “a bit difficult to see the PowerPoint.” Nevertheless, with some minor code adjustments, these issues can be quickly and easily resolved. Lastly, some additional features to be added prior to semester-long use include a whiteboard, an “instructor” role allowing the educator to mute and unmute students, and security measures such as the ability to add approved users and passwords to enter the 3D classroom.

![Figure 4. Quiz results.](image-url)
REFERENCES


We Need to Talk about the ISTE Students Standards: A Critical Analysis

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Abstract: The International Society for Technology in Education (ISTE) has been publishing technology standards to be used in the classroom since 1988, and a version of these standards has been adopted by all 50 states. Yet, little peer-reviewed research or scholarly work exists that is specifically focused on these standards. In response, this paper will introduce, describe, and contextualize the ISTE standards. The researchers will then share their concerns about the standards before offering recommendations to teacher educators for addressing them.

Keywords: ISTE Standards, Technology Standards, Educational Policy, Critical Studies

INTRODUCTION

The International Society for Technology in Education (ISTE) is one the most influential organizations in the field of educational technology. Founded originally as the International Council for Computers in Education in 1979, the organization changed its name to ISTE in 1989 (University of Oregon, 2008), and it has since flourished. In 1998, ISTE was the first organization to fill the need for general technology standards to guide educators, as the educational technologies at that time were becoming more common in classrooms (Bakir, 2016). Today, ISTE (2020a) has affiliated chapters in the United States, Canada, Russia, and Australia that offer workshops, trainings, and conferences to their local members, and ISTE’s signature event is its annual conference that attracts over 16,000 attendees (ISTE 2020b). In addition, ISTE’s standards have grown in significance, and they now guide the way technology is used in schools. Currently, ISTE is promoting its third-generation technology standards for students, and 18 states have adopted those standards. (7 states are still using ISTE’s first-generation standards, and 25 states are using their second-generation standards.) As researchers across fields, including education, have expressed over the years, standards are not neutral nor objective (Gunter, 2010; Schmidt et al., 2005). They are political statements for how the subject of the standards ought to be or ought to be treated, and the ISTE’s standards are not an exception. This paper will first provide a contextualized overview of ISTE’s standards for students before reviewing published research about them. Critiques of the standards will then be offered before concluding with recommendations.

A CONTEXTUALIZED TIMELINE OF ISTE’S STUDENT STANDARDS

In 1998, ISTE first published their National Educational Technology Standards for Students as “guidelines for planning technology-based activities in which students achieve success in learning, communication, and life skills” (ISTE,
These standards were divided into six sections that included (1) basic computer operations; (2) being aware and responsive to social, ethical, and human issues related to technology; (3) using digital tools for productivity; (4) communicating; (5) research; and (6) making decisions to solve problems. This first generation of ISTE’s standards focused on students being able to use technology for specific tasks while developing an emerging understanding of its role in society. At the time of their release, the internet was in its second generation, meaning individuals could only connect to 2G wireless networks. Across the United States, only 51% of elementary classrooms and 52% of secondary classrooms had internet access, and the student-to-computer ratios were 13:1 for elementary students and 10:1 for secondary students (National Center for Educational Statistics, 2000). With mobile technology still being in its infancy, issues such as safety, online bullying, and social media addictions were not yet in the mainstream, and educators were experimenting with pedagogies for using the internet in the classroom (Dodge, 1995). Over time, however, technology continued to evolve, and accordingly, ISTE updated its standards.

ISTE published its second-generation standards in 2007. While these standards continued the prior generation’s focus on using technology, they were expanded to include fostering students’ critical thinking, creativity, and collaboration skills (Snelling, 2016). Similar to their 1998 standards, ISTE divided them into six sections that included (1) Creativity and Innovation; (2) Technology Operations; (3) Digital Citizenship; (4) Critical Thinking; (5) Research and Information; and (6) Communication and Collaboration. To contextualize these standards, they were released in the same year that the original iPhone was introduced, the internet was in its third generation (3G), and the now social media giant Facebook was made available for everyone (previous to 2006, only high school and university students could access the platform). Regarding students’ access to technology in schools near that time, the National Center for Educational Statistics (2010) reported that on average in 2008, 98% of elementary and 99% of secondary students in the United States could access computers at school, and the student-to-computer ratio for elementary students was 3.2:1 and for secondary students it was 2.9:1. With increased levels of access to computers, ISTE’s 2007 standards reflected the need for students to develop specific skills to be responsible users of technology for academic and civic purposes, and ISTE kept those standards in place for nine years.

The most recent generation of ISTE standards was published in 2016, with the purpose “to empower student voice and ensure that learning is a student-driven process” (ISTE, 2020c, para. 1). Furthermore, ISTE (2020c) explains that whereas the 1997 standards focused on students learning to use technology and the 2007 standards were designed for students to use technology for learning, the goal of the 2016 standards was to transform learning with technology. Pippal (2020) explains that “transformative learning with technology is distinguished from basic technology use, such as rote drill and practice, simple Internet research, and traditional writing and presentation preparation in that the learner is given opportunity for self-regulated learning in a student-centered learning environment” (p. 12). To support this transformative approach to teaching, ISTE’s 2016 standards are organized into seven sections that include (1) Empowered Learner; (2) Digital Citizen; (3) Knowledge Constructor; (4) Innovative Designer; (5) Computational Thinker; (6) Creative Communicator; and (7) Global Collaborator, and each section focused on students using technology for a specific purpose (e.g., to identify, develop, construct). When these standards were released, the internet was in its fourth generation, and the 4G wireless internet networks were optimized for downloading, uploading, and streaming content as well as conferencing in real time (Fendelman, 2020), which made them ideal for students to use mobile devices. In fact, at that time, students reported a preference for using mobile devices, specifically tablets (e.g., Chromebooks, iPads, Kindles), and 78% of elementary students, 69% of middle school students, and 49% of high school student reported using tablets in schools (Polls, 2015).

Though all 50 states have adopted a version of ISTE’s standards, little information exists about the process used to create them. In fact, in their guidebook about the ISTE Educator Standards for teachers and other professionals that is used for professional developments (ISTE, 2017), it does not include any information regarding the method ISTE used to create their standards. Moreover, Trust (2018) was the only reference identified that included any remarks on this topic, and she explains that “During the 2016–2017 school year, ISTE solicited input from more than 2,000 educators and administrators and used these data to redesign the standards around seven themes” (p. 1) and then list those themes. She does not provide any additional information. Also, after completing a systematic search for additional information about their development that spanned mainstream, scholarly, and professional resources, no further information was located, and this absence carries over to the research base for the standards.
REVIEW OF LITERATURE FOCUSED ON THE 2016 ISTE STUDENT STANDARDS

There is very little peer-reviewed research that is focused on the 2016 ISTE Student Standards. For example, Amapro (2018) published a conference proceeding that compared the way digital citizenship was positioned in the 2007 Standards to the 2016 Standards. She explained that the 2016 standards use a more negative tone to describe students’ growing role from cultural and societal issues in 2007 to being more sharply focus on individual rights in 2016. For example, in Amapro’s discussion of ISTE’s 2007 Digital Citizenship standard compared to the 2016 iteration for Digital Citizen, she notes that the 2007 iteration promoted the understanding of “human, cultural, and societal issues” as opposed to the 2016 iteration that emphasized students identifying their “rights, responsibilities and opportunities of living.” Amapro argues that this change shifts students from seeing digital citizenship as based in a community context to an individualized perspective. Furthermore, Blocher et al. (2018) published proceedings that explained a pedagogical strategy that teacher educators could use to build pre-service teachers’ understanding of the standards. They suggested using a jigsaw strategy where students could unpack and make sense of the standards together, which resulted in them having a deeper understanding of the standards based on the researchers’ classroom observations. Finally, Marcovitz and Keane (2016) described a model for developing programs that prioritized the faculty’s values as the primary drivers of the program before aligning to professional standards as required by accrediting bodies, and the researchers used the ISTE Student Standards as an example.

Outside of Blocher et al.’s (2018) proceedings, no other peer-reviewed works of any kind were found that directly addressed:

1. If the standards better prepared students for academic, professional, or civic pursuits;
2. If having students engage the standards results in the development of stronger digital literacy skills;
3. If teachers are able to implement the standards with fidelity; or
4. If the standards result in students being safer online.

As Adams et al. (2000) highlighted, policy in education is typically conservative and “shaped by political and social agendas of particular times” (p. 74). Gunter (2010) further explains that standards are not the result of research-based studies aimed at identifying the essential skills and knowledge students need to know upon completion of their compulsory education; rather, they “are a political construction used to make interventions in public education in such a way as to enable neo-liberal ideas, cultures and practices to be accepted as normal” (p. 114). Neo-liberalism is the manipulation of the free-market through the enactment or revision of policies to benefit certain entities (e.g., corporations, governments, wealthy individuals) while potentially harming other specific populations (e.g., historically marginalized peoples, low-income households, unionized workers) (Kincheloe, 2008) through policies that include the removal of quality assurances, eliminating competitors, and deregulating oversight committees. In this context, neoliberalism is reflected in academic standards because standards can be used to prepare students to join the workforce, upon completion of their education, in a way that continues long-standing inequities between groups of people (Saad-Filho & Johnston, 2005). As will be discussed, neo-liberal practices are found in the ISTE Student Standards, which is reflected in the standards themselves and the revenue structure ISTE has built around the standards.

“We need to talk about the ISTE Student Standards” comes from the fact that these standards have been accepted without a critical review. With all 50 states having adopted a version of these standards, the lack of scholarly research or transparency in their development is troubling and invited further investigation. The following section will share the researchers’ critiques of the standards. Though teacher educators have an obligation to prepare their pre-service teachers to integrate ISTE’s standards into their instruction, those same teacher educators should share these and their own critiques of the standards. That way, the pre-service teachers will be equipped to use the standards in the classroom and also be ready to engage in critical discussion of them, with the purpose that those discussions will culminate in more awareness about the standards along with policy change.

CRITIQUES OF THE ISTE STUDENT STANDARDS

On the webpage that features its Student Standards (https://www.iste.org/standards/for-students), ISTE divides the standards into seven sections, and each section is dedicated to one standard. Within that section is a one-sentence statement that includes the standard’s name and description that explains the standard. For example, the fifth section is for the Computational Thinker standard, which is explained as “Students develop and employ strategies for understanding and
solving problems in ways that leverage the power of technological methods to develop and test solutions” (ISTE, 2020c, para. 6). Readers can then click the standard. A second menu will then appear that lists the indicators for the standards, and the indicators are intended to provide guidance for students to meet the standard. Drawing again from the Computational Thinker standard, its indicators describe ways that students can use technology to engage computational thinking by (5a) formulating problems; (5b) collecting, identifying, analyzing, and representing data; (5c) breaking problems into parts, extracting information from them, and developing descriptive models to interpret the problem; and (5d) developing sequences to automate solutions. To support readers in better understanding the standards, they can click on the underlined key terms in the indicators to access the corresponding definition. ISTE also produced short videos (60-85 seconds in length) that are hosted on YouTube and linked to each indicator. No additional support or information about ISTE’s Student Standards is available on their website, outside of references to them in blogs posted to the site. Currently, this is the only information accessible about the standards for free on the ISTE website. In response, this section will share four critiques of the ISTE Student Standards focused on their (1) Grade level context, (2) Equity, (3) Benchmarks, and (4) Mis-aligned professional development.

Grade-Level Context

First, the ISTE Student Standards are void of any context and does not include a progression of grade-level aligned technology skills. The language and form of the standards is formal and rigid, and they are written to be generic. The standards do not provide any grade-level distinctions, and there is no indication of when the standard should be achieved. In comparison, the Common Core State Standards for English Language Arts (National Governors Association Center for Best Practices, Council of Chief State School Officers, 2010) are based on anchor standards that are then divided into grade levels. The anchor standards state a specific skill and then areas within that skill. For example, the skill of writing includes four areas: Text Types and Purposes, Production and Distribution of Writing, Research to Build and Present Knowledge, and Range of Writing. Each area then includes an anchor standard within it. For example, the anchor standards for the Production and Distribution under the Writing area reads, “Use technology, including the Internet, to produce and publish writing and to interact and collaborate with others” (CCSS.ELA-LITERACY.W.11-12.6). Readers can then click into the grade level to view this standard evolve from kindergarten to the 11th-12th grade band, as shown in Table 1.

<table>
<thead>
<tr>
<th>Grade Level</th>
<th>Standard CCSS.ELA-LITERACY.W.11-12.6</th>
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</thead>
<tbody>
<tr>
<td>Kindergarten</td>
<td>With guidance and support from adults, explore a variety of digital tools to produce and publish writing, including in collaboration with peers. With guidance and support from adults, use a variety of digital tools to produce and publish writing, including in collaboration with peers.</td>
</tr>
<tr>
<td>Grade 1</td>
<td>With guidance and support from adults, use a variety of digital tools to produce and publish writing, including in collaboration with peers.</td>
</tr>
<tr>
<td>Grade 2</td>
<td>With guidance and support from adults, use a variety of digital tools to produce and publish writing, including in collaboration with peers.</td>
</tr>
<tr>
<td>Grade 3</td>
<td>With guidance and support from adults, use technology to produce and publish writing (using keyboarding skills) as well as to interact and collaborate with others.</td>
</tr>
<tr>
<td>Grade 4</td>
<td>With some guidance and support from adults, use technology, including the Internet, to produce and publish writing as well as to interact and collaborate with others; demonstrate sufficient command of keyboarding skills to type a minimum of one page in a single sitting.</td>
</tr>
<tr>
<td>Grade 5</td>
<td>With some guidance and support from adults, use technology, including the Internet, to produce and publish writing as well as to interact and collaborate with others; demonstrate sufficient command of keyboarding skills to type a minimum of two pages in a single sitting.</td>
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</tbody>
</table>
This example shows that standards can evolve and develop with students as they advance through the grade levels. Indeed, the iterations of the anchor standard provide an expectation that has been both mapped onto college-performance expectations and scaffolded to the different grade levels (United States Department of Education, 2020). The ISTE Student Standards do not provide such support. Rather, because they are written to be generic based on their language and form, the ISTE Student Standards only name and describe a technology-based competency or awareness of some sort. In this way, the ISTE Student Standards hold a 1st grader to the same standards as a 12th grader. ISTE does not provide the support needed to differentiate the application of their standards by grade level, which in turn does not set specific grade-level expectations for when students should be able to demonstrate the competencies. In addition to grade-level expectations, these standards lack consideration about the Digital Divide.

**Equity**

Second, the Digital Divide is a manifestation of the inequitable allocations that schools receive for technology (Rogers, 2016). These allocations include funding for schools to purchase educational technologies (e.g., tablets, robotics, laptops, or other devices) for their teachers and students to use, create and sustain the infrastructure that those technologies need to operate, and the professional development teachers need to effectively integrate the technologies into their instruction. In the United States, public school funding “comes from federal, state, and local sources, but because nearly half of those funds come from local property taxes, the system generates large funding differences between wealthy and impoverished communities” (Biddle & Berliner, 2002, p. 48), with the federal government contributing on average about 8% of a state’s education budget (Chen, 2020). The result is that the amount of money spent on each student by state is considerably different, with New York spending over $23,000 per student and Idaho spending less than $7,500 per student (Maciag, 2019). When reading the standards, they make an assumption that the technologies students need to access them are readily available. The issue is that the ISTE Student Standards do not consider the impact that funding differences have on students’ access to technology nor the professional development opportunities teachers have for using that technology in the classroom.

When viewing the videos that accompany each of the standards’ indicators, it shows students using a range of educational technologies. None of the videos show students working without technology. However, providing students with equitable access to technology or learning opportunities that embrace technology is hardly the reality in schools, and scholars’ works that utilize the Technology Acceptance Framework highlight differences in teachers’ embrace of technology (Joo et al., 2018; Scherer & Teo, 2019), such as ease of using the technology, perceived usefulness of the

<table>
<thead>
<tr>
<th>Grade Level</th>
<th>Standard CCSS.ELA-LITERACY.W.11-12.6</th>
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<tbody>
<tr>
<td>Grade 6</td>
<td>Use technology, including the Internet, to produce and publish writing as well as to interact and collaborate with others; demonstrate sufficient command of keyboarding skills to type a minimum of three pages in a single sitting.</td>
</tr>
<tr>
<td>Grade 7</td>
<td>Use technology, including the Internet, to produce and publish writing and link to and cite sources as well as to interact and collaborate with others, including linking to and citing sources.</td>
</tr>
<tr>
<td>Grade 8</td>
<td>Use technology, including the Internet, to produce and publish writing and present the relationships between information and ideas efficiently as well as to interact and collaborate with others.</td>
</tr>
<tr>
<td>Grade 9-10</td>
<td>Use technology, including the Internet, to produce, publish, and update individual or shared writing products, taking advantage of technology’s capacity to link to other information and to display information flexibly and dynamically.</td>
</tr>
<tr>
<td>Grade 11-12</td>
<td>Use technology, including the Internet, to produce, publish, and update individual or shared writing products in response to ongoing feedback, including new arguments or information.</td>
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</tbody>
</table>
technology, and overall attitude about technology. In this way, the ISTE Student Standards set an implicit expectation that students have access to technology and that teachers are inclined to use technology.

Regarding supporting teachers to use technology in a way aligned to its standards, ISTE charges $600 per teacher to complete its “Educator Certification Program” that is intended to prepare teachers to integrate the standards into their instruction (ISTE Connect, 2020). However, lower SES schools and less-funded districts are operating from a position of disadvantage in properly implementing the ISTE standards because they may not be able to fund their teachers to access that professional development opportunity, and equities due to the lack of funding carries over into the expectations for accessing technology in the classroom.

Due to states adopting the standards, states are requiring them to be taught. However, the funding required to provide teachers and students with the technologies needed to demonstrate the standards along with the professional development opportunities for teachers to learn to implement the standards is not provided. Therefore, for schools and districts with adequate funding, implementing the standards is more reasonable than schools and districts that are struggling with inadequate funding levels. Though well intentioned, the overall result is that the ISTE Student Standards may perpetuate the Digital Divide, not narrow it.

Benchmarks

Third, unlike other standards adopted by state departments of education that guide compulsory education, there is no assessment for the ISTE standards. For example, the Common Core State Standards and other academic standards adopted by state departments of education are typically assessed in end-of-course exams, annual standardized tests, through alternative assessments, or in some other way. The same does not hold true for the ISTE standards. Though all states have adopted a version of them, no authentic assessment to evaluate students’ knowledge and abilities directly related to ISTE’s student standards exist. Given the criticism of test-based accountability measures (Huilla, 2020; Petour & Assael, 2019), there are questions regarding the assurance that the ISTE Student Standards are being integrated into classroom instruction. At this point, ISTE has not put forward any plan to analyze the extent to which their standards are being implemented with fidelity.

Furthermore, without an assessment plan, ISTE has not produced student data verifying that their standards as designed are actually resulting in students being better prepared for post-secondary educational opportunities, to join the workforce, or engage in civic life. A systematic and reflective assessment plan with iterative standard revisions based on student data would help assure that there is value in states adopting them. Without that type of data or assessment plan, questions regarding the integrity of the standards and their impact on student learning and performance cannot be answered.

Mis-Aligned Professional Development

Fourth, there is a lack of resources for teachers to learn instructional strategies for implementing the ISTE Standards. Currently, the ISTE certification program for teachers is a three-part series that is focused on the ISTE Educator and Student Standards. The program begins with a two-day face-to-face learning experience in a classroom and facilitated by an ISTE Certified Educator, and the experience includes evaluating digital tools, exploring the ISTE standards for educators and students, and backward design, among a host of other topics. Next, teachers complete a series of asynchronous modules over 5-9 weeks that feature assignments, such as making presentations to colleagues about the ISTE standards and completing discussion board prompts related to technology-based scenarios. Lastly, teachers then have six months to complete a portfolio, which is the summative assessment. To complete it, teachers are to submit an artifact aligned to each indicator of the ISTE Educator Standards. In the certification program, teachers must complete each part of the series in order to unlock the next part, until they submit their summative portfolio. Then, if they successfully complete the program, they will earn their ISTE certification. If not, teachers will be provided a limited number of opportunities to redo assignments or the portfolio before they will be removed from the program. Outside of the $600 cost for the program, ISTE does not provide any specific pedagogical supports for teaching the ISTE Student Standards and their final portfolio assessment is aligned to Educator Standards, not the Student Standards. Therefore, concerns about the preparedness of teachers to implement the standards in their classroom remains.
CONCLUSION

A closing thought about ISTE standards is that they cumulatively display neoliberal tendencies. The ISTE Student Standards are positioned as expectations for using technology that were proposed by an influential organization, ISTE. A version of their standards has since been adopted by each state, which mandates that the standards are implemented. Furthermore, the only way to become “certified” is through ISTE’s own program, which carries a cost (and the certification program is not aligned to their Student Standards, but their Educator Standards). The end result is that ISTE Student Standards represent a revenue stream for the organization, not a research-supported set of skills for students to use technology. Because the ISTE Student Standards are required, teacher educators have a responsibility for preparing their pre-service teachers to integrate them into their instruction. Teacher educators also have an opportunity to demonstrate the neoliberal traits attributed to ISTE and its standards. In close, teacher educators would be wise to address both of those items in their educator preparation programs, so their pre-service teachers are equipped with the knowledge for identifying and pushing back on those and other neoliberal agendas they encounter within school settings.

REFERENCES


A Comparison of Findings of Preservice Teachers' Perceptions to Mobile Phone Integration from Three Studies—2013, 2015, & 2018

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Abstract: This paper compares the findings from three studies—2013, 2015, and 2018—on the perceptions of preservice teachers to the integration of mobile phones in the classroom. Participants include 495 students (2013, n=92; 2015, n=245; 2018, n=158) enrolled in teacher preparation programs in Kentucky, Tennessee, and North Carolina to determine their support for the use of mobile phones in the classroom as well as their perceptions regarding the benefits and barriers to the classroom use of mobile phones. Findings indicate that support for mobile phones in the classroom has more than doubled since 2013; 55% of preservice teachers surveyed in 2018 support integration. Likewise, 74% of participants in the 2018 study expressed the belief that mobile phones support learning, which was an increase of 16% from 2013. Preservice teachers primary concern about allowing mobile phones in the classroom was students’ using them to cheat. Eighty percent of teachers identified cheating as a problem. Concerns about the use of mobile phones for cyberbullying increased 50% from 2013 to 2018. Classroom disruptions, sexting, lack of access, and the negative impact of texting on writing all saw significant increases as perceived problems related to the presence of mobile phones in the classroom.

Keywords: Mobile phones, Preservice teachers, Cell phones, Educational technology integration

INTRODUCTION

Mobile phones have always had the potential to be a beneficial classroom technology, and this potential has increased over time. Over the last decade, access to mobile phones has increased. Today, 95% of adults own a mobile phone and 95% of teens have access to a smartphone (Mobile, 2018). More people are also accessing the internet via mobile phones. Today, more than two-thirds of Americans access the internet via a mobile device (Bauman, 2018), and 91% of teens age 13-17 access the internet using a mobile device (Lenhart, 2015). There has also been tremendous growth in the availability instructional applications (apps) for mobile devices. In 2010, there were 150,000 apps on the Apple store. By 2017, there were .5 million—200,000 of which were educational apps (Statista, 2018a). Schools have also changed school policies on mobile phones. In 2010, 90% of U.S. schools banned mobile phones. By 2016, that number had dropped to 65.8% overall and from 80% to 35% in high schools. These changes make mobile phones an viable technology for use by teachers and students. Considering that teachers are the gatekeepers to technology in the classroom, preservice teachers will play a role in whether or not mobile phones are integrated into the classroom.

Since most preservice teachers are only a few years removed from being in high school, they offer a unique perspective on the benefits and barriers associated with the use of mobile phone in schools. Their view of mobile phones in
the classroom have been shaped by their personal experiences as K-12 and college students. Their perspectives on the instructional value of mobile phones in the classroom continues to be shaped by the knowledge, skills and dispositions learned in their teacher preparation programs. Changes to access to mobile phones and the internet, the increase in instructional applications for mobile devices, and evolving policies on mobile phones in schools have also influenced their perceptions of mobile phones.

This study examined the perceptions of preservice teachers from four teacher preparation programs regarding the use of mobile phones in the classroom. Studies were conducted in 2013 (Thomas, O’Bannon, & Bolton), 2015 (O’Bannon & Thomas), and 2018 (Thomas, Hylen, & Carter). The purpose was to determine preservice teachers’ level of support for mobile phones in the classroom and perceived benefits and barriers over a five-year period.

**LITERATURE REVIEW**

Educators have long recognized the instructional benefits of technology, including improved students’ engagement, motivation and learning (Roblyer, 2016). Mobile technologies provide teachers with a vast array of benefits including “new and enhanced learning opportunities such as personalized and adaptivity, context-awareness and ubiquity, interactivity, communication and collaboration among learners, and seamless bridging between context in both formal and informal learning” (Nikou & Economides, 2018, p. 102). However, some of the inherent characteristics of mobile technologies, specifically mobile phones, have made it difficult for teachers to manage their appropriate use and created barriers to their integration in classrooms and schools.

The primary instructional benefit of mobile devices is their ability to engage students in meaningful learning opportunities anywhere (Traxler, 2009); therefore, teachers can use mobile phones to engage students in mobile learning (m-learning). M-learning is defined as “a type of learning that enables learners to learn anywhere, anytime using wireless technologies” (Alioon & Delialioğlu, 2019, p. 656). M-learning supports personalized learning (Lindsay, 2016), scaffolding (Hung, Hwang, Lin, Wu & Su, 2013), collaboration (Jeno et al., 2019), increased engagement (Lin, Fulford, Ho, Iyoda & Ackerman, 2012), and increased motivation (Jeno, Grytnes, & Vandvik, 2017). Research has demonstrated the use of m-learning to support student learning in P-12 content areas including math (Song & Kim, 2015), history (King, Gardner-McCune, Vargas, & Jimenez, 2014), science (Kantar & Dogan, 2015), and art (Katz-Buonincontro & Foster, 2014). Nikou and Economides (2018), in a study of students participating in a mobile assisted intervention, found a significant increase in learning in low-achieving students.

M-learning has the potential to engage students in self-directed learning. Self-directed learning is a process in which the individual determines learning needs and defines the task, sets learning goals, enacts study strategies, adapts studying, and evaluates learning outcomes (Saks & Leijen, 2014). Lindsay (2016), surveyed teachers in twenty-four schools about their use of mobile technologies for m-learning. Teachers reported one of the most frequent m-learning activities they engage students in was accessing content via the internet. Teachers reported that students used their mobile technologies to access the internet to “investigate theory, ideas, concepts and to access teacher created content at school nearly every day” (p. 886).

As noted by Jeno et al. (2019), mobile applications (apps) lend themselves to self-directed learning because of their relation to the Cognitive Evaluation Theory (CET) of Self-Directed Learning. CET maintains students’ needs for autonomy which is satisfied by learning tasks that engage them in meaningful choices, and their need for competence which is satisfied when students are challenged and provided feedback (p. 671). Some apps support students’ need for autonomy and competence and enhance student motivation and performance. For example, Jeno et al. (2019) examined the effects of mobile applications (apps) on 58 students’ achievement and well-being. They found that students using mobile apps had higher levels of perceived competence, autonomy, motivation, and positive affect than students who did not use mobile apps. Another example of how mobile apps create an environment where students’ motivation and achievement are enhanced is through assessment apps.

Mobile devices support both teacher generated formative (Hwang & Chang, 2011) and summative (Arthur, Doverspike, Muñoz, Taylor, & Carr, 2014) assessments and can be used by students for self- and peer-assessments (Lai, Hwang, & Tu, 2018). In a review of literature on the use of mobile-based assessment in education, Nikouo and Edomides (2018) found that most of the studies on the use of mobile assessment technologies demonstrated a “significant positive impact on student learning performance” (p. 113). Instructional benefits include providing instant feedback to teachers and students, which allows teachers to adjust instruction in real time, increased engagement, attention, and motivation.
(Kay & LeSage, 2009) as well as supporting student interaction, communication, and collaboration (Sung et al., 2016). Assessment technologies save time, and data can be stored for later use (Adams & Howard, 2009). Additionally, they can be used for polling (Stowell, 2015) to generate discussions and increase participation by allowing normally quiet students to provide feedback (Adams & Howard, 2009). Mobile assessment also allows teachers to introduce game-based assessments into their classrooms, which are distinguished from other forms of assessment by the energy, engagement, and motivation they generate in the classroom (Wang, 2015).

Mobile technologies prepare students for lifelong learning because learning occurs in many places and times (Wyncott, Jones, & Scanlon, 2005), and as noted by Sha et al. (2012), preparing “students with knowledge and skills for lifelong learning is regarded as a major goal of contemporary education in which mobile learning is subsumed” (p. 368).

**PURPOSE AND RESEARCH QUESTIONS**

Historically, teachers have opposed the integration of mobile phones in the classroom (Lenhart et al., 2010); however, cell phones have evolved into smart phones. Increased access to mobile phones and online content, significant growth in instructional applications, and evolving school policies, make mobile phones a viable option for classroom use. According to the U.S. Department of Education (2017), “mobile devices that connect learners and educators to the vast resources of the internet and facilitate communication and collaboration” prepare students to be successful for the future (p. 69). Mobile devices enable teachers to “personalize and customize learning experiences to align with the needs of each student” (U.S. Department of Education, 2017, p. 22) in both formal and informal learning contexts.

The purpose of this study was to examine if preservice teachers’ perceptions regarding the use of mobile phones in the classroom had changed and if so, how.

1. Has preservice teacher support for the use of mobile phones in the classroom changed?
2. Have preservice teachers’ perceptions regarding the ability of mobile phones to support student learning changed?
3. Have preservice teachers’ perceptions regarding the barriers to the use of mobile phone in the classroom changed.

**METHODOLOGY**

**Research Design**

This study examined the findings from three studies conducted in 2013, 2015, and 2018, respectively. Guided by the recommendations of Creswell (2013), each of the three studies used a survey approach to investigate preservice teachers’ perceptions of the use of mobile phones in the classroom. Survey research was the preferred method of data collection because of its economy, rapid turnaround, and the standardization of the data (Babbie, 2012). Data from the each of the three studies was compiled and is presented in the Results section.

**Participants**

The subjects for this study consisted of students enrolled in the Preservice Teacher Preparation programs at four universities that participated in the study: three small liberal arts universities—Bellarmine University and Asbury University in Kentucky and Methodist University in North Carolina—and one large liberal arts university, The University of Tennessee, Knoxville. All of the participants in the 2013 study attended Bellarmine, and participants in the 2015 study attended Bellarmine and the University of Tennessee. The 2018 study included preservice teachers from Bellarmine, Asbury, and Methodist. A total of 495 preservice teachers participated in the three studies: 92 (18.5%) in 2013, 245 (49.5%) in 2015, and 158 (32%) in 2018 (Table 1). Sixty-six (72%) of participants in 2013 were between the age of 18-31 and 26 (28%) were above 32. In the 2015 study, the mean age was 22.93 (SD 5.69). Participants in the 2018 study consisted of 97 (61.4%) between the ages of 18 and 21 and 129 (81.6%) under the age of 30 with a mean age was 24.21.
Sixty-five (71%) of participants in the 2013 study owned a smartphone and 27 (29%) owned a basic cell phone. In 2015, 214 (87.3%) owned smartphones and 31 (12.7%) owned a basic mobile phone. Of the participants in 2018, 158 (100%) owned a smartphone.

### Table 1

<table>
<thead>
<tr>
<th>Year</th>
<th>Kentucky</th>
<th>North Carolina</th>
<th>Tennessee</th>
<th>Female</th>
<th>Male</th>
</tr>
</thead>
<tbody>
<tr>
<td>2018</td>
<td>126</td>
<td>41</td>
<td>N/A</td>
<td>122 (77%)</td>
<td>36 (23%)</td>
</tr>
<tr>
<td>2015</td>
<td>113</td>
<td>N/A</td>
<td>N/A</td>
<td>132</td>
<td>48 (20%)</td>
</tr>
<tr>
<td>2013</td>
<td>92</td>
<td>N/A</td>
<td>N/A</td>
<td>71 (77.2%)</td>
<td>21 (22.8%)</td>
</tr>
</tbody>
</table>

*In the 2018 study, 16 (9%) participants were located in other states. The participants located in other states were comprised of students enrolled in an online degree program and most often lived in a bordering state.

### Data Source

Data was collected using two surveys, which were based on current literature associated with mobile phone use. In 2013, the Mobile Phone Learning Survey was used. This survey was developed by the first author. In the 2015 and 2018 studies, the Mobile Phone Use in the Classroom Survey (O’Bannon et al., 2017), a revision of the 2013 survey, was used. Both surveys gather data on participants’ demographics, phone ownership, and mobile phone usage. Participants were also asked about their support for the use of mobile phones in the classroom and the ability of mobile phones to support student learning. Additionally, the surveys gathered data on participants’ opinion on use of mobile phones for school-related work and allowing students to use mobile phones for school-related work. Data was also collected on participants’ perceptions of the benefits and barriers associated with mobile phones in the classroom. The survey contained a variety of question types including Yes/No, checklists, open-ended, and Likert-scaled questions using 5-point scales (SD = strongly disagree, D = disagree, N = neutral, A = agree, and SA = strongly agree). Likert scaled items were classified in themes.

### Data Analysis

Data was gathered and analyzed from survey results for each of the three studies. To analyze the data, a number of statistical tests were utilized. In order to characterize the data, descriptive statistics were first generated on each question from the three studies. The descriptive statistics were used to assist in describing and summarizing the data.

### RESULTS

**School Policy on Mobile Phone Use.** To determine if school-related policy on mobile phone usage had an influence on pre-service teachers’ perceptions on mobile phone use in schools, participants in the 2018 study were asked to indicate the type of mobile phone policy at their school. The 2013 and 2015 participants did not provide feedback on these questions. Results indicated that the largest number of participants (n=66) went to schools that allowed mobile phones to be used for instructional purposes. The fewest number of participants (n=2) went to school where mobile phones were not allowed. For the purpose of testing whether the school policy correlated with participant perception response, a Pearson Correlation Coefficient was calculated for each set of responses. While the results of the Pearson Correlation Coefficient did not reveal an overall statistically significant relationship between policy and perception on each question, they did reveal a small correlation between the participants’ school policy and their response to support mobile phone use (R = 0.302).

**Support for Mobile Phones in Schools.** The preservice teachers were asked if they agreed or disagreed with the statement, “I support the use of mobile phones in the classroom.” Results from the three studies demonstrated that the
percentage of preservice teachers who support the inclusion of mobile phones in the classroom had more than doubled since 2013 (Table 2). Likewise, the percentage of teacher who were uncertain about allowing phones in the classroom had decreased by more than double. Lack of support had been fairly stable.

<table>
<thead>
<tr>
<th>Year</th>
<th>Age</th>
<th>Support</th>
<th>Don’t Support</th>
<th>Uncertain</th>
</tr>
</thead>
<tbody>
<tr>
<td>2018</td>
<td>All Ages</td>
<td>55%</td>
<td>20%</td>
<td>25%</td>
</tr>
<tr>
<td></td>
<td>18-29 year olds</td>
<td>59%</td>
<td>17%</td>
<td>24%</td>
</tr>
<tr>
<td></td>
<td>30+</td>
<td>36%</td>
<td>35%</td>
<td>31%</td>
</tr>
<tr>
<td>2015</td>
<td>Did not separate by age.</td>
<td>45%</td>
<td>25%</td>
<td>30%</td>
</tr>
<tr>
<td>2013</td>
<td>All Ages</td>
<td>25%</td>
<td>22%</td>
<td>52%</td>
</tr>
<tr>
<td></td>
<td>18-31</td>
<td>25%</td>
<td>18%</td>
<td>58%</td>
</tr>
<tr>
<td></td>
<td>32+</td>
<td>26%</td>
<td>35%</td>
<td>39%</td>
</tr>
</tbody>
</table>

**Table 2**

Percentage of preservice teachers who support mobile phones in the classroom

Mobile Phones Support Student Learning. Preservice teachers’ perception that mobile phones support student learning also increased (Table 3). While data was not gathered in 2013, three-fourths of participants indicated that they believe phones support student learning, an increase of 16% from 2015-2018. The percentage of teacher who do not think they support learning and who are uncertain decreased by 11% and 5% respectively.

<table>
<thead>
<tr>
<th>Year</th>
<th>Support</th>
<th>Doesn’t Support</th>
<th>Uncertain</th>
</tr>
</thead>
<tbody>
<tr>
<td>2018</td>
<td>74%</td>
<td>10%</td>
<td>16%</td>
</tr>
<tr>
<td>2015</td>
<td>58%</td>
<td>21%</td>
<td>21%</td>
</tr>
<tr>
<td>2013</td>
<td>Not gathered</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Table 3**

Percentage of teachers who think mobile phones support student learning

Perceived Barriers to Use. Participants concerns about barriers to integration identified in the research increased in all categories from 2013-2018 (Table 4). The primary concern regarding the use of mobile phones in the classroom was the potential for student to use them to cheat, with 8 out of 10 preservice teacher perceiving cheating a problem. Concerns about cyberbullying increased a staggering 57% and by sexting 37%. While still a concern, disruption of class caused by mobile phones, fell from the primary concern to number 3. Likewise, lack of access had moved from third to fifth. Although the negative impact of writing remained at the bottom of participants perceived barriers to integration, the percentage had more than doubled since 2013.

<table>
<thead>
<tr>
<th></th>
<th>2018</th>
<th>2015</th>
<th>2013</th>
<th>2013</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cheating</td>
<td>80%</td>
<td>Cheating</td>
<td>83%         Disruption of Class (Texting, ringing phones, etc.)</td>
<td>67%</td>
</tr>
<tr>
<td>Cyberbullying</td>
<td>79%</td>
<td>Disruption of Class (Texting, ringing phones, etc.)</td>
<td>78%</td>
<td>Cheating</td>
</tr>
<tr>
<td>Disruption of Class (Texting, ringing phones, etc.)</td>
<td>77%</td>
<td>Cyberbullying</td>
<td>76%</td>
<td>Lack of Access</td>
</tr>
<tr>
<td>Sexting</td>
<td>66%</td>
<td>Sexting</td>
<td>64%   Sexting</td>
<td>29%</td>
</tr>
<tr>
<td>Lack of Access</td>
<td>49%</td>
<td>Negative Impact on Writing</td>
<td>64%</td>
<td>Cyberbullying</td>
</tr>
<tr>
<td>Negative Impact on Writing</td>
<td>48%</td>
<td>Lack of Access</td>
<td>53%</td>
<td>Negative Impact on Writing</td>
</tr>
</tbody>
</table>
DISCUSSION AND IMPLICATIONS FOR FURTHER RESEARCH

While the 2013 and 2015 studies did not gather data on the school policy on mobile phones of the participants, results from this question on the 2018 study are aligned with research on shifts in K-12 school policy, which are increasingly allowing students and teachers to use mobile phones. Based on findings that revealed a small correlation between the school policy on participants’ support for mobile phone integration, additional research should be conducted with a larger sample to determine the potential scope of the impact K-12 policy has on preservice teachers’ attitudes toward integration.

In regards to support for the use of phones in the classroom, there were several interesting results. First, the younger preservice teachers’ position on this topic had essentially flipped. In 2013, 25% supported, 58% were against, and 18% were uncertain, whereas in 2018 59% supported, 24% were against, and 17% were uncertain. Since 2013, access to smart phones has increased as has internet access. Likewise, the number of instructional features and applications available for mobile devices has increased. The changing phone policies in K-12 have provide students more opportunities to use phones in school and see them used by teachers. Research should be conducted to determine the impact, if any, on preservice teachers’ changing attitudes. Findings also revealed that the older participants’ views were closely divided, especially in the 2018 survey—36% in support, 35% against, and 31% uncertain; 2013 results were similarly close. Additional research is needed to understand why students over 30 are less supportive than their younger counterparts.

Seventy-five percent of the participants indicated that mobile phones support learning. Preservice teachers in the 2015 and 2018 studies reported using their mobile phones for a number of school related activities. These included: accessing the internet, accessing educational apps, using the calculator, and taking pictures as well as sending and receiving text messages and emails. Additional research should be conducted to determine the impact of the personal use of specific mobile and specific mobile phone tools for school-related work on preservice teachers’ perceptions of the ability of mobile phones to support learning.

Despite the significant increases in preservice teachers who support their use in the classroom and ability to support learning, the majority of teachers still have concerns about them. In fact, eight out of ten teachers are concerned about students using their phones to cheat. While this is serious issue, research indicates that only a small number of students use their phones to cheat. A 2017 survey of 1,201 U. S. students in grades 9-12 found that 29% of students use technology to cheat in school (Noguchi, 2017). Cyberbullying saw a 52% increase and moved from 5th to second on the list of potential barriers. A 2018 report from the National Center for Educational Statistics indicated that cyberbullying has been on the increase. Pew Internet (February 2018) reported that 59% of teens ages 13-17 experienced some type of cyberbullying; however, schools with rules prohibiting the use of mobile phones during the school day had a higher percentage of principals reporting “daily/weekly cyberbullying.” Sixteen percent of schools that prohibited the use of mobile phones reported “daily/weekly cyberbullying” compared to 9.7 percent of schools that did not prohibit their use (Jackson, Diliberti, Kemp, Hummel, Cox, Gbondo-Tughawa, Simon, and Hanse, 2018). Concerns about sexting increased 37%, but like cheating, this is not a wide-spread issue in schools.

A 2018 meta-analysis of 39 international studies conducted between 2009-2016 with over 110,000 participants found that 14.8% of youth (average age 15) have sent a sext and 27.4% have received one (Madigan, Ly, Rash, Van Ouytsel, & Temple, 2018). Finally, teachers continue to be concerned about the negative impact on writing despite research to the contrary. Coe and Oakhill (2011) studied the relationship between student use of textese and literacy and effect. Drouin and Driver (2014) also found a positive relationship between texting and literacy.

Limitations

The survey used in the first study was not validated and did not gather all of the same data as the 2015 and 2018 studies. Further, the studies uses a convenience sample of participants, which limits generalization of the findings and creates the potential for sampling bias. There were a large number of female participants; however, this is characteristic of a population of students in a school of education.
CONCLUSION

While educators have always been aware of the instructional benefits of mobile phones, a number of real and perceived barriers have hindered their integration into the classroom. Over the last decade, mobile phone technologies have evolved, accessed has increased, instructional apps have proliferated, and school policy banning them have softened. In conjunction with these changes, preservice teachers’ perceptions of the appropriateness of allowing phones in the classroom have increased dramatically, along with their beliefs they support student learning. Moving forward, research is needed to determine the impact, if any, of the aforementioned changes on teachers’ perceptions and use of mobile phones in their classrooms.

REFERENCES

Inclusive Instructional Technology Practices Implemented During COVID-19 to Reimagine Future Course Design

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Abstract: COVID-19 prompted a shift for the need to seek the urgent adaptation of more inclusive online teaching and learning practices (Hodges, Moore, Lockee, Trust, & Bond., 2020). The need for practices to promote online learning for all prompted a project focused on the transition to Rapid Online Teaching and Learning (ROTL). Results of this study reveal that low bandwidth was experienced by students enrolled at community colleges as well as educators. For the faculty and students who experienced barriers to the ROTL transition forms of resolution included technology and institutional supports, but were primarily overcome by personal resources.

Keywords: online teaching and learning, emergency remote teaching, course design

THEORETICAL FRAMEWORK

When considering online learners’ needs, it’s vital to design online learning experiences to encourage success for students who may have limited access to technology and high-speed internet. Low-bandwidth technologies don’t negatively impact learning and satisfaction levels of students and “may prevent students from participating because they do not have access to the computers or Internet connections needed to support these more advanced technologies.” Johnson, Benson, Duncan, Shinkareva, Taylor, & Treat, 2004). Focusing on the Empathy and Equity sections of the Mindful Course Design Model, there are tools and design practices that ensure success for all students, despite access to computers and high-speed internet.

METHODS/ DATA SOURCES

North Carolina community college educators participated in a survey to identify barriers to accessing technology experienced by both faculty and students. The survey measured access to high-speed internet, overall access to technology, and how problem-solving played a role in the development of solutions to lack of access. Participants had voluntarily requested support in their urgent transition to online teaching due to face-to-face class cancelations because of COVID19. Supports offered included one-on-one coaching for online teaching, large-audience webinars on best practices, live training sessions, and video tutorials developed to answer individual educators’ needs. Of the North Carolina community college faculty surveyed (N=502, 17.33%) responded (n=87). Individual response rates for questions are reported below.
RESULTS

Postsecondary institutions are often a resource for seeking resolution to problems. During challenging times, historically, college educators contribute to the reassurance students need and serve as guides to students during times of disruption (Steiner & Laws, 2006). Results will be discussed in more detail with session participants around issues and solutions that were found regarding faculty and their students. Online course design, representative of outstanding quality requires tools and technologies consistent with current trends (Pollacia & McCallister, 2019), peer-review (Shattuck, 2012), the ability to engage students (Bartlett, 2017), and should support the implementation of the assessment of student learning outcomes (Legon, 2015); however, none of these expectations can be met if access is not incorporated. In brief, results showed a staggering number of students and faculty dealt with issues related to internet and device access. Faculty reported the ways that both they and their students overcame these challenges and what institutions provided to help in the transition. The main help from institutions was centered around loaning devices, offering hotspots for the internet, the creation of resource guides, and extended help desk hours.

Student Issues Reported by Faculty

Participants were asked what challenges their students reported during the spring 2020 COVID19 transition to remote learning. The response rate for this question was n=85 (97.70%). The top 7 responses are shown in Table 1. All responses after these first seven are n=1.

The most prevalent student access issues as reported by faculty were related to WiFi and device access, with unreliable internet the leading cause with 82.4% (n=70) of respondents indicating this issue. Significant issues regarding student essential workers’ availability for synchronous classes were also reported at 62.4% (n=53), along with childcare issues at 2.4% (n=2).

Student Accommodations Reported by Faculty

Faculty respondents were invited to describe accommodations offered to students with accessibility issues. The response rate for this question was n=79 (90.80%). Respondents reported a variety of accommodations offered individually by the faculty themselves and wide-scale by their college. The most prevalent campus-wide accommodations reported by
faculty included device loaning, WiFi access (including opening campus buildings, extended WiFi to parking lots, sharing resources of free internet options beyond the college campus), and policy adjustments such as extended deadlines for requesting an incomplete or dropping a course. The most prevalent instructor-initiated accommodations reported were extending assignment due dates, offline coursework and content delivery options, extended class and office hours, asynchronous recorded course delivery, and varied communication methods. Nearly 4% (n=3) respondents indicated they felt they were unable to offer any help in accommodating students with access issues.

<table>
<thead>
<tr>
<th>Table 1</th>
<th>Student Challenges Reported by Faculty (n=85)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reliable internet</td>
<td>70</td>
</tr>
<tr>
<td>Limited device access</td>
<td>62</td>
</tr>
<tr>
<td>No home internet access</td>
<td>56</td>
</tr>
<tr>
<td>Sharing devices with others</td>
<td>58</td>
</tr>
<tr>
<td>Essential worker (increased hours, different/modified hours)</td>
<td>53</td>
</tr>
<tr>
<td>Low Bandwidth</td>
<td>47</td>
</tr>
</tbody>
</table>

**Faculty Issues Reported by Faculty**

Participants were asked what challenges they faced during the spring 2020 COVID19 transition to remote learning. The response rate for this question was n=62 (71.26%). The top 5 responses are shown in the table below. All responses after these first five are n=1.

<table>
<thead>
<tr>
<th>Table 2</th>
<th>Faculty Challenges Reported by Faculty (n=62)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low Bandwidth</td>
<td>30</td>
</tr>
<tr>
<td>Unreliable Internet</td>
<td>27</td>
</tr>
<tr>
<td>Sharing Devices with Others</td>
<td>17</td>
</tr>
<tr>
<td>Limited Device Access</td>
<td>8</td>
</tr>
<tr>
<td>No Home Internet Access</td>
<td>2</td>
</tr>
</tbody>
</table>

The most prevalent access issues reported by faculty were related to their own internet access, with 48.4% (n=30) indicating low-bandwidth impacted their ability to deliver remote instructions and 43.5% (n=27) reporting unreliable internet access impacted their ability to deliver remote instruction. Significant issues regarding device availability also impacted faculty teaching remotely, with 27.4% (n=17) of respondents reporting having to share a device with others impacted their ability to deliver remote instruction, and 12.9% (n=8) reporting limited device access.

**Overcoming Challenges Reported by Faculty**

When asked how issues were overcome, faculty responded with varying approaches to discovering resolution to the challenges presented while teaching remotely during Covid-19. Faculty reported incurred expenses due to the need to upgrade their equipment at home or purchase new technology for home use. The response rate for this question was n=66 (75.86%). One faculty member disclosed that they found resources by borrowing technology from family members and neighbors. Many shared that while they were working remotely, they placed the educational needs of their children first, who was also learning at home, and then began their workday. Assessing time management was another contributing factor to overcoming the challenges associated with this new reality of teaching remotely. The most overwhelming response indicated that faculty drove to neighboring WiFi access points on campus and using the internet to work during low-peak times (midnight - 6 am) helped to navigate some of the challenges. Of the reports for overcoming challenges reported by faculty responses were coded into seven themes. The themes represented include: accessing personal resources
n=21 (31.8%), managing time n=8 (12%), obtaining institutional support n=7 (10.6%), utilizing technology/software n=5 (7.6%), implementing accommodations for students n=5 (7.6%), working during non-peak hours n=3 (4.5%), traveling to access WiFi n=3 (4.5%). As faculty expressed their solutions to overcoming challenges, utilizing their personal resources was at the forefront of the choices they made to resolve issues. Faculty disclosed, in an effort to resolve challenges associated with transitioning to remote teaching, that they had purchased, out of personal funds, new software, hardware, and other technology to be able to work from home. In addition, they upgraded their personal equipment as well as purchased additional data to be able to deliver content and communicate with students remotely.

Institutional Supports for Faculty

Faculty were asked to report the types of supports provided throughout the transition by their institution. The response rate for this question was n=83 (95.40%). A range of responses was received by 83 faculty members. Overarching themes included technology support and VPN access, instructional videos, and there were reports of faculty receiving technology support throughout the weekends as they worked to transition to teaching online. Many campuses offered telework options and WiFi hotspot access from their parking lots. One faculty member shared, “Departments pooled resources so students had the necessary devices to work remotely. Hot spots were provided for those staff members with internet access issues.”

Practices can inform future course design, to include students’ needs with issues accessing technology or high-speed internet, beyond the COVID19 pandemic. Talent within these groups is important to capture and build. These students should not lose out on participating in online education, especially the flexibility that online education offers due to technology access issues.

Institutional Supports for Students

Participants were asked how their institutions supported students during this transition. The response rate for this question was n=78 (89.66%).

Figure 2. Word Cloud for Institutions Supports for Students Reported by Faculty.

Institutional supports reported ranged from ‘none’ (n=8) to help with gas, devices, resource guides, labs, help desk, and money for internet or loaned hotspots for WiFi. One participant reported, “Students were able to join classes using an independent URL connected to collaborate ultra. This enabled students to bypass Moodle and join using their smartphone or tablet. It eliminated barriers for students that were yet to set up their official college email.” While some
Participants stated that institutions helped with hotspots for WiFi, others identified that institutions encouraged students to access WiFi at the school parking lot. Many institutions added support staff and extended hours for their Help Desk to help students and faculty during the transition. A participant stated, “... the Help Desk was the #1 resource utilized by the college during this time. We had a lot of students who had no technology background now having to complete the remainder of all their courses online.”

Suggestions Moving Forward

Beyond reporting the findings of the study, we will provide suggestions on how to navigate low bandwidth and suggestions for accommodating the challenges so that online instructors can adjust their courses to accommodate students who may experience technology access issues. One participant reported, “Support was not provided to Continuing Education students but curriculum students were given hotspots & laptops. All students could come to the college parking lot and sign on to the learning centers WiFi” which strongly suggests further investigation through future research into the differences in how institutions handled continuing education vs. curriculum student supports.

SIGNIFICANCE

Three years ago, approximately one-third of all students enrolled in postsecondary education courses were enrolled in at least one course that was delivered online (Clinefelter & Aslanian, 2017; Seaman, Allen, & Seaman, 2018). This research contributes to the ongoing movement towards more inclusive and accessible online teaching and learning practices. Researchers share evidence from project-related best practices to accommodate common disruptions to online learning that were adopted in the wake of COVID19-related shifts to online teaching. Such practices can continue to benefit students with online access issues to limit learning disruptions. Community college educators were receptive of this quick transition to teaching online, defined in a research study as, “Emergency remote teaching (ERT) is a temporary shift of instructional delivery to an alternate delivery mode due to crisis circumstances.” (Hodges, Moore, Lockee, Trust, & Bond, 2020).

IRB Note: This study was approved by the North Carolina State University Institutional Review Board on June 8th, 2020.

REFERENCES

Bartlett, M. E. (2017). Integration of E-Service Learning in an Online Graduate Course, Society for Information Technology and Teacher Education 28th International Conference, SITE, Austin, TX.
Critical Success Factors of Distance Online Learning in Higher Education During COVID-19: Differences Among Students

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Abstract: Due to the swift, unusually extensive shift to distance online learning during the COVID-19 pandemic, the present study sought to examine students’ perceptions in higher education at the end of the first semester they learned this way. We conducted a preliminary study at the onset of the new experience and collected qualitative data from students regarding their difficulties and profits. Five dimensions of Critical Success Factors (CFS) in online learning were found. This indicates a need to understand the various sub-dimensions and their compositions. Little attention has been paid to the differences in CSF perceptions between students. The present study aims to Zoom-In on CSF by defining its sub-dimensions in the new online learning conditions triggered by this period, and examine differences between students in perceived CFS sub-dimensions. A closed questionnaire was constructed based on the previous study. Exploratory Factor Analysis identified ten sub-dimensions of CSF. Medium-high correlations were found between nine CSF sub-dimensions and four items representing outcomes as perceived by the students. CFS sub-dimensions’ perceptions differed between students from different economic status, employment type, academic experience, and study area. The detection of CSF sub-dimensions and related perceived outcomes in the corona period’s uncharted learning processes extends our CSF knowledge. The study also sheds light on differences between students of different backgrounds.

Keywords: critical success factors, online learning, e-learning, COVID-19, corona.

INTRODUCTION

The COVID-19 pandemic outbreak has shifted universities and colleges worldwide to Emergency Remote Teaching (ERT), allowing students to continue their studies (Altbach & De Wit, 2020). The transition occurred within days with hardly any time for proper arrangements. Faculties, teachers, and students were required to adopt new technolo-
gies alongside new teaching and learning methods and make decisions with hardly any initial preparation. Teaching and learning activities held face-to-face in the past were abruptly transformed into online teaching and learning. Remote, online learning has been widespread in the last few decades (Lee & Ferwerda, 2017; Soffer & Nachmias, 2018; Tlili et al., 2016) in varying levels ranging from courses to complete programs (Allen et al., 2016; Cohen & Baruth, 2017). In pre-corona time, researchers identified Critical Success Factors (CSF) of online learning. The literature categorized factors related to acceptance, implementation, students’ satisfaction, as well as students’ and teachers’ perceptions about online learning (Alhabeeb & Rowley, 2018; Asoodar et al., 2016; Selim, 2007; Sun et al., 2008; Wagner et al., 2008). Later on, as soon as the pandemic broke out and the transition to online learning started, a large-scale study conducted in one of Israel’s largest universities collected preliminary qualitative data through an open questionnaire. Based on the CSF literature, the students’ perceptions were classified into 101 themes dealing with facilitating and debilitating remote learning factors that converged into five CFS dimensions: 1. Student 2. Teacher 3. Learning content 4. Learning environment 5. Organization. The descriptive framework developed was termed Distance Learning Success Dimensions – DLSD (Baruth et al., under review). This study zooms in on each dimension of DLSD to examine its sub-dimensions and their composition. In doing so, the study assists in research and practical work on sub-dimensions of CSF in online teaching during the pandemic and later when it is over.

In addition to CSF literature dealing with success factors classification, some comparative studies have also been performed. For example, differences were found in CSF related to online learning adoption processes between universities from different cultural backgrounds (Lin et al., 2011). Different perceptions among different stakeholders were also found. For example, between online learning technology experts and teachers expert in the field (Bhuasiri et al., 2012), between teachers and students (Alhabeeb & Rowley, 2018), and between students from different cultural backgrounds (Cortés & Barbera, 2013). Even before COVID, little has been known about differences in CSF perceptions of students from different groups. To this end, this study seeks to examine differences among students.

Studies both before and during COVID, have shown that economic condition affects online learning experience. This malfunction relation stems from the digital gaps manifested through limitations such as infrastructure quality, access to equipment and software (Alam, 2020; Alipio, 2020; Collin & Brotocone, 2019; Girik Allo, 2020), and digital skills (Demirbilek, 2014; Scherer & Siddiq, 2019). Besides, the lower economic condition has been found related to lower living conditions quality and the extent of privacy (Evans & Kantrowitz, 2002), which may impact online-home learning experience (Evans & Kantrowitz, 2002). Another prominent characteristic to examine is the students’ employment condition given data showing an increase in working students’ proportions, which engenders damage in time on learning and in dropping percentages (Hall, 2010; Hovdhaugen, 2013).

It is also interesting to look into students’ academic traits. Academic experience has been shown to affect students’ perceptions and learning satisfaction (Bradford & Wyatt, 2010). In the early stages of the corona crisis, a qualitative study focused on online learning CSF found differences between first-year students and advanced students in the frequency of statements related to each CSF dimension (Baruth et al., under review). Area of study, another academic trait, has also been shown to relate to participation degree, ability to embrace, and online learning perceptions (Finnegan et al., 2008; Xu & Jaggars, 2013). This calls for further inspection of these traits’ role in the context of online remote learning CSF.

In light of this, this study examines the students’ perceptions of online remote learning CSF during the corona crisis by zooming in on CSF sub-dimensions and traits of different learners groups. The study’s insights could help research and design online remote learning both during a crisis and in routine.

THE STUDY

Following the swift and unusually comprehensive transition to online remote learning during the corona crisis, this study sought to examine the students’ perceptions at the end of the first semester they had experienced this type of teaching for the first time. The study’s aims are twofold: 1. to zoom in on learners’ perceptions of CSF’s sub-dimensions in online teaching and learning during the period’s particular conditions. 2. to examine the differences in learners’ perceptions of CSF between different learners’ groups. The following research questions were thus posed:

Q1. What are the sub-dimensions and their constructing components of DLSD framework-based CSF based on perceptions of higher education students in Israel following the first semester of online remote learning during the corona period?
Q2. What are the differences in learners’ perceptions of CSF between learners’ groups differing in their economic status, employment status, academic experience, and study area?

METHODOLOGY

This study constitutes the second stage of comprehensive research conducted from the outset of the corona crisis with the transition to remote learning. In the first stage, qualitative data were collected through an open questionnaire. Based on the data, we developed the DLSD framework of CSF, which contained five dimensions with themes fitting in each dimension; in the second stage, we developed an electronic closed-questionnaire in Hebrew based on the five dimensions and their matching themes, in addition to some literature-based adaptations. This questionnaire was distributed to students in higher education institutions in Israel, both through social media and with the national student association’s help. 517 students responded to the questionnaire; 192 are men, and 322 are women (N=514). The average age of the respondents is M=27.2, with a standard deviation of SD=8.17 (N=494).

The 53 questionnaire statements related to the five CSF dimensions were matched with a 1-5 Likert scale (1 – strongly disagree; 5 – strongly agree). The questionnaire’s items were phrased either positively or negatively to overcome respondents’ tendencies to answer positively or negatively and in an automatic manner. The respondents were also prompted to fill in their age and gender and the background information relevant to classify the learners according to the four group variables examined: 1. Economic status (bad, fair, good, very good). 2. Two questions examined employment status: a. “Are you working”? b. the number of week working-hours. 3. Academic experience was examined based on the study year. 4. Study area was examined by asking, “what faculty you belong to”?

To answer Q1, we conducted an Exploratory Factor Analysis (EFA) independently for each of the five dimensions of the DLSD framework. Each dimension rendered sub-dimensions (a.k.a. the factors). Internal reliability of the items belonging to each sub-dimension was verified (Chronbach Alpha), and an index was constructed for each sub-dimension. Items phrased negatively were recoded to concur with the positive orientation of the constructed indexes.

Group variance tests were conducted to answer Q2. The dependent variables were the sub-dimensions built using the EFA (represented by the constructed indexes), and the independent variables represented the four traits of the groups we examined. The following coding assembled the independent variables: economic status (bad – 1, fair – 2, good and very good – hereafter termed good-and-above – 3); employment status (not working, part-time job – up to 33 hours a week, full-time job – over 33 hours a week). The cur-point between part and full-time jobs of 33 hours a week was ruled based on an 80% job volume in a 42-hours week work; academic experience (first-year students – freshman students, beyond first-year – veteran students); the myriad of faculties were aggregated into two overarching areas: Humanities and Social Science, and Science Engineering and Medicine.

FINDINGS

Students’ perceptions of CSF (Q1)

Based on EFA, ten sub-dimensions were formed for the five CSF dimensions (Figure 1). In student dimension two factors were created – flexibility, convenience and routine (comprised of 12 items that accounted for 49.79% of the variance with factor loadings from 0.82 to 0.61) and parental coping ability (comprised of one item that accounted for 8.43% of the variance with factor loading of 0.73); In teacher dimension two factors were shaped – communication quality: teacher & content-student (comprised of six items that explained 30.32% of the variance with factor loadings from 0.45 to 0.83) and techno-pedagogical ability (comprised of 4 items that explained 28.84% of the variance with factor loadings from 0.51 to 0.85).
Figure 1. CSF five dimensions; ten sub-dimensions.

Three factors were created in the learning content dimension – **learning process quality** (comprised of seven items that explained 26.09% of the variance with factor loadings from 0.51 to 0.81), **informal learning materials contribution** (comprised of three items that accounted for 16.05% of the variance with factor loadings from 0.72 to 0.79) and **formal learning materials contribution** (comprised of four items that accounted for 14.8% of the variance with factor loadings from 0.45 to 0.74).

Two factors were shaped in the learning environment dimension – **few technical problems** (comprised of five items that explained 38.21% of the variance with factor loadings from 0.44 to 0.83) and **financial and time efficiency** (comprised of two items that explained 24.88% of the variance with factor loadings from 0.87 to 0.88); One factor was created in organization dimension – **organization policy clarity** (comprised of five items that accounted for 55.61% of the variance with factor loadings from 0.50 to 0.85).

The empirical data and known theoretical meaning of – learning motivation, individual learning quality, teaching quality, and ability to accomplish the semester or the degree – have led us to include these items in neither factor. Instead, these variables are defined in this study as outcomes (based on students’ perceptions). These four outcome variables had medium-high significant correlations with nine out of ten CSF sub-dimensions (the sub-dimension parental coping ability in student dimension was the only exception). Most of the correlations were higher than 0.5, but for two sub-dimensions in the learning content dimension – formal learning materials contribution and informal learning materials contribution – with significant yet relatively low correlations to the outcomes (0.26-0.46).

**CSF DIFFERENCES BETWEEN LEARNERS’ GROUPS (Q2)**

The second research question dealt with group differences based on the four variables in CSF’s perception composed of the ten indexes constructed for the ten sub-dimensions.

**Economic status**

Running the Anova test, we found significant differences in eight out of the ten indexes (Table 1), wherein average was higher for the higher economic status, except for one index – financial and time efficiency. In financial and time efficiency, the average was nearly identical for fair and bad economic statuses.
Table 1
Analyses of variance (Anova) of indexes between different economic statuses

<table>
<thead>
<tr>
<th>Dimension</th>
<th>Sub-dimension</th>
<th>F</th>
<th>Total df</th>
</tr>
</thead>
<tbody>
<tr>
<td>Student</td>
<td>Flexibility, convenience and routine</td>
<td>5.75**</td>
<td>516</td>
</tr>
<tr>
<td></td>
<td>Parental coping ability</td>
<td>1.08</td>
<td>363</td>
</tr>
<tr>
<td>Teacher</td>
<td>Communication quality: teacher &amp; content-student</td>
<td>14.73***</td>
<td>513</td>
</tr>
<tr>
<td></td>
<td>Techno-pedagogical ability</td>
<td>7.9***</td>
<td>512</td>
</tr>
<tr>
<td></td>
<td>Learning process quality</td>
<td>8.8***</td>
<td>510</td>
</tr>
<tr>
<td></td>
<td>Formal learning materials contribution</td>
<td>7.04**</td>
<td>508</td>
</tr>
<tr>
<td></td>
<td>Informal learning materials contribution</td>
<td>1.32</td>
<td>509</td>
</tr>
<tr>
<td>Learning content</td>
<td>Learning environment</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Few technical problems</td>
<td>25.28***</td>
<td>510</td>
</tr>
<tr>
<td></td>
<td>Financial and time efficiency</td>
<td>5.12**</td>
<td>509</td>
</tr>
<tr>
<td></td>
<td>Organization</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Organization policy clarity</td>
<td>25.35***</td>
<td>516</td>
</tr>
</tbody>
</table>

*p<0.05, ** p<0.01, *** p<0.001

The post-hoc Tukey tests of these eight indexes revealed that the significant differences were mainly between good-and-above status and the two lower statuses, and occasionally also between fair and bad status. In financial and time efficiency, the differences were solely between good-and-above and fair economic status. Therefore, the findings suggest that students in better economic conditions are likely to perceive the CFS sub-dimensions more positively.

Employment status

An Anova test showed significant differences in eight out of the ten indexes (Table 2). Of these indexes, except for parental coping ability, an interesting pattern emerged, of index average being lowest for the part-time job, followed by not working and highest for the full-time job. In contrast, the average parental coping ability was lowest for the full-time job, followed by not working, and highest for the part-time job. The post-hoc Tukey tests of these eight indexes revealed that the significant differences were mostly between the full-time job versus not working or part-time job (in the learning process quality index, no significant difference was found between the full-time job and not working). These mixed findings suggest students with full-time jobs, unlike students with part-time jobs or non-working students, are likely to perceive most of the CSF sub-dimensions more positively; they may, on the other hand, perceive the parenteral coping ability sub-dimension more negatively.

Table 2
Analysis of variance (Anova) of indexes between different employment statuses

<table>
<thead>
<tr>
<th>Dimension</th>
<th>Sub-dimension</th>
<th>F</th>
<th>Total df</th>
</tr>
</thead>
<tbody>
<tr>
<td>Student</td>
<td>Flexibility, convenience and routine</td>
<td>2.43</td>
<td>509</td>
</tr>
<tr>
<td></td>
<td>Parental coping ability</td>
<td>9.23***</td>
<td>356</td>
</tr>
<tr>
<td>Teacher</td>
<td>Communication quality: teacher &amp; content-student</td>
<td>7.99***</td>
<td>506</td>
</tr>
<tr>
<td></td>
<td>Techno-pedagogical ability</td>
<td>5.16**</td>
<td>505</td>
</tr>
<tr>
<td>Learning content</td>
<td>Learning process quality</td>
<td>8.11***</td>
<td>503</td>
</tr>
<tr>
<td></td>
<td>Formal learning materials contribution</td>
<td>4.71**</td>
<td>501</td>
</tr>
<tr>
<td></td>
<td>Informal learning materials contribution</td>
<td>7.78***</td>
<td>502</td>
</tr>
<tr>
<td>Learning environment</td>
<td>Few technical problems</td>
<td>11.24***</td>
<td>503</td>
</tr>
<tr>
<td></td>
<td>Financial and time efficiency</td>
<td>.57</td>
<td>502</td>
</tr>
<tr>
<td>Organization</td>
<td>Organization policy clarity</td>
<td>13.41***</td>
<td>509</td>
</tr>
</tbody>
</table>

*p<0.05, ** p<0.01, *** p<0.00
**Academic experience**

A T-test showed significant differences in six of the ten indexes (Table 3). Five indexes exhibited a pattern of higher average among the veteran learners. The informal learning materials contribution index showed an opposite pattern. Thus, the findings suggest that freshman and veteran students perceive CSF sub-dimensions differently, albeit in a mixed manner.

<table>
<thead>
<tr>
<th>Dimension</th>
<th>Sub-dimension</th>
<th>t</th>
<th>df</th>
</tr>
</thead>
<tbody>
<tr>
<td>Student</td>
<td>Flexibility, convenience and routine</td>
<td>-2.19*</td>
<td>511</td>
</tr>
<tr>
<td></td>
<td>Parental coping ability</td>
<td>.95</td>
<td>358</td>
</tr>
<tr>
<td>Teacher</td>
<td>Communication quality: teacher &amp; content-student</td>
<td>-2.34*</td>
<td>508</td>
</tr>
<tr>
<td></td>
<td>Techno-pedagogical ability</td>
<td>-3.47**</td>
<td>507</td>
</tr>
<tr>
<td>Learning content</td>
<td>Learning process quality</td>
<td>-1.64</td>
<td>505</td>
</tr>
<tr>
<td></td>
<td>Formal learning materials contribution</td>
<td>-2.64**</td>
<td>461.43</td>
</tr>
<tr>
<td></td>
<td>Informal learning materials contribution</td>
<td>3.85***</td>
<td>504</td>
</tr>
<tr>
<td>Learning environ-</td>
<td>Few technical problems</td>
<td>-1.64</td>
<td>505</td>
</tr>
<tr>
<td></td>
<td>Financial and time efficiency</td>
<td>-1.93</td>
<td>504</td>
</tr>
<tr>
<td>Organization</td>
<td>Organization policy clarity</td>
<td>-2.13*</td>
<td>511</td>
</tr>
</tbody>
</table>

*p<0.05. ** p<0.01. *** p<0.001

**Study area**

The T-test analysis showed significant differences in five of the ten indexes (Table 4). Of these five significant indexes: the averages of communication quality: teacher & content-student, teacher’s techno-pedagogical ability, and organization policy clarity were higher in the Humanities and Social Science; by contrast, the averages of students’ parental coping ability and informal learning materials contribution were higher in the Science Engineering and Medicine. Thus the findings suggest students who come from fundamentally different study areas (Humanities and Social Science versus Science Engineering and Medicine) possibly perceive the CSF’s sub-dimensions differently and in a mixed fashion.
### Table 4
Analysis of variance (T-test) of indexes between different study areas: Humanities and Social Science, Science Engineering and Medicine

<table>
<thead>
<tr>
<th>Dimension</th>
<th>Sub-dimension</th>
<th>t</th>
<th>df</th>
<th>Humanities and Social Science</th>
<th>Science Engineering and Medicine</th>
</tr>
</thead>
<tbody>
<tr>
<td>Student</td>
<td>Flexibility, convenience and routine</td>
<td>-.53</td>
<td>291.68</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Parental coping ability</td>
<td>-3.62***</td>
<td>188.07</td>
<td>Humanities and Social Science</td>
<td>&lt; Science Engineering and Medicine</td>
</tr>
<tr>
<td>Teacher</td>
<td>Communication quality: teacher &amp; content-student</td>
<td>3.69***</td>
<td>350</td>
<td>Humanities and Social Science</td>
<td>&gt; Science Engineering and Medicine</td>
</tr>
<tr>
<td></td>
<td>Techno-pedagogical ability</td>
<td>2.02*</td>
<td>302.124</td>
<td>Humanities and Social Science</td>
<td>&gt; Science Engineering and Medicine</td>
</tr>
<tr>
<td>Learning content</td>
<td>Learning process quality</td>
<td>1.13</td>
<td>301.68</td>
<td></td>
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<tr>
<td></td>
<td>Formal learning materials contribution</td>
<td>1.64</td>
<td>346</td>
<td></td>
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<tr>
<td></td>
<td>Informal learning materials contribution</td>
<td>-2.62**</td>
<td>347</td>
<td>Humanities and Social Science</td>
<td>&lt; Science Engineering and Medicine</td>
</tr>
<tr>
<td>Learning environment</td>
<td>Few technical problems</td>
<td>.87</td>
<td>347</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Financial and time efficiency</td>
<td>-.18</td>
<td>302.82</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Organization</td>
<td>Organization policy clarity</td>
<td>2.63**</td>
<td>353</td>
<td>Humanities and Social Science</td>
<td>&gt; Science Engineering and Medicine</td>
</tr>
</tbody>
</table>

*p<0.05. ** p<0.01. *** p<0.001

**DISCUSSION AND CONCLUSIONS**

This study examined learners’ perceptions of online learning’s CSF at the end of the first corona-time semester. The DLSD framework of five CSF dimensions was devised earlier in a qualitative study, adjusting to existing models. Thus, we developed this study’s quantitative questionnaire based on the findings of the earlier study.

Ten sub-dimensions were found for the five dimensions of the DLSD framework. Previous studies (e.g., Asoodar et al., 2016; Selim, 2007; Sun et al., 2008) that classified learners’ CSF perceptions in routine online learning before the corona mainly built the sub-dimensions of the dimensions based on the literature and to a lesser extent based on data collected from the field. However, this study has adopted the sub-dimensions produced in an earlier qualitative study that collected data from the field, using opened questions, during the first stage of the ERT, which started abruptly without any preparation of the parties involved. This study’s questionnaire was thus built based on the preliminary qualitative study, which aimed to “listen” (through an opened questionnaire) to the advantages and disadvantages of the new learning form during the corona crisis (Baruth et al., under review). Some of the sub-dimensions detected in this study are similar to those reported in the aforementioned pre-corona literature. However, some new sub-dimensions have appeared in our study (e.g., flexibility, convenience and routine, parental coping ability, financial and time efficiency, and organization policy clarity). The unique online learning circumstances during the corona may explain this; while some sub-dimensions are likely to disappear in post-corona online learning, others may remain.

Furthermore, the findings propose the produced sub-dimensions as potential predictors of outcomes such as learning motivation, learning quality, and teaching quality. These findings broaden the existing CSF literature, which mainly
examined relations between sub-dimensions and learners’ satisfaction. This study has also uncovered a period-unique outcome – the ability to accomplish the semester or the degree.

We found perceptions of CSF’s sub-dimensions differed based on the four students’ traits examined. Students better-off economically may perceive most of the CSF’s sub-dimensions more positively. The other traits show a mixed trend. In employment status, the findings are mixed. They suggest students in full-time jobs, unlike those in part-time or non-working students, may perceive most of the CSF sub-dimensions more positively. In contrast, the parental coping ability is perceived more negatively among them. It is possible that while students already working in full-time professional jobs acquire professional tools, yet their long working hours diminish the ability of the parent working-student to learn and study simultaneously. In academic experience, the findings suggest freshman and veteran students perceive differently, albeit in mixed fashion, some of the CSF sub-dimensions. Veteran students perceived some sub-dimensions more positively, while informal learning materials were perceived more positively among freshmen. It may stem from freshmen still unconfident in their learning (Hung et al., 2010), which also instigates their search for different learning strategies.

As for the study area, the findings indicate that students in fundamentally different study areas (Humanities and Social Science versus Science Engineering and Medicine) are likely to perceive some CSF sub-dimensions differently and in a mixed manner. The Humanities and Social Science responded more positively to sub-dimensions concerning students’ communication with the content, the teacher, and the organization; and to the teachers’ technical ability. Perhaps, in these fields, inter-personal communication is considered more prominent. Moreover, in science, perhaps the teachers must provide more practical training that hampers the teachers’ online teaching. In contrast, Science, Engineering, and Medicine perceived more positively the informal learning materials. Underestimated communication and the difficulties in creating practical training may push students in these areas to obtain more learning materials. Additional variables, such as age or gender, may account for the more positive parental coping ability in Science, Engineering, and Medicine.

This study advances the knowledge about CSF’s sub-dimensions and their outcomes during the corona period’s remote online learning, which brought about unfamiliar processes. Additionally, the study contributes to knowledge about differences in perceptions of CSF sub-dimensions between students whose traits differ. Future study is required in more higher-education institutions to enlarge the sample size such that diverse populations are represented. For example, learners whose native language differs from the language of instruction should be reached. CSF sub-dimensions should also be validated against objective learning outcomes.

REFERENCES

Baruth, O., Gabay, H., Cohen, A., Bronshtein, A., & Ezra, O. (under review). Students’ perceptions regarding distance learning during the coronavirus outbreak and differences in perceptions between first-year and more advanced students.


Designing Motivating Online Assignments and Telecollaborative Tasks in the Time of a Pandemic: Evidence From a Post-Course Survey Study in Japan

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Abstract: Online learning methods in a variety of forms have been used for many years. However, the key difference between teaching conventional courses and emergency online courses necessitated by the global health crisis (Hodges et al. 2020) is the speed and urgency with which transition is expected to take place and the effect of other social and psychological factors on this process (Green et al. 2020). Studying under these conditions influences students’ motivation to complete and turn in course-related assignments, especially newly enrolled freshmen taking L2 online courses. The aim of this qualitative study is to examine various factors influencing Japanese college freshmen’s (n=80) motivation when completing graded online assignments as part of asynchronous English reading courses held during the COVID-19 pandemic. The post-course survey of students from three separate classes was used to capture a detailed panorama of learner motivation. Results from an inductive content analysis of responses indicated that higher levels of motivation were strongly associated with assignments that facilitated learner autonomy, social interaction, personal interest, and practical utility of the task. Conversely, demotivation appears to be strongly associated with assignments reinforcing the perception of high difficulty, personal inefficacy, and cognitive overload.

Keywords: Online assignments, instructional design, learner motivation, COVID-19, Japanese college freshmen.

INTRODUCTION

Students’ attitudes toward online learning are closely related to intrinsic motivation to satisfy curiosity and extrinsic motivation to engage with the course material (Kim and Frick 2011). Thus, they suggest that the instructional design of self-directed online learning environments can play an important role in enhancing learners’ experiences (Ferrer et al. 2020). Given that instructional strategies are key for stimulating student motivation and engagement during online learning, previous studies suggested that online assignments should (1) provide learners with relevant and useful content, (2) incorporate multimedia presentations with hands-on and real-world activities, (3) create collaborative learning opportunities using online communication tools, and (4) match content difficulty with the learners’ zone of proximal development (Martin and Bolliger 2018).

In addition to the design of online assignments, formative assessments conducted online through group discussions and interviews, quizzes, and tests have been positively associated with student engagement and learning performance (Dalby and Swan 2018). These findings have implications for how learners can be engaged in an online course, and the instructors’ need to design online learning environments that foster student engagement and interest. Moreover, these assignment designs and formative assessment strategies are consistent with the Attention-Relevance-Confidence-Satisfaction (ARCS) theoretical model that links instructional design and learner motivation (Keller 1987). They more generally link with the Expectancy-value theory (EVT) of motivation, suggesting that students’ expectations for success and subjective task values predict their motivation to complete a given assignment (Rosenzweig et al. 2019). Online assignments designed by teachers have a major effect on how students approach online learning. However, the nature of this interaction has not been explored qualitatively to date, in the context of L2 online learning involving Japanese freshmen, nor on the current understanding of emergency online learning during the COVID-19 pandemic. This study contributes to the empirical and the theoretical understanding of the mechanisms that link assignment design and freshmen motiva-
tion within an asynchronous online learning environment, and by accounting for environmental conditions related to the pandemic situation.

**LITERATURE REVIEW**

Over the past decade, many studies have been undertaken to examine what motivates or demotivates students to perform tasks in both online and face-to-face learning environments. Expectancy-value theory was developed to explain how individuals’ expectancies and values affect their motivation to pursue certain tasks and activities (Eccles and Wigfield 2002). According to EVT, two main factors determine students’ motivation to learn including how well they expect to perform a task and how much they value their outcome of the assignment completion (Hidi, Renninger and Northoff 2019). Self-determination theory (SDT), in contrast, posits that the attainment of autonomy, competence, and relatedness are key determinants of motivation to learn and perform tasks (Ryan and Deci 2000). It is not coincidental that SDT, with its inclination toward self-growth and personal development, has played an important role in invigorating scholarly debates on intrinsic and extrinsic motivation within the educational context. These studies show, for example, that when driven by internal rewards that are naturally satisfying, intrinsically motivated learners generally demonstrate persistence and high qualifications. When learning online, they demonstrate a deeper understanding of the course material (Hoskins and Van Hooff 2005) and exhibit lower attrition rates (Kim and Frick 2011). Autonomy plays a key role in motivating learners because of its volitional (self-endorsed) functioning (Ryan and Deci 2000). From this point of view, autonomy supports motivation and engagement by promoting personally valued interests and needs.

Another useful model to consider is the motivational design of instruction or the ARCS model (Keller 1983). This model focuses on improving the motivational appeal of instructional materials, including course assignments and tasks. The difference between this model and other theories of motivation is that ARCS uses four conceptual categories that characterise human motivation (Attention, Relevance, Confidence, Satisfaction) to develop a set of strategies to improve the motivational appeal of instruction. In terms of assignment design, this model promotes the instructional techniques that attract learners’ attention by arousing their interest and sense of the relevance of tasks at hand. For example, studies of online learning posit that during activities and assignments the engagement levels of learners who are personally interested in the topic are higher (Xie et al. 2006).

**THE AIM OF THE STUDY AND RESEARCH QUESTIONS**

The aim of the current study is to qualitatively examine various factors influencing Japanese college freshmen’s motivation when completing online assignments during an asynchronous English reading course conducted during the COVID-19 pandemic. The study was guided by the following research questions:

1. What factors influence students’ motivation and interest to work effectively on assignments in L2 emergency online courses, and which assignments are perceived as motivating?

2. What factors influence students’ amotivation and disengagement when working on assignments in L2 emergency online courses, and which assignments are perceived as demotivating?

**METHODOLOGY**

**Participants**

The current research utilised the convenience availability sample of three separate first-year undergraduate student classes (n=80), predominantly Japanese (95%), enrolled in English reading skills online courses at a large public university in Japan. There were 37 (46.3%) men and 43 (53.7%) women. Only four students (5%) were international, and none of them were native speakers of English. The students were enrolled in a fully asynchronous online course during the spring semester (May–August) of 2020, taught through the learning management feature of the Microsoft Teams application. Students who completed and returned the post-course surveys belonged to media arts, science and technol-
ogy (22.5%), humanities (32.5%), comparative culture (28.8%), Japanese language and culture (6.2%), and Chemistry (10.0%).

Procedures, Data Collection and Analysis

Due to the on-demand nature of the instruction, the word ‘assignment’ is used rather flexibly in this study to denote homework and/or classwork, depending on the time the students were completing it. Both researchers took part in the assessment of the assignments submitted by their respective groups, providing their students with detailed feedback as well as regular guidance throughout the course using the Microsoft Teams app chat and email facility. In Appendix, we present an overview of the eight assignment designs that we analysed in this study. A semi-structured post-course question guide was developed by the researchers based on motivation theories and constructs reviewed in the previous section.

The questionnaire was sent to students one week after the final grades were announced to eliminate the fear that their responses might influence instructors’ subjective end-of-course evaluation. The questionnaires were distributed in electronic format using the Microsoft Forms application, which allowed the creation of both open-ended and multiple-choice questions. The use of this format was determined by the convenience of participating in the survey using both mobile and desktop devices. Eighty out of 91 students (87.9%) have completed and returned the post-course survey. Following Silverman (2004), the collected survey responses were analysed using an inductive content analysis approach.

To ensure the reliability of the content analysis to the extent that both researchers agreed on the coding of the content of interest and applied the same coding procedure, the authors engaged in an intercoder reliability test. A total of 156 open-ended responses were analysed, producing 185 units of meaning. Ten cases involved a disagreement between the researchers when including certain units of meaning into specific categories. The test resulted in 94.6% inter-coding agreement on the analysed content. The researchers did not edit the student responses for grammatical correctness before or during the coding stage to avoid miscoding the data.

RESULTS

Q1: What factors influence students’ motivation and interest to work effectively on assignments in L2 emergency online courses, and which assignments are perceived as motivating?

Content analysis of the students’ responses identified ten themes associated with motivation and interest when completing online assignments (see Figure 1). The primary focus of the content analysis was to present the range of factors affecting students’ motivation to complete course-related assignments rather than to highlight some factors over others. These themes included learner autonomy, social interaction, personal interest in the topic, perceived practical utility, meaningful activity, self-efficacy, sense of joy and/or discovery, authentic activity, outside pressure, instructor guidance and/or feedback.

Three themes, learner autonomy, social interaction, and personal interest in the topic of assignment were more frequently mentioned by freshmen. Among these three themes, a significant number of responses, as shown in Figure 1, emphasized the Social interaction was mentioned in student responses when describing the lack of opportunities for face-to-face socialisation with peers during pandemic-induced remote learning. One response is typical in this category: ‘... because I really enjoyed talking with my friends in English, and it was an extremely rare chance for me to talk with my new friends from the University during the epidemic.’ Other students mentioned various useful aspects of online peer-to-peer learning, including: ‘They [online team members] were not from the school of science and engineering which I belong to. Thus, we could exchange information about classes in other departments.’ Another student added that ‘it was refreshing to talk to other people and do an assignment. It took a lot of time, but it was fun.’

Responses under the third most frequently mentioned theme were characterised by students’ high level of personal interest, even though some learners initially perceived these assignments as difficult or challenging. One student’s response can illustrate this sentiment: ‘I had a hard time coming up with more than 500 words for the essay, but I was able to write about something that I like, so it was much more motivating for me than just writing about something I am not interested in.’ Another student said that ‘the book Rich Dad, Poor Dad itself was interesting. I usually do not like reading assignments because it is obvious that it takes much time. However, this assignment luckily had a topic that I was interested in, so I enjoyed it.’
A more detailed look into students’ responses revealed that the online assignments, such as writing a 500-word free-style essay by comparing or contrasting two pieces of information (e.g. a favourite book, manga comics, movie, etc.), or conducting a virtual interview of classmates after reading a newspaper article were perceived as motivating by many students (see Figure 2). Students who mentioned these assignments were more likely to mention learner autonomy, social interaction, personal interest in the topic, and perceived practical utility as their primary motivators.
Q2. What factors influence students’ amotivation and disengagement when working on assignments in L2 emergency online courses, and which assignments are perceived as demotivating?

Similarly, the researchers conducted an inductive content analysis of the students’ responses to examine themes associated with amotivation and disengagement when given online assignments. Coincidentally, the analysis facilitated the identification of ten themes (see Figure 3), including perceived high difficulty of task, low self-efficacy, cognitive overload, outside pressure and/or obstacle, perceived lack of meaning and/or learning effect, lack of personal interest, unclear and/or insufficient instructions, fatigue, lack of feedback on completed assignments, and perceived lack of incentives. From these ten demotivating factors, students mentioned perceived high difficulty of task, negative self-efficacy, and cognitive overload more frequently.

For example, the perceived high difficulty of a task appears to hinder the effective completion of the task by many students. One typical student response in this context was ‘I am not very good at reading in English, and the chapter was too long for me. So, I hesitated to read and do the work.’ Many responses highlighted the low self-efficacy associated with students’ perceived lack of necessary knowledge and skills to complete an assignment: ‘I could not figure out what was What I Know by simply reading the chapter’s title that I had never seen before.’

In addition, many students complained about cognitive overload related to their perception of the excessive amount of work and time required: ‘I was reluctant to start reading the chapter due to the amount of time required to finish it and the theme of this assignment.’ Such factors as outside pressure and/or obstacle (‘It was difficult to adjust our [virtual teamwork] schedule because we watched the video lesson and read the document during the time of this class. So, we had to make the meeting time on the days we did not have other classes, such as on Sunday.’), perceived lack of meaning and/or learning effect (‘I thought the book Rich Dad, Poor Dad was not the correct option to choose to make us make the KWL Graph. That book tells us the opinion of that author, so we could not find any facts.’), lack of personal interest (‘It was least motivating for me because the [chapter of the] book Digital Minimalism had a long content [sic] and was not really interesting for me.’) have also been considered by students as demotivating.

Lastly, significantly few students believed that such factors as unclear and/or insufficient instructions (‘Actually, I thought that the instruction was not enough. When I started the assignment, I got confused and did not understand what to do.’), fatigue (‘It was a very long chapter for me. I was so tired to read, and I could not fully understand the story.’),

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Figure 3. Factors influencing demotivation to complete online assignments.
lack of feedback on completed tasks (‘However, I chose this one because there was an unclear criterion for the correct answers compared to other assignments. I wish I could learn more about why those answers were correct.’), and perceived lack of incentives (‘We had a lot of work to do, but there were not many points allocated for this assignment.’) played a demotivating role when performing a task.

As for the specific assignments (see Figure 4), notably, many respondents mentioned that reading a book chapter from Digital Minimalism, summarising its main idea, identifying key information and new vocabulary were associated with their experiences of demotivation. Less frequently, respondents mentioned the other seven assignments, including writing a 500+ word-free-style essay, watching a short YouTube video, and comprising essential questions as well as being less motivating and interesting.

![Figure 4. Assignment types perceived as demotivating.](image)

**Figure 4.** Assignment types perceived as demotivating.

The results suggest that many theories of motivation provide useful instruments to explain what kinds of instructional materials and assignments to motivate freshmen to learn online during the pandemic. In the current study, the self-determination theory’s analytical constructs have proven helpful in explaining why many freshmen find certain kinds of assignments more motivating and interesting than others. The SDT’s autonomy and relatedness constructs were particularly noteworthy in this context. This study also determined that higher levels of freshman motivation were associated with learner autonomy and social interaction. These results are consistent with the existing research on motivation in online learning in pre-pandemic situations, suggesting that online learners are more likely to exhibit motivation when they are given a certain degree of freedom over the content and pace of their learning (Abuhassna et al. 2020; Patall and Hooper 2019). Likewise, they are more motivated when given opportunities to interact and socialise with other students through virtual tasks (Hsu et al. 2019).

These results suggest that freshmen taking L2 online courses have been strongly affected by intrinsic motives when performing course tasks (Kim and Frick 2011). Thus, personal interest, enjoyment, freedom of choice, need to socialise during school closure, and social distancing have played important roles. Very few responses reflected learners’ motivation from such factors as outside pressure, grades, fear of failure. In contrast to previous research (Hartnett 2016), this study has found a relationship between the instructor’s role and students’ motivation to learn, suggesting that in the asyn-
chronous learning environment, the assignments that promote learners’ freedom of choice may be positively linked to intrinsic motivation. The researchers are of the view that at the time of major pandemic, or for that matter, any emergency of natural or socio-political character, intrinsic motivation plays a more explicit role in enhancing learners’ engagement with instructional materials and tasks.

Along with SDT, expectancy-value theory supports several key findings of this study. For example, the results are consistent with the theory that Japanese freshmen’s motivation to perform L2 online tasks was associated with their positive expectations to perform a task and how much they valued the outcome of the assignment’s completion (Hidi, Renninger, and Northoff 2019). All three forms of perceived task value (Eccles and Wigfield 2002; Trautwein et al. 2019) were strongly reflected in freshman responses, including intrinsic value, attainment value, and utility value. Compared to previous research suggesting personal relevance and utility value as more predictive of students’ motivation to perform tasks (Hulleman and Barron 2016), the current qualitative study observed no significant differences among the three forms of perceived task value. Overall, these findings are consistent with previous research indicating that personal interest in the topic and practical utility play key motivational roles in online learning (Xie et al. 2006).

Moreover, this study argues that the intrinsic value of enjoyment/interest, attainment value of self-worth, and utility value or meaningfulness of the experience are related to learners’ intrinsic motives more than to extrinsic ones. Thus, the instructional design that promotes these values may likely result in greater learner motivation and engagement. The ARCS Model of Instructional Design (Keller 1983) is worth mentioning in this context. The design of the assignments in this study and the results of the experiment were found to be compatible with the ARCS model’s four constructs (attention, relevance, confidence, and satisfaction). Because this model builds on EVT and several other theories of learner motivation, it is not coincidental that freshman participants paid closer attention to tasks that required their self-reflection or independence, or that they found tasks practical and useful. When working on assignments that were within students’ zone of proximal development their personal judgements of self-efficacy, confidence, and possibly their satisfaction were also affected.

It is important, as well, to deconstruct factors that led to freshman demotivation and disengagement. Demotivation seems to be closely related to the perceived high difficulty of tasks as well as Japanese students’ perception of inefficacy and cognitive overload, preventing their effective work on assignments. We posit that these triggers of student demotivation are closely interconnected. For example, all three could be explained by the lack of direct academic and social interventions aimed at freshmen during the first months of the study. The need for social distancing during the pandemic caused the cancellation of face-to-face freshmen orientation sessions and suspended all in-person tutoring programs.

Cognitive overload may have played a critical role in shaping students’ perception of online assignments as being excessively difficult. An overwhelming majority (75.4%) of students in the current study were enrolled in 16 or more online courses simultaneously during the spring semester. This tendency varies across academic majors, but in general, it reflects the fact that Japanese college freshmen tend to attend many classes per semester. As a result, they exhibit higher levels of fatigue (Ono 2020). Based on this finding, we suggest that the need to be simultaneously enrolled in many online courses during the COVID-19 pandemic is one of the critical elements differentiating emergency online learning from conventional online learning.

**CONCLUSION**

Based on this finding, it is crucial to apply a multi-faceted approach to the analysis of factors related to motivation when examining learner motivation in both conventional and non-conventional circumstances (such as the current pandemic or some major crisis). One approach that the authors found particularly promising is the situation-dependent explanation of motivation (Hartnett 2016; Turner and Patrick 2008). From this perspective, it is helpful not to restrict one’s approach to a simple dichotomous analysis of intrinsic versus extrinsic motivation of online task performance, but instead to consider the influence of broader sets of factors such as psychological (autonomy, utility, relevance), cognitive (information overload), social (relatedness, interaction), technological (synchronous, asynchronous), and environmental (crisis, uncertainty, isolation). Though this analytic strategy may look complex initially, it could eventually serve to calibrate instructional materials to address the learners’ motivational needs better. In sum, the findings of this study are aligned with the proposition that self-determined motivation requires ‘qualitatively differentiated learning experiences ... [that must] begin with the students, aligning what they learn (content), how they learn (processes), and the outcomes of their learning (products) with who they are’ (Hartnett 2016, p. 115). The study recommends that teachers deliberately and
extensively employ strategies to enhance the motivational appeal of instructional materials and assignments, especially during emergencies.

REFERENCES


APPENDIX

An overview of assignment design for the English reading online courses

<table>
<thead>
<tr>
<th>#</th>
<th>Module’s topic</th>
<th>Assignment description</th>
<th>Points</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Find the essential information</td>
<td>Watch a video titled “Why One Man Owns 2,371 Cell Phones” and write down fifteen 5W1H questions to find out the key information.</td>
<td>5</td>
</tr>
<tr>
<td>2.</td>
<td>Find the topic sentence</td>
<td>Please read the passage titled “A Letter to a Pet-sitter” and answer the following five questions using the online quiz.</td>
<td>5</td>
</tr>
<tr>
<td>3.</td>
<td>Find the main idea</td>
<td>Read the article “Does Japan Get Enough Sleep?” and, based on the main idea, conduct an online interview of your classmates.</td>
<td>10</td>
</tr>
<tr>
<td>4.</td>
<td>Compare &amp; contrast information</td>
<td>Write a 500+ word free-style essay by comparing or contrasting two pieces of information (e.g., your favourite book, manga comics, movie, etc).</td>
<td>20</td>
</tr>
<tr>
<td>5.</td>
<td>Vocabulary in context</td>
<td>Take a 20-question online quiz.</td>
<td>20</td>
</tr>
<tr>
<td>6.</td>
<td>Identify cause &amp; effect</td>
<td>Mini-task #1: Complete the following sentences with their likely effects. Mini-task #2: Complete these sentences with possible causes. Mini-task #3: Match the causes with their likely effects.</td>
<td>15</td>
</tr>
<tr>
<td>7.</td>
<td>Distinguish facts from opinions</td>
<td>Read chapter one of the book “Digital Minimalism”. Summarize the main idea. Identify the key information, one or two opinions and facts, and describe 2–3 new vocabulary discovered.</td>
<td>10</td>
</tr>
<tr>
<td>8.</td>
<td>Identify the order of importance</td>
<td>Read chapter one of the book “Rich Dad, Poor Dad” and complete the KWL Chart.</td>
<td>15</td>
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</table>

A Pilot Study of Using Online Collaborative Problem-Based Learning in an Undergraduate Translation Course

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Abstract: English-Chinese Translation is a required course for most undergraduate students of English major in Chinese universities, and it was taught traditionally through introducing translation theories and appreciating the translated masterpieces. With the development of machine translation technology and online translation collaboration platforms, it is urgent to guide students to be able to work in a more authentic online collaborative working environment. This article reports an online problem-based learning (PBL) model designed and implemented for the first time in delivering an undergraduate English-Chinese translation course. By doing so, we intend to familiarize students with the real-world work cycle of professional translation projects, enhance skills required as professional translators, and comprehensively cultivate students’ translation competence. This pilot study shares experience gained and lessons learned with applying PBL in an online translation course. Teaching advice and future research directions are also discussed.

Keywords: Problem-Based Learning, Online Learning, Undergraduate Education, Translation

INTRODUCTION

Translation is typically an essential course for students of foreign language studies at the tertiary level. For undergraduate students majored in English in China, English-Chinese translation is a required course series, some institutes scheduled up to four courses as required for English major. The learning objectives of the translation courses include the basic concepts, principles and standards in translation, translation methods and techniques, translation for different genre and purposes. By learning the translation theories and practices, the translation courses intend to familiarize students with translation professional ethics and norms of translator, and improve their cross-cultural communication skills ((Xue & Pan, 2012).

However, with the rapid development of machine translation and the online collaborative working platforms, the paradigm shifting of translation profession is expeditious. Translators’ work is no longer involving line-by-line translation throughout the text, instead, human translator is playing the role of collaborator with machine translation, examiner of the machine translation results, and the “contextualizer” to help address the nuances of the language and better serve the specific requests. In response to this trend and market need, some translation education programs have incorporated machine translation into the curriculum for graduate students to be career-ready (Lee SuGyeong, 2016). Yet this integration is rarely observed either in undergraduate translation education or in Chinese context, students learn translation mainly through translation theories lecturing and translated masterpieces appreciation.

In order to address this trend posts by the rapid technology development, and prepare students to be career-ready as translators, researchers in this study designed and implemented an online collaborative instructional strategy under the
guidance of problem-based learning (PBL) pedagogy, in a third-year undergraduate translation course in a Chinese university. In the following sections, we briefly reviewed the rationale of adopting PBL pedagogy and the existing studies of applying PBL in tertiary English education, followed by the theoretical framework we adopted and adapted. We then report the pilot study we conducted with students in Spring 2020, and present the online collaborative PBL translation teaching model we summarized. The experience, lessons learned, and future directions are discussed.

LITERATURE REVIEW

In this section, we review the origin of PBL and rationale of adopting PBL as the pedagogy in undergraduate English and translation classroom. Then we propose the theoretical framework of our instructional model design.

Problem-Based Learning

Problem-based learning (PBL) is an instructional strategy originated in medical education in the early 90s and recently found popular in the education domain. Different from traditional classroom that instruction is conducted in large-class, instructor-driven, lecture-based deliveries within a curriculum, which compartmentalized the content (Barrows, 2002). Barrows identified four key components of PBL: Ill-structured problems that trigger not only students’ thoughts on the cause but also the solution; Student-centered approach that allows students to decide what they need to learn; Teachers serve as facilitators and tutors, instead of traditional knowledge provider, guide students to ask meta-cognitive and gradually release learning responsibilities to students; Authenticity of problems presented to students to learn, keeping alignment to professional or ‘real world’ practice. With the four key components of PBL set forth, Savery (2006) defined PBL as an instructional approach that is learner-centered and empowers learners to conduct research, integrate theory and practice, and apply knowledge and skills to develop a viable solution to a defined problem.

An increasing number of instructors have recognized the importance of PBL and implement PBL into various courses and curricula, the evidence could be observed from PBL application in various domains and subjects in undergraduate studies, which include but not exclude to medical education, biomedical engineering (Perrenet, Bouhuijs & Smits, 2000), chemical engineering (Woods, 1996), software engineering (i.e. Córdova & Baade, 2018), and thermal physics (van Kampen et al., 2004). PBL has shown its effectiveness in the above fields, but studies also found that the connection between PBL and humanities and social studies are tenuous (Rosinski & Peeples, 2012), due to the theoretical nature of these domains. But in recent years, studies on successful PBL applications in these areas are seen in publications as well (i.e. Ulger, 2018).

Although traditionally English courses are designed to consist of reading and writing with the instructor and peer students as the only source of feedback, and the learning results contain restricted application in the real-world context. Educators and researchers have started feasible plans to implement PBL in the English education domain. Studies on applying PBL in English courses are merging as well: Persichetti (2016) applied PBL in an undergraduate English writing and publishing class and prepared students to face the shift of publishing industry from offline working condition to online editing and collaborating; Lin (2018) applied PBL in a web-based English reading class examine the impact of PBL on the participants’ English reading comprehension (RC) and to explore the participants’ perceptions of PBL. However, examples of PBL designed and implemented for translation classroom have been scares. In the current study, we intend to fill this gap.

PBL Application in Undergraduate Instruction

In terms of PBL application in course designing, many studies have reported implementing PBL as a module into undergraduate courses (i.e. biomedical engineering) (LaPlaca, Newstetter, & Yoganathan, 2001). Semester-long courses were also observed implementing PBL such as software engineering (Dunlap, 2005) and materials science (Henry et al., 2012). Through literature review, it is also observed that PBL is employed throughout an entire curriculum or program (Goodin, Caukin & Dillard, 2019), targeting facilitating students to develop the learning strategies and soft-skills for their future success.
Among subdivisions of English-related professions, translation is a highly practical and applicable subdivision. The translation profession is undergoing an inherent and unpredictable technological revolution due to the fast development of machine translation (Chang & Yamada, 2020). Although in the real world translators are required to work with clients to fulfill their needs and collaborate with others on large translation projects, students of English major focus on translation are rarely trained to serve as translators in the real world. In the translation classroom, it is typical that students are assigned to translate literature work and the instructor serves as the only reviewer of the translation work that students submitted, students’ grades of their translation courses solely assessed by the instructor’s evaluation. However in the translation profession, translation projects belong to various domains, translation tasks are typically assigned to multiple translators through online translation platforms. With the clear deadline set in the system, translators are responsible for completing the translation tasks on time and upload to the platform for grammatical error review and revision, followed by refinement and revision according to the needs of clients. With the fast development of machine translation, the major responsibility of the translator is no longer line-by-line translation, but revision and revise of machine translation. Therefore, students typically need 2-3 years of adjustment and adaptive period to be fully ready to face the fast-changing landscape of translating and become a skillful and experienced translator.

Hanney (2013) pointed out that that PBL has the potential to mirror professional practice, hence it is an effective instructional pedagogy if the learning content is designed to build long-term retention skill development (Strobel & Van Barneveld, 2009).

To respond to the rapid growth of language service industry in the era of globalization and information, and to meet the demand of translation industry for high-level, application-oriented and versatile translation talents, researchers and educators from China Translation Association and scholars of translation education have been working on reforming the training objectives and training mode of translation talents. The aim is to realize the transformation from teaching “translation abilities” to help students construct “translator competence in a collaborative way”, as well as to cultivate their “translator literacy” (Li, 2011), so as to enhance learners’ skills in problem solving, cooperative communication and critical thinking.

To cultivate “translator competence”, it is essential to examine the knowledge and technical skills which are required for translation, and these skills and knowledge are referred to as translation competence (Esfandiari et al., 2019). Multiple authors have attempted to describe the components of translation competence, PACTE Group’s research is one of them who provided a good perspective. The group considers translation competence as the underlying system of knowledge and skills required by a translator to complete a translation job, task or project (PACTE, 2003). Since many undergraduate English majors in China have not received systematic translation training, and their overall translation ability has not yet reached the standard of professional translators, Zhang & Wang (2020) proposed a model of students’ translation competence based on PACTE group’s description of components.
According to this competence structure shown in Figure 1, translation cognitive ability is the core of translation competence, which activates other sub-competencies for identifying and solving practical translation problems. Translation cognitive ability includes the ability to recognize and reconstruct semantic information in the cultural context of source and target languages, i.e., the ability to think in terms of generating translation strategies to solve problems based on a cognitive perspective. Bilingual language ability refers to the lexical, grammatical, discourse and pragmatic abilities required for communication between two languages. Specialized knowledge ability is mainly the ability to reserve and retrieve general knowledge and knowledge of relevant subject matters. Translation professionalism is comprised of translation project management, terminology management, professional identity and other abilities and awareness. Tool use ability refers to the ability of word processing, translation software application, information retrieval, etc. These five translation sub-competencies are interrelated and complementary to each other, forming a systematic organic whole. The intricacy and complexity that the process of competence cultivation is endowed with fits the definition of “ill-structured problem”, which involves working on problem that are complex, ill defined, opened ended, and realistic (Ge & Land, 2003).

**RESEARCH DESIGN AND CONTEXT**

This study was conducted with the background of coronavirus spreading in China from January to May in 2020 (Huang et al., 2020), the school system shut down temporarily, students are required to take classes online and instructors deliver class through online platforms regardless the instructional nature of the class. Given the background, the researchers designed and delivered an undergraduate online PBL course for English-Chinese Translation, to conduct a real-world translation project, familiarize students with the life cycle of translation projects and enhance their translation skills. This study provides resources to illustrate how PBL can be used when transitioning a traditional face-to-face translation course to an online problem-based learning class. The instruction model is shown as below in Figure 2.
This study took a purposeful sample of undergraduate translation major students currently enrolled in a university in central China. These 3rd year students took this course toward receiving the Bachelor of Arts degree in English with a focus on English-Chinese translation. Given the undergoing technical revolution of machine translation, students are expected to work as translators who examine the machine translation results, and make contextualized adjustment to better address the specific translation requests. To help students to be career-ready, this course design made two instructional adjustments: (1) adopting online translator collaborator working platform YiCAT\(^1\) for students to complete their course assignments, and (2) assign students real-world translation project and invite professional translation reviewers to provide students feedback.

In order to evaluate the course design and the learning results of students, we applied a mixed research methodology. We adopted Esfandiari et al. (2019)’s sub-competence framework for educating future translators to collect quantitative data, and conducted semi-structured focus group interviews with 10 student translation collaboration groups to acquire qualitative understanding. The quantitative survey aiming at measuring students’ self-assessed competences and sub-competences that are required for translation practice. It consists of 40 Likert-type (5-point, 1 = not at all satisfied, 5 = very satisfied) items to measure students’ perceptions of their translation service competences. The 40 questions could be categorized into six competences: language, thematic, intercultural, translation service provision, information mining and technological competence. Participants of this study were 60 students who took the translation course, 51 female participants and 9 male participants. The reliability and construct validity of the questionnaire was good (\(\gamma = 0.987\), KMO = 0.861). The focus group interviews with each student groups lasted for 20-30 minutes, the qualitative data was transcribed and coded, and conducted thematic analysis.

\(^1\) YiCAT is a widely adopted professional translation collaboration platform in China.
FINDINGS, DISCUSSION AND FUTURE DIRECTION

To understand which sub-competences are most nerve-wracking for students and pose as difficult problems to solve, we ranked the answers of “not at all satisfied”, “slightly satisfied”, and “moderately satisfied” for each question from highest to lowest, and the three Likert-type items that add up to more than 50% are shown below in Figure 3.

Among the 40 items relating to different sub-competences required by professional translators, there were 16 questions that received more than 50% of moderate, less and almost no satisfaction. All 16 questions could be categorized into six competence classes: intercultural (Q37, Q8, Q11, Q18), language (Q1), thematic (Q6), translation service provision (Q26, Q29, Q31), information mining (Q27, Q7, Q33, Q35), technological (Q38), and thematic (Q17). It shows that intercultural, translation service provision and information mining are the top three categories that students perceived as their weaknesses.

The goal of translation education prepares students to acquire long-lasting translation competence and prepare students for the translation profession in the future. According to Savery (2006), who proposed that the ill-structured problem can be divided into a series of smaller student-structured projects that keep the course based in real-time professional practice, the study intends to apply PBL in the English translation classroom and design an instructional model that can help preparing students for future real-world translation problems.

We coded and analyzed the data generated from the focus group interviews. The codes could be categorized into five themes: online collaboration learning experience, the usage of online translation platform, the translation challenges, understanding the feedback from the professional reviewer, and the role of instructor in the new teaching pedagogy.

In the theme of online collaboration learning experience, many students commented that conducting translation project online collaboratively with their peer teammates was a new and fun learning experience. This experience was different from most of other courses they had taken thus far, therefore left them deep impression. Students all admitted that this learning experience provided them opportunities to experience how professional translators work as a team, especially how they collaborate online by completing their assigned chapters, and kept their translation terms and genre aligned with other translators.

However, there are also a few challenges and issues revealed from the interview. First, students reported that they felt insufficiently prepared when asked to collaborate online with their teammates. Although all the students in these two class sessions studied in cohort model, namely everybody acquainted with one another, they lacked experience of col-
laborate with each other to complete a project. Moreover, when conducting the collaborative discussions, students experienced the inefficiency. As a student in Group 8 said,

We are all from the same dorm, we are too familiar with each other as friends and classmates, but when it comes to collaboration, I felt we spent too much time chatting how we want to collaborate, instead of talking about how to get the translation work done. That is why we are slower (the translation place) than other groups.

Other collaboration related issues are also reflected in other groups. Students voiced that they could not always find a time everybody was ready to discuss the pace and the progress of their translation, and assumed other team members would do the term unification work. Although in each group, one student was elected as the person in charge for their group translation project, the responsibility of the team leader remained blurred in the actual translation practice. More often than not, the team leader merely put together each translated section from all the team members into one file, without examining through the entire translated text.

Although commented as an authentic experience by students, the usage of online translation platform also projected challenges for students to complete their translation and collaboration on. YiCAT is a professional translation collaboration platform that offered free usage at the beginning of the COVID pandemic, students had no experience of using the platform and thus not familiar with its navigation and features. Therefore, quite some students expressed their frustration of locating specific functions and had to turn to their team members for help.

Students’ comments also revealed several key points in the translation project itself. The transition project was the Guide to the History of Anti-Japanese War for a local Museum students generally commented that they enjoyed the authenticity of the project, as they felt their work could be used one day by the museum, which encouraged them to play their best in the practice. However, some students also voiced they wish different types of translation projects could be provided in the future, and they could select the project they wanted to work on with team members with the same choice. Besides, how to search the appropriate terms to translate the project was found challenging for students. Many students tried to find “the most appropriate” terms for translation and waiting for the instructor to give them the green light on using these words, instead of making decision on the term choice and providing justification for their choices. This phenomenon showed students lacking of critical thinking and independent problem solving skills in translation project.

Last, facing the reviews provided by the professional reviewers, students felt lacking of thorough understanding of these comments and did not know how to revise accordingly. As a student in Group 4 said,

I know we did not do a good job in translation this section. I also read the reviewers telling us this sections was ‘not authentic’ and ‘Chinglish-like’, but we did not know how to revise it, what we submitted was of the best knowledge and capacity of my group. I wish a standard translation can be provided to us and we know.

From this quote we can see that students believed a “standard translation” could help them improving their accuracy and appropriateness of their translation. At the same time, a more precise, detailed feedback is needed for each student group, and the instructor should be responsible for elaborating the feedback for students and with students.

Learned from quantitative and qualitative data, we found that online collaborative translation instruction is a new experience for many students, which also means it challenges students in multiple ways when conducting it. When implementing the online PBL translation instruction for the second time in the near future, the following lessons should be learned. First, collaborative activities on translation learning should be designed and included for students. Students should be familiarize with the collaboration within a team, before collaborating on completing translation project directly. Second, familiarize students with the translation platform usage with small collaborative translation projects, before assigning long-lasting projects involves larger scale of collaboration. Third, multiple real-world translation projects with different genre should be provided to students and have them chose from according to their interests, instead of having all the students learning from one project. This choice based on personal preference also fit the real-world project choices of professional translators, and allow students to develop their specialty in certain genre(s). Last but not least, the course instructor should serve beyond a course instructor and organizer, but also feedback interpreter and communication facilitator between students and professional reviewers, in order for students to better experience the authentic translation working cycle with the professionals.
REFERENCES

Barrows, H. S. (2002). Is it Truly Possible to Have Such a Thing as dPBL? Distance Education, 23(1), 119-122.


Are We Making Progress? Gender Perceptions of Identity, Math, Teamwork and Social Support in Introductory Computer Science

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Abstract: Gender differences in perception and pursuit of computer science have been examined for many years and a wide variety of recommendations have been proposed to increase the number of women who engage in the field. Unfortunately, the percentage of women who obtain a bachelor’s degree in computer science remains stubbornly low, causing one to wonder how much progress, if any, we have made in our attempts to increase the appeal of CS to women. We present a current snapshot of how 120 students from eight different high schools perceive computer science based on four key metrics: identity, math, teamwork and social support. Our goal was to see if perceptions in these critical areas are equalizing between the two genders, and we discovered some encouraging signs that suggest advancements have been made. In particular, females do not see math as a barrier into CS and feel just as supported as males do by their social support system to pursue CS. However, females still need stronger identification with the field and teamwork opportunities should be more appealing to females.

Keywords: Introductory computer science, Computer science gender perceptions, Mathematics barriers, Computer science social structures, Career aspirations

INTRODUCTION

The number of women graduating with a degree in computer science in the United States has not budged much in the last fifteen years and remains stubbornly low at around 18%. The latest figures from 2017 show that only 19.1% of computer science bachelor’s degrees were earned by women (Hale, n.d.), compared to 13.6% in 1970 and a peak of 37% in 1984 (Writers, 2019). Though gender differences in computer science have been studied for many years and a wide variety of recommendations have been proposed to increase the number of women who engage in the field, one wonders if we have made any progress in these collective attempts to increase the appeal of CS to females. Numerous studies have been conducted to learn more about why women choose not to pursue CS, with wide-ranging findings that include persistence of stereotypes, barriers of accessibility, lack of confidence, and introductory courses that somehow miss the mark.

In this report we present data that provides us with a current snapshot of how 120 female and male students from eight different high schools perceive computer science based on four key metrics: identity, math, teamwork and social support. Our goal is to understand if we have made any progress in equalizing the perceptions between genders. As this high school generation is poised to be the next cohort to earn college degrees, we need to know how their collective attitudes towards CS might be changing. In analyzing the data, we found a number of encouraging results, but also areas where we must do better and where educators can make a real difference.
RESEARCH DESIGN

The data we analyzed is from pre-course surveys completed by participating students in an introductory computer science course—the Joy and Beauty of Computing (Paxton, n.d.)—during three consecutive semesters from fall 2018 through fall 2019. Students in several classes at different schools were asked to complete self-report measures regarding their attitude toward working in teams vs. working alone, the relationship between math skills and computer science, their identity or social image in relation to computer programming, characteristics of jobs that might be appealing to them, and other social factors related to computer science learning and careers. A total of 120 students from eight high schools around the state who identified as either female (n=30) or male (n=90) completed our pre-course survey.

RESULTS AND DISCUSSION

Early in the semester, students rated their agreement with 10 statements about their self-concept, beliefs, work style and sense of social support related to working with computers, using a 7-point scale (1 = Strongly Disagree, 2 = Disagree, 3 = Somewhat Disagree, 4 = Neither Agree nor Disagree, 5 = Somewhat Agree, 6 = Agree, 7 = Strongly Agree). Mean scores for males and females on these 10 questions are presented in Table 1. To facilitate analysis and discussion, each statement has been subsequently tagged as belonging to one of the following categories: Identity (ID), Math (MA), Teamwork (TW), and Social Support (SS). These categorizations are indicated in column one.

Table 1
Mean agreement of male and female students with computing-related attitude statements before jbc course

<table>
<thead>
<tr>
<th>Cat</th>
<th>Question</th>
<th>Female (n = 30) Mean Agreement (SD)</th>
<th>Male (n = 90) Mean Agreement (SD)</th>
<th>Test statistic</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>ID</td>
<td>Working with computers is part of who I am.</td>
<td>3.87 (1.41)</td>
<td>4.84 (1.48)</td>
<td>$t_{(118)} = 3.178$</td>
<td>.002**</td>
</tr>
<tr>
<td>ID</td>
<td>People like me become computer programmers.</td>
<td>3.43 (1.30)</td>
<td>4.36 (1.39)</td>
<td>$t_{(118)} = 3.189$</td>
<td>.002**</td>
</tr>
<tr>
<td>MA</td>
<td>If a math problem is too hard for me I walk away.</td>
<td>2.87 (1.33)</td>
<td>2.83 (1.36)</td>
<td>$t_{(118)} = -0.117$</td>
<td>.907</td>
</tr>
<tr>
<td>ID</td>
<td>It is very unlikely that I will get a job in computer programming in the future.</td>
<td>3.77 (1.70)</td>
<td>3.58 (1.73)</td>
<td>$t_{(118)} = -0.521$</td>
<td>.604</td>
</tr>
<tr>
<td>TW</td>
<td>Working in teams helps me solve problems quicker than when I work independently.</td>
<td>3.73 (1.26)</td>
<td>4.44 (1.53)</td>
<td>$t_{(118)} = 2.299$</td>
<td>.023*</td>
</tr>
<tr>
<td>TW</td>
<td>I do my best work when I can work alone.</td>
<td>4.80 (1.22)</td>
<td>4.59 (1.24)</td>
<td>$t_{(118)} = -0.809$</td>
<td>.420</td>
</tr>
<tr>
<td>SS</td>
<td>I am afraid that people will think it is odd or strange for me to have a job in programming.</td>
<td>2.50 (1.68)</td>
<td>2.42 (1.74)</td>
<td>$t_{(118)} = -0.214$</td>
<td>.831</td>
</tr>
<tr>
<td>TW</td>
<td>If given the choice between a group project or an independent project, I prefer group projects.</td>
<td>3.33 (1.52)</td>
<td>4.38 (1.70)</td>
<td>$t_{(118)} = 2.991$</td>
<td>.003**</td>
</tr>
<tr>
<td>MA</td>
<td>To be good in computer science you also have to be good in math.</td>
<td>4.97 (1.24)</td>
<td>4.62 (1.27)</td>
<td>$t_{(118)} = -1.294$</td>
<td>.198</td>
</tr>
<tr>
<td>SS</td>
<td>I feel supported by friends and family as I study computer science.</td>
<td>5.13 (1.14)</td>
<td>5.17 (1.38)</td>
<td>$t_{(118)} = 0.120$</td>
<td>.905</td>
</tr>
</tbody>
</table>

** p < .01
* p < .05
Identity

Table 2 displays the response rates for each Identity related question for males and females and, together with Table 1, shows that males continue to see themselves as belonging more in the world of computers than females do. Whereas 34% of males agree or strongly agree that working with computers is part of who I am, only 10% of females do. Similarly, 19% of males say that people like me become computer programmers, but only 3% of females do. The gap between females and males is smaller when asked about getting a job in computer programming in the future. The importance of “seeing oneself” as belonging in a particular field of study critically influences interest, pursuit, and persistence in that field (e.g., Dubow et al., 2016). The disconnect between how males and females envision themselves working with computers is something we can do better with. By educating girls at a young age about computing, breaking down stereotypes (e.g., Cheryan et al., 2013), removing common barriers of intimidation, and highlighting the various careers that are possible—many of which do not involve typical stereotypes associated with computer scientists—we can improve on how girls see themselves fitting into and contributing to this still predominantly male world.

Table 2
Gender views of Identity – Responses Before JBC Course

<table>
<thead>
<tr>
<th>Question</th>
<th>Group</th>
<th>Strongly Disagree</th>
<th>Disagree</th>
<th>Somewhat Disagree</th>
<th>Neither Agree nor Disagree</th>
<th>Some-what Agree</th>
<th>Agree</th>
<th>Strongly Agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>ID</td>
<td>Female</td>
<td>6.7 %</td>
<td>16.7</td>
<td>3.3</td>
<td>40.0</td>
<td>23.3</td>
<td>10.0</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Male</td>
<td>-</td>
<td>11.1</td>
<td>4.4</td>
<td>22.2</td>
<td>27.8</td>
<td>20.0</td>
<td>14.4</td>
</tr>
<tr>
<td>ID</td>
<td>Female</td>
<td>10.0</td>
<td>16.7</td>
<td>13.3</td>
<td>43.3</td>
<td>13.3</td>
<td>3.3</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Male</td>
<td>3.3</td>
<td>8.9</td>
<td>7.8</td>
<td>33.3</td>
<td>27.8</td>
<td>13.3</td>
<td>5.6</td>
</tr>
<tr>
<td>ID</td>
<td>Female</td>
<td>6.7</td>
<td>20.0</td>
<td>23.3</td>
<td>16.7</td>
<td>10.0</td>
<td>20.0</td>
<td>3.3</td>
</tr>
<tr>
<td></td>
<td>Male</td>
<td>7.8</td>
<td>26.7</td>
<td>17.8</td>
<td>21.1</td>
<td>8.9</td>
<td>10.0</td>
<td>7.8</td>
</tr>
</tbody>
</table>

Note. N=30 female and 90 male students. Each row contains the proportion (percentage) of participants who gave each response to the question. Row percentages may not add to exactly 100% due to rounding. Rows in bold font indicate questions with statistically significant mean differences between males and females.

Math

The field of mathematics is often considered to be a “masculine domain” and this belief may negatively impact females’ pursuit of STEM majors in college (e.g., Makarova et al., 2019). Studies show that students associate being good in math as a precursor to being good in computer science (e.g., Falkner et al., 2015). The results of our survey are promising in this regard on two counts as shown in Table 3. First, while a third of our female respondents agree or strongly agree that to be good in computer science you also have to be good in math, almost as many males endorsed that statement and there was not a statistically significant difference in the likelihood of this misconception between females and males. Perhaps even more encouraging is that about half of both females and males disagreed or strongly disagreed that if a math problem is too hard for me I walk away. In fact, no females agreed or agreed strongly with that statement. We know that girls are just as competent as boys in mathematics, but historically they have less confidence in themselves (e.g., Hargreaves et al, 2008). Our results suggest that females may be gaining self-efficacy in math and greater expectation that they can handle difficult problems, a finding that bodes well for the future of STEM and computer science.

We want to be careful in this discussion not to uncouple skill in math and success in computer science completely as there are unarguably many areas of CS that are highly dependent on math. However, we also believe that students should
not rule out the pursuit of computer science for the sole reason that math may not be their strongest—or their favorite—subject. We need to continue to educate students that there are many fields and opportunities within CS that do not depend highly on math, areas where they can be successful and find fulfillment in CS without being exceptionally talented in math.

Table 3
Gender views of Math – Responses Before JBC Course

<table>
<thead>
<tr>
<th>Question</th>
<th>Group</th>
<th>Strongly Disagree</th>
<th>Disagree</th>
<th>Somewhat Disagree</th>
<th>Neither Agree nor Disagree</th>
<th>Somewhat Agree</th>
<th>Agree</th>
<th>Strongly Agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>If a math problem is too hard for me I walk away.</td>
<td>Female</td>
<td>13.3</td>
<td>33.3</td>
<td>26.7</td>
<td>6.7</td>
<td>20.0</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Male</td>
<td>14.4</td>
<td>35.6</td>
<td>20.0</td>
<td>16.7</td>
<td>8.9</td>
<td>4.4</td>
<td>-</td>
</tr>
<tr>
<td>To be good in computer science you also have to be good in math.</td>
<td>Female</td>
<td>-</td>
<td>6.7</td>
<td>6.7</td>
<td>10.0</td>
<td>43.3</td>
<td>26.7</td>
<td>6.7</td>
</tr>
<tr>
<td></td>
<td>Male</td>
<td>-</td>
<td>7.8</td>
<td>13.3</td>
<td>16.7</td>
<td>35.6</td>
<td>24.4</td>
<td>2.2</td>
</tr>
</tbody>
</table>

Note. N=30 female and 90 male students. Each row contains the proportion (percentage) of participants who gave each response to the question. Row percentages may not add to exactly 100% due to rounding. Rows in bold font indicate questions with statistically significant mean differences between males and females.

Teamwork

Many believe that women are more drawn to cooperative, teamwork environments than men, but the reality is more complicated (Kuhn & Villeval, 2014). In our study, as shown in Table 4 only one in ten females agree or strongly agree that if given the choice between a group project or an independent project, I prefer group projects, but about a third of males would choose group projects. Females in our sample tended to believe that they solve problems more quickly when they work alone. Only 3% of females agree or strongly agree that working in teams helps me solve problems quicker than when I work independently, compared to 27% of males, and slightly more females than males think they do their best work alone.

If it is true that working in teams or groups is demonstrably better for engaging students and helping them learn and build confidence, as Ying et al. (2019) suggest in their research on pair programming, then we need to do a better job making this more appealing to females. One approach is to further understand the misgivings that females might have about working with others and counterbalance any deleterious effects, real or perceived. For example, perhaps in some situations working in teams on CS projects is disadvantageous for girls if boys are overbearing, dominate the workspace, and receive an undue amount of credit and attention from teachers. Teachers can help mitigate such situations by controlling the makeup of groups, creating assignments that mandate equal contributions, and consciously praising and rewarding quieter group members.
### Table 4
Gender views of Teamwork – Responses Before JBC Course

<table>
<thead>
<tr>
<th>Question</th>
<th>Group</th>
<th>Strongly Disagree</th>
<th>Disagree</th>
<th>Somewhat Disagree</th>
<th>Neither Agree nor Disagree</th>
<th>Somewhat Agree</th>
<th>Agree</th>
<th>Strongly Agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>TW Working in teams helps me solve problems quicker than when I work independently.</td>
<td>Female</td>
<td>-</td>
<td>23.3</td>
<td>13.3</td>
<td>23.3</td>
<td>-</td>
<td>3.3</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Male</td>
<td>2.2</td>
<td>10.0</td>
<td>13.3</td>
<td>26.7</td>
<td>21.1</td>
<td>16.7</td>
<td>10.0</td>
</tr>
<tr>
<td>TW I do my best work when I can work alone.</td>
<td>Female</td>
<td>3.3</td>
<td>-</td>
<td>3.3</td>
<td>33.3</td>
<td>20.0</td>
<td>6.7</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Male</td>
<td>-</td>
<td>6.7</td>
<td>8.9</td>
<td>32.2</td>
<td>30.0</td>
<td>15.6</td>
<td>6.7</td>
</tr>
<tr>
<td>TW If given the choice between a group project or an independent project, I prefer group projects.</td>
<td>Female</td>
<td>10.0</td>
<td>20.0</td>
<td>30.0</td>
<td>20.0</td>
<td>10.0</td>
<td>6.7</td>
<td>3.3</td>
</tr>
<tr>
<td></td>
<td>Male</td>
<td>5.6</td>
<td>10.0</td>
<td>14.4</td>
<td>23.3</td>
<td>15.6</td>
<td>20.0</td>
<td>11.1</td>
</tr>
</tbody>
</table>

Note. N=30 female and 90 male students. Each row contains the proportion (percentage) of participants who gave each response to the question. Row percentages may not add to exactly 100% due to rounding. Rows in bold font indicate questions with statistically significant mean differences between males and females.

### Social support

Given the critical impact that social support from family and friends has on women’s pursuit of and persistence in computer science (Wang et al., 2015; Dubow et al., 2016), the fact that almost half (46%) of the females we surveyed agree or strongly agree that they feel supported by friends and family as I study computer science is very encouraging (Table 5). This response rate is about the same for males (47%). Corroborating this sentiment, neither females or males tend to be afraid that people will think it is odd or strange for me to have a job in programming, with less than 10% of either group agreeing or strongly agreeing with that statement. As females continue to receive positive social reinforcement for pursuing studies and careers in computer science, we would hope to see an uptick in their overall numbers.

### Table 5
Gender views of Social Support – Responses Before JBC Course

<table>
<thead>
<tr>
<th>Question</th>
<th>Group</th>
<th>Strongly Disagree</th>
<th>Disagree</th>
<th>Somewhat Disagree</th>
<th>Neither Agree nor Disagree</th>
<th>Somewhat Agree</th>
<th>Agree</th>
<th>Strongly Agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>SS I am afraid that people will think it is odd or strange for me to have a job in programming.</td>
<td>Female</td>
<td>36.7</td>
<td>26.7</td>
<td>10.0</td>
<td>13.3</td>
<td>6.7</td>
<td>3.3</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Male</td>
<td>42.2</td>
<td>26.6</td>
<td>7.8</td>
<td>8.9</td>
<td>6.7</td>
<td>5.6</td>
<td>3.3</td>
</tr>
<tr>
<td>SS I feel supported by friends and family as I study computer science.</td>
<td>Female</td>
<td>-</td>
<td>-</td>
<td>3.3</td>
<td>36.7</td>
<td>13.3</td>
<td>36.7</td>
<td>10.0</td>
</tr>
<tr>
<td></td>
<td>Male</td>
<td>-</td>
<td>5.6</td>
<td>5.6</td>
<td>20.0</td>
<td>21.1</td>
<td>31.1</td>
<td>16.7</td>
</tr>
</tbody>
</table>

Note. N=30 female and 90 male students. Each row contains the proportion (percentage) of participants who gave each response to the question. Row percentages may not add to exactly 100% due to rounding. Rows in bold font indicate questions with statistically significant mean differences between males and females.
CONCLUSIONS

Our research study focused on gender perceptions in four categories that heavily influence females’ pursuit of computer science: Identity, Math, Teamwork and Social Support. The survey we administered to 120 students from around the state of Montana provides an important glimpse into current views held by students when they first enter an introductory course in computing. In some ways we see that real progress is being made. For example, even though the field of mathematics is often thought of as being “masculine” and many associate doing well in math with success in CS, our findings illustrate that females are not afraid of challenging math problems and they do not necessarily see math as a required gateway into CS. Also very positive is the result that just as many females as males feel supported in their pursuit of CS by their social support system, including family and friends. Real inroads have been made that challenge stereotypical beliefs that STEM fields are predominantly for men, and that educate the population about the importance of having women involved in the development of computing technology.

However, our research also highlights areas in need of improvement. Females are less likely than males to see themselves as belonging to the field of computer science. Persistent negative stereotypes or lack of awareness of the variety of opportunities made possible by a degree in CS may contribute to these CS identity issues for women. We can help mitigate these misperceptions by showcasing wide-ranging career opportunities, highlighting the interdisciplinary nature of CS, and providing diverse role models. These measures can be better integrated in early CS classes, but other methods should also be used to increase awareness among the high school population such as clubs, community outreach, marketing and publicity.

We were somewhat surprised at the negative view many females have of teamwork. Because teamwork can help students feel an increased sense of belonging, accomplishment, and confidence, we need to do a better job making collaborative work more appealing to females. This involves developing a deeper understanding and resolving issues about why women may be reluctant to work with others in CS contexts. Solutions might include more careful deliberation of team assignments, structure, expectations and teacher attention.

Findings about how different genders perceive critical issues that influence the pursuit of CS can inform how we make the field more attractive to a diverse population. In the future, we hope to expand this study by comparing student responses to these same questions both before and after CS courses. This will help us to determine if perceptions change as a result of engaging with the curriculum, and inform how we might enhance course experiences to improve the perception of CS for all.

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REFERENCES


AMTE’s 2021 NTLI Fellowship: Using a Framework to Teach Preservice Mathematics Teachers How to Professionally Notice within Technology-Mediated Learning Environments

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Abstract: Professional noticing of students’ mathematical thinking in a technology-mediated learning environment is a complex, but incredibly important skill for preservice secondary mathematics teachers to develop. The purpose of this study is to examine how explicitly sharing a framework for professional noticing of students’ mathematical thinking in technology-mediated learning environments and providing opportunities for practice influence pre-service secondary mathematics teachers’ engagement with professional noticing in technology-mediated environments. A pre- and post- video-based assessment was used to examine changes in PSMTs’ professional noticing as a result of engaging with the framework. The results of this study suggest that using this framework to support pre-service teachers’ development of this skill has promise, especially related to coordinating students written and spoken mathematical thinking with their technology engagement.

Keywords: Teacher noticing, Pre-service secondary mathematics teachers, Technology mediated learning, Rational functions

Effective mathematics teaching positions students’ thinking as the primary resource for making informed pedagogical decisions. The importance of professional noticing of students’ mathematical thinking is emphasized in AMTE’s Standards for Preparing Teachers of Mathematics (Bezuk et al., 2017): “well-prepared beginners commit themselves to
noticing, eliciting, and using student thinking to assess student progress in understanding the mathematics and to adjust instruction in ways that further support and advance learning toward the intended learning goals” (p. 16). Professional noticing is a complex practice that becomes more challenging with the introduction of a technology tool. Research has shown that the ways students interact with a technology tool can provide insight to their mathematical thinking and learning (e.g., Dick & Hollebrands, 2011; Trouche & Drijvers, 2010). Thus, noticing student thinking in such a context requires paying attention to not only what students say and write but also the ways they engage with the technology.

As one-to-one device classrooms and open-source technological tools became more prevalent, it is vital to carefully consider the preparation of teachers to notice in such environments. This is particularly important, as research indicates that pre-service secondary mathematics teachers (PSMTs) have difficulty describing how technology tools inform students’ mathematical understanding (e.g., Chandler, 2017; Wilson et al., 2011). Thomas et al.’s (2015) work provides evidence that providing teachers a framework to guide their professional noticing is a worthwhile strategy in non-technological contexts. Thus, we conjecture that a similar strategy would be helpful to support PSMTs’ noticing in technology-mediated learning environments. The focus of this study is to investigate the ways in which PSMTs engage in professional noticing when using a framework specific to noticing students’ thinking in technology-mediated learning environments.

BACKGROUND LITERATURE

Professional noticing (Jacobs et al., 2010) is defined as a set of often hidden pedagogical skills that includes attending to students’ strategies, interpreting their understanding, and deciding how to respond on the basis of those understandings. The practice of professional noticing is a challenging practice for all teachers, particularly preservice mathematics teachers (e.g., Jacobs et al., 2010; Krupa et al., 2017; Monson et al., 2020). This practice is further complicated when students use technology as it requires the dual and interconnected attention to students’ mathematical thinking and the ways they engage with the technology as they are learning. Our focus here is specifically the technological tools used in the teaching of mathematics.

Research has shown that student engagement with a technological tool is essential because technological tools mediate students’ sense-making (e.g., Baccaglini-Frank & Mariotti, 2010; Dick & Hollebrands, 2011). Furthermore, the ways students interact with a technology tool can provide insight to their mathematical thinking and learning (e.g., Arzarello et al., 2002; Baccaglini-Frank & Mariotti, 2010; Trouche & Drijvers, 2010). Research has demonstrated that PSMTs struggle to explicitly coordinate students’ mathematical thinking with their engagement with the technology. Lovett et al. (2019) studied how PSMTs notice students’ mathematical thinking in a technology-mediated learning environment. They indicated that the majority of PSMTs either placed more emphasis on students’ spoken and written responses than their technology engagement or they attended to students’ spoken and written responses separately from technology engagement. These findings suggest that PSMTs have trouble coordinating attending to both students’ spoken and written response, and technology engagement. A similar trend emerged for interpreting; PSMTs more frequently interpreted students’ spoken and written responses separately from technology engagement. Additionally, they found some evidence of coordination between students’ spoken and written responses and technology engagement. Such findings illuminate the potential benefit PSMTs may draw from explicit instruction on professional noticing within technology-mediated learning environments. Thomas et al. (2015) indicated that using a framework supported teachers’ development of noticing; thus, it is our aim to use a framework that supports PSMTs’ professional noticing of students’ mathematical thinking within a technology-mediated environment.

A FRAMEWORK FOR PROFESSIONAL NOTICING IN A TECHNOLOGY-MEDIATED LEARNING ENVIRONMENT

Dick et al. (2020) suggested a framework for Professional Noticing of Students’ Mathematical Thinking in Technology-Mediated Learning Environments [NITE]. Grounded in research indicating that PSMTs struggle to coordinate students’ work with technology with their spoken and written mathematical thinking (Lovett et al., 2019), NITE focuses on technology use when attending and interpreting students’ mathematical thinking. Specifically, they suggest fine-grained layers of attention and interpretation building on the noticing framework proposed by Jacobs et al. (2010) to include technology engagement while acknowledging the interrelated nature of the three noticing components. The framework (Fig. 1) separates the attention to and interpretation of students’ written or spoken responses from the attention to and in-
interpretation of students’ technology engagement to draw attention to the importance of considering and coordinating this aspect of students’ strategies, and emphasizes the necessity of vertical coordination between the components as skills of attending and interpreting are interwoven (Superfine et al., 2017).

![Diagram of professional noticing in technology-mediated learning environments](image)

**Figure 1.** Professional Noticing of Students’ Work in a Technology-Mediated Learning Environment.

**CONTEXT**

To support PSMTs in their development of the skill of professional noticing in technology-mediated learning environments, we are in the process of designing curriculum materials that use the NITE framework and video cases of secondary students. Guided by the tradition of design research in curriculum development (e.g., Clements, 2007; Cobb et al., 2003), we are engaging in cycles of refinements based on feasibility and pilot testing of the materials as they are being developed. The first lesson introduced the NITE framework. PSMTs were provided with a 3-minute video clip of a pair of students engaged in a Desmos activity in which they used sliders to explore the parameters of a quadratic function in vertex form (i.e., $f(x) = ax^2 + bx + c$). This particular clip was focused on the students’ exploration of $a$. PSMTs watched the video and then were asked to attend to and interpret the students’ thinking. Next, each of the components of the NITE and the importance of coordinating among them were discussed. PSMTs then watched the same clip again and refined their attend and interpret responses. Next, as a whole class we built upon the work of the small groups and created what we agreed were robust attend and interpret responses - fully coordinating what the students wrote and said along with the ways they engaged with the sliders to describe and make sense of their understanding of the effect the parameter $a$ has on the graph of the function. Finally, we wrapped up the lesson by sharing tips for effective attending and interpreting, and discussed how the practice of professional noticing is foundational to the 5 Practices for Orchestrating Productive Mathematics Discussions (Thomas et al., 2015) providing the bigger picture of what we were building toward across this course and others in the program.

At the time of this study, tasks for four modules had been developed and were being piloted (a total of seven modules will eventually be created). The design of these tasks was guided by our design principles for examining student practices in a technology-mediated learning environments (Dick et al., 2020). Mathematical topics included the concept of function, rate of change, and function families. In each case, PSMTs examined carefully selected video clips of pairs of students working together on technology-based tasks (e.g., Desmos, GeoGebra). The question prompts that accom-
panied the videos were guided by the NITE framework, often beginning with a focus on attending and interpreting students’ thinking and later adding other practices that build on noticing (e.g., questioning, predicting, selecting, sequencing, and connecting). For example, one of the tasks was around a Desmos activity named *Function Carnival*. PSMTs had completed the Function Carnival task in a prior lesson. Here they watched a video of a pair of students working on a portion of the activity in which they were to draw the time vs. distance traveled graph for a car that was traveling along a curvy road. PSMTs collaborated in an interactive platform (i.e., GoReact) to tag moments in the video that they thought were mathematically important given the learning goals (Fig. 2). Next, PSMTs were asked to write up their interpretations of the students’ current understandings related to the learning goals (i.e., describing qualitatively the functional relationship between two quantities by analyzing a graph, describing qualitatively the functional relationship between quantities by analyzing a simulation of their interaction, and sketch a graph that exhibits the features of a function described through a simulation of the resulting action). While only a subset of the modules were ready to be piloted at this time, additional video-based tasks were used with the PSMTs throughout the semester in similar ways. These included small groups of students working on technology-based geometry and statistics tasks.

**Figure 2.** PSMTs Collaborate to Attend to Students’ Mathematical Thinking on a Desmos Activity.

**THE STUDY**

As noted above, this study is situated within the context of a larger project that is creating a series of modules for mathematics teacher educators to use with PSMTs to examine secondary students’ mathematical practices. These materials are being created using an iterative design and refinement process guided by the design principles for examining student practices in a technology-mediated environment (Dick et al., 2020). The data presented in this study was from the first iteration of the implementation of project materials. Specifically, this study focuses on the introductory module aimed at providing PSMTs a framework that connects research to practice and provides them a lens through which they can examine student work in technology-mediated environments.

Research has illustrated that PSMTs and practicing teachers often struggle with the skill of deciding how to respond (e.g., Dick, 2017; Jacobs et al., 2010), and the skill of deciding is even more complex for a task situated in a tool-mediated learning environment. Given this complexity, we believe it is first important to understand the ways in which PSMTs attend and interpret. We aim to answer the following research question: How does explicitly sharing the NITE framework and providing opportunities for practice during a single course influence PSMTs’ engagement with professional noticing skills of attending to and interpreting students’ mathematical thinking in technology-mediated environments?
The context for this study is a course focused on teaching secondary mathematics with technology at a university in the southeast United States that occurred in Spring 2020. The earlier portion of the course was carried out in person, and the latter was carried out remotely (a mixture of synchronous and asynchronous online settings) due to COVID-19. While the transition to an online setting in the middle of the semester did change the structure of some of the course materials, it did not change the content of the course materials or plans for data collection.

Figure 3. Snapshot of the Desmos Activity.

PSMTs completed a written pre- and post-video case noticing assignment during the first and last weeks (respectively) of the course. The assessment included a video clip of students working on a task and written prompts for the PSMTs. The three-minute video clip showed a pair of students engaged with a Desmos activity that enabled the dynamic exploration of the relationship between rational functions and vertical asymptotes (Fig. 3). Prior to completing the noticing assessment and in line with the design principles, PSMTs engaged with the Desmos activity as a learner so they would have context for the video clip they would later examine. After PSMTs watched the video clip, they responded to two noticing prompts (Fig. 4). One prompt focused on attending to the students’ spoken and written mathematical thinking and engagement with the technology. The second prompt focused on interpreting the students’ understanding of vertical asymptotes. The written responses to these prompts are the data sources for this study.

1. **Describe how the students determined the location of the vertical asymptote for a rational function of the form** \( f(x) = \frac{k}{ax+b} \).

2. **Interpret the students’ current understanding of vertical asymptotes. Provide evidence from the video to support your claims.**

Figure 4. Noticing Prompts.

**Participants**

Eight of nine PSMTs enrolled in the course agreed to participate in the study. Unlike the typically female dominated population of US teachers (National Center for Education Statistics, 2020), our group of PSMTs was an even split (50% female and 50% male).
female, 50% male, 0% other). All of the eight participants, had completed at least through Calculus 2, are math majors and secondary mathematics education minors, and are preparing to be high school math teachers. The participants will be referred to using pseudonyms.

**Data Sources and Analysis**

Data included the PSMTs written responses to the prompts in the noticing assessment. We collected eight responses on the pre-noticing assessment and seven on the post-noticing assessment. The one PSMT who did not complete the post-assessment was excluded from analysis. Data was analyzed using a coding rubric (Fig. 5 and Fig. 6) designed based on the NITE framework and included four components: attending and interpreting students’ spoken and written mathematical thinking and technology engagement. To develop the coding rubric, the research team identified the mathematically significant details of the students’ exploration in the video clip according to the four components. Similar to the coding scheme used by Jacobs et al. (2010), the rubric included three levels (i.e., lacking, limited, and robust) on each of the four components in the framework. Since research indicates that the skills of attending and interpreting are interwoven (e.g., Superfine et al., 2017), we coded PSMT responses across both prompts (e.g., if a student attended in the interpret prompt, it was coded as attending). The coding rubric was refined using a broader cross-institutional sample of responses from the larger project. We used an iterative process of refinement to achieve consistent application of the codes by the entire research team (DeCuir-Gunby et al., 2011). Using the final coding rubric, the research team assigned two researchers to individually code the data and all discrepancies were discussed by the entire team until reconciled.

<table>
<thead>
<tr>
<th>Verbal Spoken &amp; Written Mathematical Thinking</th>
<th>Robust</th>
<th>Limited</th>
<th>Lacking</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>• Students recognize that only ( b ) and ( a ) affect the location of the vertical asymptote</td>
<td>Two of the bullets above</td>
<td>One or none of the bullets above or incorrect</td>
</tr>
<tr>
<td></td>
<td>• Students recognize that rather than ( \frac{1}{a} ) it is the opposite (( -\frac{1}{a} )) and explain it by saying it is one of those “weird flippy things that graphs do” or some paraphrase of this student language</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Students write ( x = -\frac{b}{a} ) (or ( -x = \frac{b}{a} )) as the location for a vertical asymptote</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Technology Engagement</td>
<td>Robust</td>
<td>Limited</td>
<td>Lacking</td>
</tr>
<tr>
<td></td>
<td>• The students change each of the sliders and watch / discuss how they do (or do not) affect the location of the vertical asymptote</td>
<td>Three or four of the bullets above</td>
<td>Two or fewer of the bullets above or incorrect</td>
</tr>
<tr>
<td></td>
<td>• The students set ( k = 0 ) so that the function is no longer rational OR they state that ( k ) has no effect</td>
<td>Exception: If one of the 3-4 includes noting that ( k = 0 ) and they are no longer looking at a rational function, it should be scored as robust.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• The students change ( b ) and then move ( a ) and notice both have something to do with the asymptote. (e.g. “I think whatever ( b ) is is your vertical asymptote, but it has something to do with ( a ) too.”)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• They test the conjecture with multiple values of ( a ) and ( b ) on the sliders</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Once they conjecture that the vertical asymptote is located at ( x = -\frac{b}{a} ) AND then test the conjecture with additional values of ( a ) and ( b ) on the sliders</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Figure 5.** Rubric for Attending to Students’ Spoken and Written Mathematical Thinking and Technology Engagement.
Figure 6. Rubric for Interpreting Students’ Spoken and Written Mathematical Thinking and Technology Engagement.

**FINDINGS**

Through comparison of the rubric levels (i.e., lacking, limited, robust) of the pre- and post-assessment, we documented level changes of PSMTs’ engagement with professional noticing of students’ mathematical thinking in technology-mediated environments. We discuss the findings (Tab. 1 for summary of results) according to the four components of the NITE framework in the rubric: attending and interpreting students’ spoken and written mathematical thinking and technology engagement.

### Table 1
Summary of PSMTs’ change in coding level from pre- to post-noticing assessment

<table>
<thead>
<tr>
<th>Attention</th>
<th>Spoken and Written Mathematical Thinking</th>
<th>Technology Engagement</th>
<th>Interpret</th>
<th>Spoken and Written Mathematical Thinking</th>
<th>Technology Engagement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Remained robust</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Improvement in level</td>
<td>3</td>
<td>3</td>
<td>0</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Same level</td>
<td>2</td>
<td>4</td>
<td>3</td>
<td>6</td>
<td>6</td>
</tr>
<tr>
<td>Decline in level</td>
<td>1</td>
<td>0</td>
<td>4</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

**Attention to Students’ Spoken and Written Mathematical Thinking**

In regard to PSMTs’ attention to students’ spoken and written mathematical thinking, three of the seven PSMTs improved from either lacking or limited to robust, one maintained a score of robust, and two PSMTs maintained a score of limited. As an example of the improvement from lacking to robust, we share Naomi’s responses on the pre- and post-assessment. On the pre-assessment Naomi (coded lacking) stated:

They started by setting a to 0 and moved b and then set b to 0 and moved a. By doing that they finally figured out that a and b are closely related when figuring out the vertical asymptote. … Eventually they realized that to find the vertical asymptote they got the equation of a/b and switch the sign.
Naomi did identify that the students arrived at a formula, but incorrectly identified the formula as divided by instead of negative divided by. Furthermore, Naomi did not explicitly discuss how the students determined that only and affect the location of the asymptote, nor did she discuss the language used by the students. This starkly contrasted with Naomi’s post-assessment (coded robust):

They set ‘k’ to 0 and moved both ‘a’ and ‘b’ to determine that the asymptote moves when sliding the slider negatively and positively. By moving the sliders ‘a’ and ‘b’ they came to realize that ‘a’ is half of ‘b’ and that determines the location of the vertical asymptote. They determined that the vertical asymptote is the variable ‘b’ divided by the variable ‘a’. … Then they came to the conclusion that the sign in front of the vertical asymptote is opposite sign of the division when they mention that they think “it’s one of those flippy thingys”. The students current understanding of vertical asymptotes is that it is variable ‘b’ divided by variable ‘a’ and the sign flipped.

On the post-assessment, Naomi correctly attended to all three details of the students’ mathematical thinking and identified the formula that the students produced, took note of the students’ language, and addressed that only and affect the location of the asymptote. PSMTs who showed improvement consistently demonstrated more detailed responses on the post-assessment; however, there was no consistent pattern of which details PSMTs included on the post-assessment but did not include on the pre-assessment.

Attending to Students’ Engagement with the Technology

When attending to technology engagement, there were five details PSMTs had to include for their response to be considered robust. None of the PSMTs were able to capture all five details in their pre- or post-assessment. However, six of the seven PSMTs showed improvement from lacking to limited or maintained a score of limited in terms of attention to students’ engagement with the technology. There were three PSMTs that improved their scores from lacking to limited. Consider Taylor as an example of a PSMT who improved from lacking on the pre-assessment to limited on the post. On the pre-assessment she did not take note of when or how the students used the technology to refine their understanding of which variables affect the location of the asymptote, nor did she comment on how the students tested their conjectures using the technology:

They knew from the graph that both a and b changed the vertical asymptote, it was just determining how they were connected. They figured out that it was b/a and then changing the sign which is the equivalent to setting it equal to zero and solving the equation, they just didn’t know to solve the equation that way.

On the post assessment, Taylor explicitly noted how the students manipulated the sliders:

At first the students didn’t think you could determine the asymptote with those numbers alone, and also thought a and b did the same thing, while moving all the sliders. When moving the sliders, they said that k didn’t move the vertical asymptote, but a and b did. Then moving only a and b sliders, one student said she thought it could be b/a because it wasn’t exactly b or a. Then, the other student noticed that 2/-4 which was b/a was -1/2 and the vertical asymptote was at ½. So, they determined it was b/a by trying it multiple times with different numbers but giving it a negative which they referred to as “one of those weird flippy thingy’s” “I would tell my friend to divide b/a=x”.

Notice how Taylor articulated how the students tested multiple values to refine their understanding. Even though Taylor did not attend to how the students changed and then moved to figure out that the vertical asymptote is determined by both and (bullet 3 on the rubric), she was the only PSMT to attend to the fact that the students continued to test their conjecture after they formulated a rule (bullet 5 on the rubric). Even though no PSMTs attended at a robust level, since Taylor was able to capture this detail, it is reasonable to conclude that PSMTs are capable of attending to technology engagement at the robust level.
Interpretations of Students’ Spoken and Written Mathematical Thinking

We did not see parallel growth in PSMTs’ interpretations of students’ spoken and written mathematical thinking as we did in their attending. Instead, three PSMTs maintained a score of limited while the remaining PSMTs regressed. PSMTs did interpret students’ understanding of the location of the vertical asymptote (i.e., \( \frac{a}{b} \)); however, continued to struggle interpreting the students’ understanding in terms of rational functions and/or setting the denominator equal to zero (Fig. 6). While it is disheartening that four students regressed in their interpretations, three of the PSMTs’ responses were considered robust on the pre-assessment. Olivia’s response typified these PSMTs’ responses that included all three details:

The students seem to have a good understanding of how to calculate the location of a vertical asymptote. … However, there are two concepts regarding vertical asymptotes that they still need to understand. They knew from experience that the answer was the opposite sign of what you would think initially, but they were unsure of exactly why... Another concept that may be absent from the students’ understanding of vertical asymptotes is why the location is only dependent on \( a \) and \( b \). Based off the video, you cannot say for sure that they know when the denominator in the function is zero, the value is undefined. Mia and Evelyn understand how to find vertical asymptotes, but not why they exist.

Although we do not know why these PSMTs regressed in their interpretations, we know that it is possible for PSMTs to interpret the students’ mathematical thinking at a robust level.

Interpreting Students’ Engagement with the Technology

In terms of interpreting students’ technology engagement, there was little evidence of growth. Five PSMTs maintained a score of lacking and one a score of limited. Logan was the only PSMT to demonstrate improvement from a score of lacking to limited. On the post-assessment Logan was able to connect the language to how the technology helped the students to their understanding of vertical asymptotes:

The students point out that they “think [the vertical asymptote] is \( \frac{b}{a} \) divided by a because -2 (b) divided by 4 (a) is \( -\frac{1}{2} \).” Although the arithmetic is correct, the numbers do not quite match what is shown on the graph. The vertical asymptote is \( \frac{1}{2} \) rather than \( -\frac{1}{2} \) but the students point out that they “think it’s one of those flippy thingies”

Common among the PSMTs whose interpretations were coded as lacking was that they either included only an interpretation of the students’ use of the technology to make sense of the “weird flippy thing” or did not mention the students’ engagement with the technology at all.

DISCUSSION AND IMPLICATIONS FOR TEACHING

Findings from this study suggest that using the NITE framework did support PSMTs’ professional noticing of students’ mathematical thinking within a technology-mediated environment; this is consistent with Thomas et al.’s (2015) findings in non-technological environments. However, it did not seem to support PSMTs on all components of the framework in the same way. For example, results show that PSMTs can develop the skill of attending to technology engagement in coordination with students’ spoken and written mathematical thinking—and the NITE framework appears to support them in their engagement with this work. Despite this encouraging finding, there was not a parallel growth in the PSMTs’ skill of interpreting technology engagement in coordination with the students’ spoken and written mathematical thinking. Our findings are consistent with the literature indicating that interpreting students’ mathematical thinking is a difficult practice (e.g., Jacobs et al., 2010) as PSMTs’ interpretations are dependent upon attending as the skills are interwoven (e.g., Superfine et al., 2017). In fact, when compared to other studies that focused on developing PSMTs’ noticing, these findings suggest the skill of interpreting in a technology-mediated environment is even more challenging than when technology is not involved.

While we cannot fully explain the lack of growth related to PSMTs’ interpretations, we share a few potential reasons for this result. It is possible that the PSMTs’ content knowledge of rational functions influenced their interpreta-
tions, which would be consistent with prior research connecting noticing to content knowledge (e.g., Dick, 2017; Dreher & Kuntze, 2015; Sanchez-Metamoros et al., 2015). While the PSMTs all had extensive prior experiences with rational functions, they were not explicitly discussed in this course. As a result, it is possible that the PSMTs’ interpretations of this particular video example is not representative of their skills as a whole. Another possible interpretation is related to PSMTs’ visions of high quality mathematics instruction, which also influences the practice of noticing (e.g., Sherin et al., 2008; Sherin, 2014). If PSMTs hold the belief that teaching should focus on imparting procedural knowledge, it follows that those PSMTs would focus on the students finding a rule for locating the vertical asymptote instead of focusing on how the students are or are not grappling with the conceptual meaning. Lastly and importantly, the COVID-19 pandemic undoubtedly influenced the PSMTs. There were multiple PSMTs that had robust interpretations of the students’ written and spoken work in the pre-assessment that regressed in the post-assessment. As the skill of interpreting demands a heavier cognitive load than attending, it is possible that the PSMTs’ emotional loads from the pandemic (e.g., stress and anxiety) interfered with their available cognitive load to interpret to the best of their ability. Specifically, we noted that the PSMTs’ responses on the post-assessment were less detailed than the pre-assessment.

**Implications for the Design of the Project Modules**

Based on the findings from this study, several important refinements to the design of the assessment and modules have been made. Given that noticing is a complex skill that develops over time (Jacobs et al., 2010) the fact that we only piloted a subset of the module materials, yet we saw growth in PSMTs’ skill of attending is actually quite encouraging. Findings here suggest that PSMTs may need more opportunities to engage with examples of students working in technology-mediated learning environments and that PSMTs’ early experiences may benefit from careful scaffolding using the language of the NITE framework. As a result, we have refined our introductory module to include an explicit example of what robust attention to and interpretation of students’ written or spoken responses and of students’ technology engagement entails. We also revised the activities to more carefully scaffold PSMTs’ noticing development throughout the modules. For example, early activities asked the PSMTs to attend to and interpret students’ spoken and written mathematical thinking and attend to technology engagement separately. Activities later in the module combine students’ spoken and written mathematical thinking and technology engagement for the skill of attending and for the skill of interpreting to emphasize the horizontal coordination that should take place (Fig. 1). In addition, we have included questions that require PSMTs to consider how interpreting students’ mathematical thinking is dependent upon the ability to attend and how these skills are interwoven (e.g., Superfine et al., 2017). We anticipate that the explicit language in the prompts, the inclusion of scaffolds, and additional experiences will benefit PSMT growth.

Finally, the pre- and post- assessments have been updated to explicitly reflect the language of the NITE framework. The original attending prompt in the pre- and post-noticing assessment stated, “Describe how the students determined the location of the vertical asymptote for a rational function of the form ?”. We originally used the term “describe” because PSMTs had not been introduced to the term “attend” prior to being introduced to the framework. Findings suggest PSMTs might not have read “describe” as equivalent to being asked to “attend”, so the prompt has been changed to read: “Attend to (i.e., describe in detail) how the students determined the location of the vertical asymptote for a rational function of the form “. We hope that this will not only clarify expectations but also support PSMTs’ recognition that any time they are asked to describe students’ thinking (regardless of the terms used in the prompt) it should be at the level of detail described in the attend components of the NITE framework.

**CONCLUSION**

Professional noticing of students’ mathematical thinking in a technology-mediated environment is a complex, but incredibly important skill for preservice teachers to develop. The results of this study suggest that using the NITE framework to support PSMTs’ development of this skill has promise, especially related to coordinating students’ attention to written and spoken mathematical thinking with their technology engagement. We hope that with further refinements to the project modules based on the findings of this study, we see similar results related to PSMTs’ interpretations.
REFERENCES


Abstract: Traditional geospatial education labs involve students and computers with geographic information systems (GIS) software analyzing existing satellite imagery and air photos spatial data on their screens. These approaches are passive and thus limit student engagement. One major advance in this field has been the adoption of drones, for acquiring data for analysis. Drones can be expensive; require training, certification, insurance; are banned in many places, and have limited flight time. An alternative to the use of drones involves using simpler hands-on approaches of kite, balloon and pole aerial photography to capture low-elevation high-resolution data. It also involves modifying, designing and creating 3D printed platforms for cameras. This paper discusses how faculty employed these technologies in the classroom and outdoors in a constructivist, tinkering and discovery approach that shifted from a computer-screen dominant model to a technology integrated, concrete method of learning that is driven by personal experiences and exploration.

Key words: geospatial technologies, 3D printing, aerial imagery, GEO STEM, Earth observation, concrete learning, kites, balloons, poles, photogrammetry

INTRODUCTION

Working with Earth observation data such as satellite imagery and air photos is an important part of remote sensing and geospatial education. However, these approaches are relatively passive and thus limit student engagement largely to the computer screen. To render geospatial education more concrete, the curriculum was revamped, supplementing computer screens with hand tools, building materials and a 3D printer. This new curriculum follows a constructivism design, where students build and test their own lift platforms outside to acquire aerial imagery. Constructivism (Piaget 1936) is “an approach to learning that holds that people actively construct or make their own knowledge and that reality is determined by the experiences of the learner” (Elliott et al., 2000, p. 256). In this new curriculum design, concrete experiences and representations make information easier to understand and readily links to students’ own prior (everyday) experiences in the domain (Goldstone & Son, 2005).

Consequently, as students are building, experimenting, and redesigning their lift platforms, tinkering also comes into play (Boon, 2006). “Tinkering is exploring through fiddling, toying, messing, pottering, dabbling and fooling about with
a diverse range in things that happen to be available in a creative and productive pursuit to make, mend or improve” (Bianchi & Chippindall 2016, p. 3).

This geospatial education revamping effort began when a GIS professor with the support of the Hicks Honors College, partnered with two educational technology professors in the College of Education to design and run an experiential learning class focused on hands-on concrete learning, or GeoSTEM. This new class and curriculum design included deliberate play, tinkering, outdoor education/field work, discovery, and the joy of creating and testing new and unique constructions. A key objective was to get students to produce their own useful content: actionable Earth observation and imagery data.

The GIS professor was already experienced with capturing aerial imagery using drones, kites, balloons and poles as well as processing that imagery using photogrammetry software. He included students in previous kite aerial photography sessions using research-grade equipment, not student-built materials. The educational technology professors were experienced in constructivism, instructional design, 3D printing and concrete learning. After several discussions, a new course was designed and proposed to the Dean of the Hicks Honors College at the University of North Florida. That dean was keen on supporting experiential learning and agreed to offer this experimental course and to purchase some of the supplies. The Dean’s Office in the College of Business, where the GIS professor works, also purchased supplies. The professor also brought equipment purchased with previous teaching and research grant funds. The educational technology professors assisted with design and 3D printing of lift platforms and other associated needs.

The application of strategies of Experience, Hands-on, Take Apart, Mechanical, Tinkerer, and Visual/Spatial are also closely related to the retention of students in engineering, and research has shown that visual-spatial ability is highly correlated to success in science (Baker & Krause 2007). Additionally, this new design integrates outdoor teaching. Outdoor education has a positive impact on a number of outcomes; including changes in self-concept, self-confidence and locus of control. These outcomes seem not only to be retained over time but to increase still further and are more effective with adult-age participants (Cason & Gillis, 1994; Hattie, Marsh, Neill, & Richards, 1997). Other studies have shown that innovative outdoor field work “can contribute powerfully to student achievement” (Munge et al., 2018, p.48). We expected these strategies to produce positive learning outcomes while also boosting interest in geospatial applications.

KITE AERIAL PHOTOGRAPHY

The class met in the STEP (Solve, Tinker, Explore and Play) Lab, an open and configurable space in the College of Education and Human Services. It contained plenty of working tables, tools, supplies and of course, 3D printers. Students began by building kites out of plastic material, wooden dowels and tape using web-based kite designs to be used as lift sources for remote sensing. The first model was a sled kite made from garden leaf bags and 3/16” dowel rods (see figure 1 for an image of the Tyvek kite under construction). The design is simple, and students worked it out fairly quickly, cutting the spars to the right length and taping them in place. Figuring out the bridle and how to attach it took a bit longer. As soon as the students completed this kite, they tested it outside in an area behind the building (they were provided kite spools with appropriate line).
In addition to flying their lifting devices on campus, students tested these kites at a nearby beach. Given that the beach is usually windy enough to fly kites, most students flew theirs high and steady, and were quite pleased with their results. Nevertheless, as the students tested these kites, they found that this design did not provide enough pull to lift the heavier camera and platform setups. Some also found spar issues with the thinner dowels breaking with a strong wind, so thicker spars were needed. From this they deduced that they needed larger kites with more lifting capacity.

Their final kite build was a classic diamond design, a Hata fighter kite, a “foolproof flier” (Into the Wind 2019). In this iteration, students examined the provided 2’3” x 2’0” kite model and then used that to design their own using ripstop nylon fabric kite, and either hand sewed or used a sewing machine, rather than tape, to not only sew the edges but to create pockets to hold the spars. They were able to properly measure, cut and bend the cross spar and sew on a tail using scraps from the ripstop nylon. These kites flew very well, even on campus. While the tail added stability, students learned the necessary flying skills to pull and ease out on the line to make it move and “fight” (see Figure 2 for an image of students outside testing their hand-built lifters). These kites also proved too small to lift a payload (camera); again, a larger size would be needed, but finding the ripstop material for these bigger designs was difficult and cost-prohibitive. The foolproof characteristics of this kite gave the students a sense of achievement.
Figure 2. Students flying and testing the lifting ability of the kites they constructed on campus.

3D Printing

After students understood how kites worked, they moved onto 3D printing. Websites such as Thingiverse.com, Instructables.com, PublicLab.org and Kaptery.com provided 3D designs for camera platforms to use in kite and pole aerial photography. The basic design for the kite camera housing involved a frame for attaching the camera, held up by a picavet, which is a cross-shaped piece to which the kite string attaches at four holes (see Figure 3) and then auto-balances itself like a marionette. This stabilizes the camera even while the kite is moving. Students experimented with a variety of 3D printed picavets, from simple cross structure to more complicated designs. One thing they noted was that the plastic holes that held the kite string were not effective, causing too much friction which affected the stabilization of the platform. Modifying these models by adding eye bolts greatly improved the Picavet control.

Figure 3. Student 3D printed picavet that also used eye bolts.
Regarding the perspective of acquired images, students found that their 3D printed camera housing platforms worked well for attaching GoPro cameras and capturing imagery (see Figure 4), however, the view depended on the location the camera was facing. To overcome this and enhance perspectives, students were then provided with thin aluminum camera frame kits from Brooxes.com. These kits included the frame and picavet, but more importantly, a servo motor and a controller (Gentles click pan pro) to pan the camera as it flew (see Figure 5). This allowed photography from all four cardinal directions (see figure 4 for an image of the aluminum housing). The servo motor did require some modification, which involved drilling and replacing hardware, and this enhanced student learning and their ability to use tools.

![Figure 4. Student 3D Printed Picavet Camera Housing.](image1)

![Figure 5. Purchased Metal Picavet Camera Housing With a Servo Motor and Pan Control Device.](image2)

With their new Brooxes frames, students were able to fly during a particularly windy day with a research-grade kite and a GoPro camera to acquire imagery from the central part of campus. Curious onlookers stopped and talked to the students, even as one got his kite line stuck in a tree but worked methodically to untangle it and continue the flight. This resulted in actionable data, showing some of the buildings on campus, along with a lake and natural areas (see figure 6 for the kite captured campus image), as opposed to repeated images of the open field adjacent to the classroom.

![Figure 6. Picture Taken of Campus by Students Using Kites as Lifting Tools and Metal Picavet for Camera Mount.](image3)
Balloon Aerial Photography

The next project was a natural transition from kites. Students already had their camera rigs (Brooxes frame with the panning features) and now just needed a balloon strong and steady enough to raise the rig. The first approach involved filling mylar emergency sleeping bags with helium. These thermal survival blankets (metalized plastic sheets) came already sealed into the shape of a sleeping bag, with one large opening. The Physics Department provided the helium, and students were able to fill two bags as well as test the lifting ability of their camera payloads. Back in the STEP Lab, students used a plastic cup and handfuls of nickels to determine the lifting force of the balloons. We found that they did not have enough lift to carry the heavier Brooxes based camera payload, but were sufficient to lift the simpler 3D printed lift platform and camera—if it was not windy.

The next step was to use a larger balloon designed for such tasks. We acquired a latex/chloroprene 5.5 foot diameter balloon from PublicLab.org. The new balloon took longer to fill and required more helium, but the lifting capacity was superior to the mylar bags. Students were able to fly in a part of campus where a new dorm was located on one occasion, as well as a newly built road that cut into a forested part of the university during another session. Location was limited though as the balloon was too large to fit in any standard vehicle. By the next day, the lifting capacity diminished due to loss of helium, and the balloon would no longer raise the camera housing. However, it would lift a simple and light 3D frame with a GoPro camera, and we (professors) used this setup (see Figure 7 for an image of the helium balloon) to acquire imagery over a second new road being built on the other side of campus. By the third day, the balloon was no longer usable because of the helium loss through the skin of the balloon.

Figure 7. Using a helium balloon as the lifting tool with the student 3d printed picavet.
Pole Aerial Photography

Imagery acquisition was easier and faster this time. Online, students found and printed a 3D design to attach a Go-Pro camera to an extendable paint pole with a metal thread at the end (see Figure 8 for an advanced example designed to carry four cameras or GoPro spherical camera). Each student printed their own with the assistance of the educational technology faculty. With the GoPro camera attached to the pole, students were instructed to find statues on campus and take 360° photos of them. They started at the bottom of the figure, taking pictures as they moved around the statues. They repeated this process for the middle and top of the statues and later processed their work into 3D models using DroneDeploy software.

Figure 8. 3D printed pole mount with camera.

Another project involved extending the pole to its full 12’ length and then walking the perimeter of a fenced-in construction area to later create an orthomosaic image. Another student captured aerial video of one of the gardens on campus. On another occasion, students drove along one of the new roads, capturing imagery during the construction phase (see Figure 9 of a pole aerial image captured along a newly developed road).

Figure 9. Pole mounted camera image of a new road under construction on campus.

Figure 10. Orthomosaic constructed map of beach area showing elevation through color.
RESULTS

This class proved successful in meeting its educational objectives, but students exceeded the objectives. This was determined by one simple measure: students repeatedly stayed after class for an hour or two to work on their projects and test out their new creations [tinkering and deliberate play (Boon 2006, O. Varol, personal communication, January 7, 2021)]. Students discovered that they could personally construct and modify their own remote sensing lifting platforms and then use the data collected in various applications. Students expressed how much fun they had with the design and construction projects and how they also enjoyed being outside. One biology student mentioned that during all her biology/environmental classes she had taken, students went outside only once, which is a problem noted in many STEM fields (National Research Council 2012, Winn, Stahr, Sarson, Fruland, Oppenheimer & Lee 2005, Jones 2010). This lack of applied experience is something that needs to be addressed in courses. While traditional classroom lecture, textbook reading, and laboratory experiments are cost and time efficient, this may not be enough to develop in-depth conceptual understanding. Application of concepts in experiential, real-life outdoor contexts between the field and the classroom results in memorable, comprehensive, and long-term learning (Barlow, 2015; Breunig, Murtell, & Russell, 2014; Thornburn & Marshall, 2014).

The imagery that students acquired with the GoPro cameras using kites, balloons and poles were processed using photogrammetry software such as DroneDeploy or Pix4D. This was possible because the GoPro cameras have both a built-in GPS to georeference the photos, and an intervalometer, which takes pictures at set times, such as every 5 seconds. The specialized software then processes and stitches all the photos, just like it does for drone-generated imagery, to produce final products such as orthomosaics, vegetation health maps, elevation and 3D models (see Figure 10). This was also possible because the software manufacturers provided a trial version that allowed students to process the imagery gathered during the semester. On some occasions professors used the student georeferenced photos with their licenses to process data so that students could see what the endgame was about—creating a historical imagery dataset of campus and nearby locations that could be used to track land-use and land-cover change, a key theme in geospatial (GeoSTEM) education.

From what was learned with the students in this class, future students will construct fewer kites, start with larger ones and sew them, rather than tape them when possible. Additionally, there is a planned project to construct their own camera sensors using Raspberry Pi computers and programming them with basic Python coding. These small sensors will not only decrease the payload but will add to the student building competencies. Another project will involve adding GPS data loggers to georeference acquired imagery. Other possibilities include cross listing or co—teaching the class with an environmental sciences course where students build their lift platforms and sensors to collect applied environmental science data.

REFERENCES


Integrating Mathematics in Science Instruction: Perceptions of In-service Middle School Science Teachers

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**Abstract:** Teachers’ attitudes and perceptions significantly contribute towards students’ academic success and career choices. The purpose of this study is to explore sixth grade in-service Earth Science teachers’ attitudes and perceptions about integrating mathematics in science education, and to understand the usefulness, appropriateness, and feasibility of such an initiative. Using a qualitative approach, sixteen Earth Science teachers were interviewed about using math concepts in an Earth Science unit plan. Results revealed that most teachers agreed about the usefulness and appropriateness of integrating mathematics knowledge to teach Earth Science, but differed in their views of the feasibility of such an approach. This study has implications for researchers, policymakers, teacher educators, and practitioners interested in supporting efforts to integrate mathematics into science courses.

**Keywords:** Science teachers, mathematics integrated science lessons, in-service teachers, teacher’s perceptions.

**INTRODUCTION**

Developing connections in the subject areas of science, technology, engineering, and math (STEM) has been recommended by research (Common Core, 2011; National Research Council [NRC], 2012) to improve students’ attitudes and achievement. The American Association for the Advancement of Science ([AAAS], 1993) further highlighted the importance of integrating subject areas on three premises: (a) *integrated planning* of curriculum by encouraging collaborations among STEM teachers across grade levels; (b) *interconnected knowledge* to signify and highlight the relationships among and between science, mathematics, and technology; and (c) *coherence* so that students’ experiences add up to more than a collection of miscellaneous topics (p. 320). Integrating science and mathematics instruction might help in improving science education as science involves mathematics, and both subjects involve process skills (Furner & Kumar, 2007). Although integration of disciplines has long been recommended by researchers, there is little known about teachers’ readiness to integrate, and the usefulness, appropriateness, and feasibility of such an initiative. This report examines in-service teachers’ attitudes and perceptions about integrating the two disciplines.
Theoretical Framework

Why integrate? The Benchmarks for Science Literacy (AAAS, 1993) highlighted the significance of integrating STEM disciplines and stated, “...the ideas and practice of science, mathematics, and technology are so closely intertwined that we do not see how education in any one of them can be undertaken well in isolation from the others” (pp. 321–322). The eight practices reported as essential for all students to learn in the Framework for K-12 Science Education (NRC, 2012) included “Analyzing and interpreting data” and “Using mathematics and computational thinking” that further illustrate the commonalities between science and math. From the national standards-based documents and literature (Common Core, 2011; NRC, 2012), it is clear that integration of science and mathematics is a step in the right direction towards improving student achievement. Several methods courses that were developed to integrate mathematics and science were in response to these recommendations (Austin, Converse, Sass, & Tomlins, 1992; Foss & Pinchback, 1998; Haigh & Rehfeld, 1995; Lonning & DeFranco, 1994).

Importance of Teachers’ Beliefs and Attitudes in Integrating. Teachers’ attitudes and perceptions influence their teaching style, use of resources as well as their classroom establishment. Teachers’ attitudes and perceptions are often passed on to their students through their teaching (Barnyak & Paquette, 2010) and can have a significant impact on the educational experiences and opportunities for students (Reeves, 2002). Since teachers’ attitudes and perceptions influence not only students’ motivation to learn but also the entire environment in which they learn (OECD, 2009), numerous studies focused on studying them (National Reading Panel, 2000; Kher & Burrill, 2005). Some available research reported obstacles in integrating science and mathematics education that included teachers’ perceptions and attitudes among them (Berlin & White, 2012). Understanding these obstacles can provide teachers and policy makers a deeper insight into the efforts and resources needed for successfully integrating the two disciplines.

Present Report

A group of researchers from a public university in the US in the field of Computer Science, Geology, Instructional Technology, and Math Education created a unit plan for sixth grade Earth Science integrating mathematics and computational thinking (CT). This unit plan was a part of the bigger project to implement math integrated science lessons in all middle grades science courses. This effort begins with sixth grade Earth Science to develop relationships with schools, to formulate a baseline of students’ math abilities, and to develop realistic expectations for developing higher grade unit plans.

An instructional unit plan was prepared for an Earth Science concept—Plate Tectonics: Earthquakes—that involved incorporating mathematics and CT aligned to integrated planning, interconnected knowledge, and coherence (AAAS, 1993). The researchers chose the topic of plate tectonics because this is something that many students and educators find relevant. The unit plan was designed for students to answer questions using sixth grade state math standards from two domains: Number System (2 of the 7 standards) and Statistics & Probability (4 of the 5 standards). The unit plan was shared with in-service Earth Science teachers.

Research Questions

The purpose of this study is to explore sixth grade in-service Earth Science teachers’ attitudes and perceptions about integrating mathematics in science education, and to understand the usefulness, appropriateness, and feasibility of such an initiative. The following research questions guided the inquiry:

1. What math concepts do teachers currently integrate in their classrooms?
2. To what extent do teachers feel confident they can successfully integrate mathematics into their Earth Science classroom?
3. To what extent do teachers indicate the integration of mathematics benefits or hinders student learning?
METHODS

Research Design: Basic Qualitative Study

The researchers designed and implemented a basic qualitative study (Merriam & Tisdell, 2016) to understand Earth Science teachers’ attitudes and perceptions related to integrating mathematics into their science teaching practice. Qualitative research is naturalistic, occurring in a real-world setting, and it involves understanding the meanings participants give to the phenomena they experience. These meanings are inextricably tied to the contexts in which experience occurs (Crotty, 1998). The researchers have assumed an interpretive stance, recognizing that “reality is socially constructed” (Merriam & Tisdell, 2016, p. 9).

Sampling and Recruitment

The researchers used purposeful sampling (Patton, 2015) to identify a sample of participants who could provide insights on the phenomenon of interest to identify school districts within 60 miles of the researchers’ university (National Center for Education Statistics [NCES], n.d.-a) and to identify the middle schools within these districts (NCES, n.d.-b). Researchers, then, emailed current middle grades Earth Science teacher participants with an invitation to participate, including informed consent documentation.

Participants

Sixteen in-service Earth Science teachers participated, and thirteen were female and three were male. Participants’ schools were situated in seven rural, three town, and six suburban locales. In 2018-2019, within the participants’ schools, the percentage of students eligible for free or reduced lunch services ranged from 26% to 93% (NCES, n.d.-a); and the percentage of 8th grade students passing the summative science exam ranged from 19% to 61%. See Table 1 for more details.

<table>
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<tr>
<th>Teacher Reference</th>
<th>Gender</th>
<th>Interview Length in Minutes</th>
<th>Locale</th>
<th>% Students Eligible for Free or Reduced Lunch</th>
<th>% 8th Grade Students Passing Summative Science</th>
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<td>54%</td>
</tr>
<tr>
<td>Teacher 6</td>
<td>F</td>
<td>70</td>
<td>Rural: Fringe</td>
<td>69%</td>
<td>34%</td>
</tr>
<tr>
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<td>Town: Distant</td>
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<td>21%</td>
</tr>
<tr>
<td>Teacher 8</td>
<td>M</td>
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<tr>
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</tr>
<tr>
<td>Teacher 15</td>
<td>F</td>
<td>74</td>
<td>Rural: Fringe</td>
<td>51%</td>
<td>19%</td>
</tr>
</tbody>
</table>

Note. Locale data and free and reduced lunch data are from NCES (n.d.-a) and pertain to the 2018-2019 school year. Data related to student performance are from the state accountability system and pertain to the 2018-2019 school year. “Passing” the summative science was determined by the percentage of students performing at the “distinguished” or “proficient” levels on the end-of-course summative science exam administered by the state.
Data Sources and Data Collection

The primary source of data for this study was in-depth interview. Secondary sources of data included a short questionnaire preceding the interview, and two archival sources about each participant’s school context.

**Interview.** The researchers explored participants’ attitudes and perceptions (Patton, 2015) using semi-structured interviews (Patton, 2015) that included twenty-one questions, eight of which explicitly addressed questions related to integrating math or computation in middle grades science. The interview questions included experience, behavior, values, feeling, knowledge, background, and demographic questions. Interviews were conducted on Google Meet platform (approx. 74 minutes each) and spoken data were transcribed for thematic analysis.

**Questionnaire.** The researchers developed a questionnaire in Qualtrics that contained a mix of 17 open- and closed-ended questions (approx. 7 minutes completion time). It served several purposes: detailing the research project and informed consent; collecting information about participants’ Earth Science classes structures and resources; shedding light on various aspects of teaching; and enabling participants to indicate their preferred interview time.

**Archival Documents.** The researchers collected archival documents for the participants’ schools to gain information such as: locale and free or reduced lunch (NCES Search for Public Schools website); school’s performance for 2018-19 (state-managed data reports); and students’ information including mobility rate, students with disabilities, English language learners, 8th grade reading level, and 8th grade performance on core summative assessments.

Data Analysis

Data analysis was an ongoing activity occurring throughout the data collection process, and team members wrote memos about evolving patterns and participated in weekly discussions of the data. The lead researcher conducted thematic analysis, an iterative process involving the organization and categorization of the interview data using codes (Braun & Clarke, 2008; Merriam & Tisdell, 2016). The lead researcher began with an initial set of codes based on the theoretical framework and research questions. After successive passes through the dataset, she reached a point of saturation, and she combined coded extracts into categories. Along the way, to support methodological rigor (Merriam & Tisdell, 2016), the lead researcher shared the emergent categories during weekly meetings with the team, providing evidence for the findings, and refining based on the group’s input.

RESULTS

Research Question 1: Currently Integrated Math Concepts

Most teachers revealed that their science instruction incorporates math concepts wherever they are applicable. Teachers with more experience with math (e.g., STEM coordinators or those who previously taught math) are using more math skills in their science instruction. Almost all teachers incorporate graphing techniques to depict the relationship between two variables, integers to understand positive and negative changes, computing using basic operations, converting between metric and American systems, and averaging techniques.

Research Question 2: Science Teachers’ Confidence with Math Integration

Teachers’ responses to this question varied. Some teachers linked their confidence directly with their students’ ability to use the required math concepts. Teachers felt confident when their students could successfully use math to carry out the scientific investigation and felt the opposite way when they found their students struggling. Teachers reported that the math concepts used in the plate tectonics unit plan were weaved in successfully and they could use integrated lessons like that where math skills go naturally with science instruction.

Teachers also revealed that they will be needing additional support in the form of covering prerequisites or introductory videos to successfully execute integrated lessons in their classes. Some teachers believe that successful integration is possible only by strong collaboration between math and science teachers, and they do rely on math teachers to explain some concepts in their science classes whenever they struggle.
Research Question 3: Benefits and Challenges of Math Integration

All teachers expressed their support for integrating math concepts in the science instruction, and its effectiveness in fostering the learning of both disciplines. Teachers emphasized that integration facilitates students in honing their science as well as math skills. Teachers found that students are engaged in science lessons when they can use something that they have learned in their math class.

One constraint for integrating math in science instruction comes from the additional preparation time needed for the integrated lessons. Moreover, time required to execute the integrated lessons depends on the readiness of the students and the class structure. Sometimes teachers need to teach or reteach the math skills, and it slows down the pace of the class. Teaching integrated lessons in classes with honors students requires less time than the general education classes, and teachers need to prepare additional materials for their honors students’ classes.

Scholarly Significance

Integration of mathematics into science concepts is an effective way to improve science education, and educators should work towards integrating whenever it is possible in the curriculum. Mathematics plays a crucial role in understanding the relationship between scientific concepts. Student motivation and engagement in meaningful learning relies on the degree to which math and science are integrated. The occasional incorporation of math concepts into Earth Science lessons has the potential to confuse students and hinder their educational experience. Students may be quick to protest learning math in a science class. These reactions leave teachers with the perception that their students, and they themselves cannot focus on math and science simultaneously. However, when math and science are regularly integrated, the response towards math from students may be drastically more neutral or positive. Educators should help students develop confidence in using math as a tool for scientific inquiry.

For reducing teachers’ planning time and efficiently managing the integrated instruction, there is a need for equipping teachers with instructional strategies, resources and access to resources. Design and implementation of integrated instruction is dependent on collaboration and teamwork among departments. Teachers need appropriate math and science content knowledge, and pedagogical strategies to handle the overlaps in content. Providing teachers with tools (i.e., charts or tables) where they can identify the correlation between state math and science standards might increase their feasibility in integrating the two disciplines. Teacher education programs should be attentive to these elements that may help allay the attitudes and perception related to feasibility of integrating two disciplines.

REFERENCES


Reeves, J. (2002). Secondary teachers’ attitudes and perceptions of the inclusion of ESL students in mainstream classes.