ENGAGEMENT IN THE INSTEP PROFESSIONAL LEARNING PLATFORM: DEVELOPING EXPERTISE TO TEACH DATA AND STATISTICS

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In this study, 82 middle and high school teachers engaged with the InSTEP online professional learning platform to develop their expertise in teaching data science and statistics. We investigated teachers' engagement within the platform, aspects of the platform that were most and least effective in building teachers' expertise, and the extent to which teachers' self-efficacy changed. Using mixed methods, we collected, analyzed and integrated multiple data sources.

Keywords: Professional Development, Data Analysis and Statistics, Online and Distance Education

Introduction

Many recognize the importance of preparing students for pathways that lead to careers in data science and statistics (DS&S) and improving data literacy for all, including individuals who do not pursue data intensive careers. However, graduates are generally underprepared in statistics and data skills (Finzer, 2013), making a career pathway in a data intensive career unattainable for many (Kwasny, 2015). This is in spite of decades long support for the inclusion of statistics and data in K-12 education (NCTM, 2000), efforts by the American Statistical Association to have guidelines and support for K-12 (e.g., Bargagliotti et al., 2020; Franklin et al., 2007; 2015), the adoption of Common Core State Standards (2010), and many state-level efforts to include DS&S in grades 6-12 (e.g., Jones, 2018). To prepare students who are data literate and ready to pursue careers requiring DS&S skills, *teachers* need to effectively integrate data experiences into an already packed mathematics curriculum, when they themselves may be underprepared to do so. In fact, teachers are often trained in programs that do not support becoming effective statistics teachers with a robust understanding of key data and statistics ideas (Groth & Meletiou-Mavrotheris, 2018; Justice et al., 2018; Lovett & Lee, 2018; Zieffler et al., 2018).

Recently, there have been some well documented large-scale professional learning experiences that have supported teachers' learning to teach statistics. The Stats4STEM online learning environment for AP statistics students (Simoneau, 2018) has a teacher training component and teacher message board to support teachers who are implementing Stats4STEM resources with students. Lee and Mojica have designed and implemented larger scale online professional learning focused on teaching statistics in grades 6-14, serving over 4000 teachers. Over multiple studies, they have found that teachers increased: their confidence to teach statistics, beliefs and practices in using real data, investigative approaches, and use of visualization tools, and developing statistical habits of mind such as attending to variability and embracing uncertainty (e.g., Lee et al., 2017; Lee et al., 2020; Mojica et al., 2018).

Our work is situated in an online professional learning experience, Invigorating Statistics and Data Science Teaching through Professional Learning (InSTEP), aimed at supporting teachers in

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developing their expertise to teach DS&S. We investigated the following research questions: *RQ1: How do teachers engage in the InSTEP online professional learning platform focused on teaching DS&S? RQ2: What portals are most effective and least effective in supporting teachers' professional growth to teach DS&S? RQ3: After engaging in the InSTEP online professional learning platform, to what extent are there changes in teachers' self-efficacy to teach DS&S?*

Theoretical Framework

Over four years, the NSF-funded InSTEP project designed and implemented an online professional learning platform to support 6-12+ grade teachers in developing expertise to teach DS&S. We see the InSTEP online professional learning platform as an affinity space (Gee, 2005), where teachers with diverse experiences and backgrounds engage with the space to build their expertise and learn about innovative approaches to teaching DS&S. An important component of an affinity space is its content, or *generator*, which is the InSTEP platform itself. Teachers engage with the content and possibly each other through *portals*. While the InSTEP platform can also be viewed as a portal since this is where teachers acquire resources and tools, portals can also be subspaces of the larger space. Examples of portals in the InSTEP platform include engagement with data investigations, discussion forums, microcredentials and individual resources or tools. Other important aspects of an affinity space are the *internal* grammar, the way the space is designed and organized, and the *external* grammar, how individuals interact with the content or others.

InSTEP Platform Design

We believe that teachers can support students' learning about DS&S by engaging them in data investigations using a Data Investigation Process (Lee et al., 2022) and developing statistical and data habits of mind and dispositions. Thus, an emphasis in professional learning in the InSTEP platform is providing learning experiences that support developing the skills and knowledge to apply innovative approaches to teaching DS&S with data investigations. Within the platform teachers have three opportunities to learn about teaching DS&S by engaging with *data investigations*, *learning modules* and *microcredentials*. Teachers can learn at their own pace and choose any pathway that meets their goals. While teachers can choose linear pathways, the platform is designed to allow teachers to pick and choose in any order. *Data investigations* provide opportunities for teachers to engage in solving problems themselves with data by using a Data Investigation Process (Lee et al., 2022). This involves solving a problem with large, real, messy data using a technology tool. Often the tool is the Common Online Data Analysis Platform (CODAP). *Learning modules* are organized by 7 interrelated dimensions of learning environments that support the teaching and learning of DS&S, adapted from Ben Zvi et al. (2018): data and statistical practices, central statistical ideas, data, technology, tasks, argumentation and discourse, and assessment. Within each dimension, there are multiple learning modules. Modules contain *essential* and *extended* resources. *Microcredentials*, performance assessments, provide opportunities for teachers to learn and demonstrate their competency about ideas presented in data investigations and learning modules that relate to teaching DS&S.

While it is beyond the scope of this paper to discuss the design of the InSTEP platform in more detail, it is important to highlight an important aspect of the platform. A major goal is to personalize learning to support teachers' professional learning goals through customized recommendations. While the development of customization is ongoing, in our initial study, we used multiple surveys and assessments to measure teachers' expertise and confidence. We refer

to these throughout this report as personalization surveys. We created logic models to map results from these personalization surveys to provide recommendations to engage with specific content in the platform related to data investigations and resources in learning modules.

Methods

In this section, we describe our context and participants, data collection and analysis.

Context and Participants

During Fall 2022, 82 teachers participated in professional learning using the InSTEP online professional learning platform from August to December. Teachers were recruited nationally through DS&S education networks, including K-12 district and state educational professionals, educators and scholars in higher education and formal and informal networks (e.g., Messy Data Coalition). Almost 200 teachers indicated interest, and 99 teachers were selected to participate with an initial goal of 75. Eight teachers never logged in, and eight withdrew from the study. Throughout, unless otherwise noted, $n = 82$. Incentives were provided for participation in professional learning and the research activities described below.

Teachers provided demographic information when indicating their interest in participating in our study. Most were mathematics teachers (70%), 24% were science teachers and 6% were both mathematics and science teachers. About half (51%) of these teachers focused on high school, 43% focused on middle school and 6% indicated they focused on both middle and high school. Primary responsibility and years of teaching experience were only provided by 79 teachers. They were overwhelmingly classroom teachers (91%), where 5% identified as mathematics coaches/district supervisors, 3% were professional development leaders, and 1% was a college or graduate student. Teaching experience ranged from novice to very experienced, ranging from 1 to 38 years ($M = 17$, $SD = 8.25$). Over three-quarters of these teachers had not previously engaged in professional learning related to teaching DS&S.

Data Collection and Analysis

We used mixed methods to collect, analyze, and integrate multiple sources of data: post-experience survey, self-efficacy survey, microcredential responses, and interviews. All 83 teachers were invited to participate in each of these research activities.

Post-experience survey. In the final weeks of the study, 45 teachers responded to a survey to share their experiences engaging in professional learning using the InSTEP platform. They responded to 13 Likert scale questions using a 6-point or 7-point scale (very ineffective to very effective), with multiple items for each question, and 4 open-ended questions. To analyze responses related to the effectiveness of features of the platform for Likert scale questions, frequencies and percentages for each rating were calculated per item. A grounded approach was used to analyze open-ended responses, including using open coding and constant comparative methods to identify emergent themes (Glaser & Strauss, 1967; Strauss & Corbin, 1990).

Self-efficacy survey. The *Self Efficacy for Teaching Statistics (SETS) Survey* (Harrell-Williams et al., 2019) was used to measure teachers' self-confidence to teach DS&S, a 44-item survey where teachers identify their confidence to teach specific topics/tasks using a 6-point Likert scale (ranging from 1-not at all confident to 6-completely confident) aligned with the GAISE framework (Franklin et. al., 2007, Bargagliotti et. al., 2020). The instrument provides an overall score of a teacher's confidence to teach statistics and sub-scale scores that correspond to Levels A-C in the GAISE framework. Level A is considered more concrete and introduces

students to the problem-solving process, and level C is considered the most abstract with full development of statistical literacy (Bargagliotti et. al., 2020). Teachers (n = 41) completed SETS both before and after their professional learning experience using the InSTEP platform.

Initial analysis of the 44 6-point Likert scale items included calculating pre- and post-scores that corresponded to the 6-point Likert scale. These were calculated by summing each teacher's responses and dividing each sum by the number of items. Using the same procedures, sub-scale scores were also calculated for each teacher. A gain score was calculated for each teacher as the difference of post- and pre- scores for each item. Means were computed for pre-, post-, and gain scores, and a Matched Pairs t-test was conducted to test for the significance from pre- to post-.

Microcredential response. Twenty-six teachers submitted a microcredential, a performance assessment to demonstrate competency related to ideas presented in the module focused on key ideas, habits of mind and dispositions of DS&S. We analyzed one of four parts of the microcredential where teachers were asked: How do you plan to use your understanding of what statistics and data science are, especially how it is used in careers and data, as well as statistical habits and dispositions, to provide instructional support for students' learning of statistics and data science? As with the open-ended post-implementation survey questions, we utilized grounded theory, including using open coding and constant comparative methods to identify emergent themes (Glaser & Strauss, 1967; Strauss & Corbin, 1990). A data-driven codebook was also developed with definitions and examples (DeCuir-Gunby et al., 2010).

Interview. Four sets of interviews were conducted throughout the study. Three sets of interviews used semi-structured protocols: focus group interviews, individual interviews with wireframes (i.e., mock-ups of the platform), and individual interviews with the development platform, an early version of the platform. A fourth and final interview was conducted at the conclusion of the study, where 11 teachers participated in a 1-hour interview using a structured interview protocol to understand teachers' experiences using the InSTEP platform. Interviews were viewed and analyzed by summarizing the responses to each question from the interviews.

Findings

We share findings related to teachers' engagement in the InSTEP platform, portals from the InSTEP platform that were most effective and least effective in supporting professional learning, and the extent to which teachers' self-efficacy changed after engaging in professional learning.

Engagement in the InSTEP Online Professional Learning Platform

Over a four-month period, over half the teachers engaged in professional learning utilizing data investigations and learning modules. Sixty two percent of the teachers engaged with the platform for 10 hours, 54% engaged in professional learning for 20 hours, and 15% completed 30 hours of professional learning. Approximately 34 hours of professional learning were available in the learning modules at the end of the study.

Fewer teachers engaged with microcredentials. While only 32% of teachers submitted a microcredential, 46% of those who submitted (n = 26) were successful and earned a microcredential certificate of completion. Only four teachers who were initially unsuccessful receiving the microcredential certificate of completion resubmitted a response. Of those who resubmitted, 75% eventually earned a microcredential certificate of completion. A majority (81%) of microcredential responses were submitted in the final weeks of the professional learning experience; thus, a low resubmission rate may in part have been impacted by time.

Thirteen percent of teachers completed 20 hours of professional learning and earned a microcredential certificate of completion. Interestingly, no one who engaged in professional learning for only 10 hours earned a microcredential certificate of completion. For those who engaged in less than 10 hours of professional learning, only one teacher also earned a microcredential certificate of completion. Four percent of teachers engaged in 30 hours of professional learning also earned a microcredential certificate of completion.

Analysis is ongoing to examine datalogs to investigate teachers' pathways and engagement with specific resources and tools in the learning modules, as well as other features of the InSTEP platform. This will be shared in future research reports.

Impact on Teachers' Expertise to Teach DS&S

Across multiple sources of data, we examined the InSTEP platform features and opportunities to engage with data investigations, learning modules and microcredentials that were most effective and least effective in supporting teachers' development in their expertise to teach DS&S. Here we summarize themes that emerged.

Data investigations and technology tools were critical in developing teachers' expertise. Teachers identified that engaging in data investigations and using technology tools were critical in supporting them in applying what they learned about teaching DS&S to their practice. In an open-ended question in the post-experience survey, teachers were asked if there were any specific activities, frameworks, resources, or supports in the InSTEP professional learning platform that were critical in helping them apply what they learned to their practice. Data investigations were identified most frequently, followed by CODAP and/or other technology tools. Thirty-two percent of respondents indicated that data investigations, many specifically identifying the Roller Coaster Data Investigation, were essential to their learning. Twenty-nine percent indicated that CODAP and 9% identified other technology tools (e.g., Gapminder and Tuva) as being a key factor in their learning. Overall, when specifically asked about the effectiveness of data investigations on the post-implementation survey, 96% of teachers suggested that the data investigations were effective or very effective in supporting their professional learning. In interviews, teachers also indicated that engaging with data investigations and technology tools, CODAP in particular, supported their professional growth.

Engaging with microcredentials was a positive experience and opportunity to reflect. For teachers who attempted the microcredential, 65% described the experience as positive in the post-experience survey, while 26% suggested the experience was negative and 9% were neutral. In open-ended responses on this survey, 39% of teachers who attempted a microcredential indicated that doing so provided an opportunity to reflect on their practice, and 17% described the experience as a way to get feedback. In the wireframe and development platform interviews, teachers indicated that it was important for them to get feedback in their engagement with the platform. In the final interviews, over a third of teachers (36%) also indicated that the microcredentials were a tool for reflection on practice and professional growth.

An analysis of the microcredential responses where teachers were asked how they plan to use their understanding of DS&S, as well as statistical habits and dispositions, to support students' learning of DS&S provided insight into impact on their practice. In their reflections, about half the teachers who submitted a microcredential indicated that they planned or were already providing opportunities to make data relevant to their students (54%), use real (46%) and use large data (38%). While only 19% of teachers discussed engaging students in four or more of the

six phases of a Data Investigation Cycle (Lee et al., 2022), 69% reflected on engaging students in the *consider and gather data* phase. Their responses about the importance of making data relevant to students was highly connected to asking students to collect their own data. Over a third (36%), also indicated they planned to or were providing opportunities for students to *explore and visualize data*. Typically, teachers in mathematics classes emphasize the *analysis* of data (Zieffler et al., 2018). There is evidence that these teachers valued exploring and visualizing data and not just providing opportunities to select a model. Over a quarter of teachers (26%) also indicated that they would provide opportunities for students to engage with data analysis or other technology tools. Lastly, in relation to developing dispositions to support students' learning of DS&S, two dispositions emerged as being important to teachers. Thirty percent of teachers reflected that they planned to or were providing opportunities to encourage skepticism, and 30% also wanted to develop students' curiosity.

Discussion forums and playlists were less effective in supporting professional learning. Other features of the InSTEP platform were less effective in supporting teachers' professional learning. In the post-experience survey, 47% of teachers indicated that they never used discussion forums, and only 29% of teachers found them to be effective or highly effective. While teachers valued being able to save resources and tools as described above, the ability to save resources and tools to a playlist was not as highly valued. Fifty-eight percent of teachers never used the ability to save resources and tools to a private playlist, and 64% of teachers never utilized the ability to create a public playlist. Less a third of teachers rated the ability to create private and public playlists as effective or highly effective, 31% and 24%, respectively. This was surprising since during the wireframe and platform development interviews a majority of teachers indicated that they thought saving resources as a playlist would be a feature they would use. However, only a couple of teachers shared this view in the final interview which aligns with the post-implementation survey results.

Customized recommendations supported personalizing teachers' professional learning. Teachers highlighted that completing personalization surveys was an important part of supporting them in their professional growth. In the post-implementation survey, where teachers were asked about the effectiveness of the personalization surveys, 78% indicated they were effective or very effective. In the interviews, half of the teachers described using the personalization surveys as reflection tools to assess their confidence, knowledge and practice and then as a tool to reevaluate where they were at the end of their learning experience.

By our design, the personalization surveys were highly connected to recommendations provided to teachers in the platform. In the post-implementation survey, where teachers were asked about the effectiveness of the recommendations, 82% stated that recommendations were effective or highly effective. Some teachers also indicated that they used recommendations to direct their learning pathway in the platform during their interviews.

Features related to tracking progress were effective in supporting professional growth. Teachers identified several features of the InSTEP platform as being effective. In the post-implementation survey, the following features were rated by teachers as being effective or highly effective: ability to track progress within a module (using a sidebar to track individual resources and tools) (93%), ability to track progress on a Dashboard (89%), ability to earn certificates of completion (for every 10 hours of professional learning) (89%), ability to save resources (76%), and ability to view results from personalization surveys (71%). In final interviews, these features

were not directly addressed by most teachers. However, 33% of those interviewed indicated that they began their professional learning experiences using the Dashboard since they could track what had been completed and what was incomplete. In previous interviews with wireframes of the platform and the development platform, teachers overwhelming indicated that the ability to track progress within a module for individual resources and on a Dashboard was helpful.

Time is an important factor in teachers' professional learning. Teachers identified time as a factor that impacted their professional learning experience. In two of the four open-ended questions on the post-experience survey, time generated the greatest number of codes in both instances. In one instance, teachers reflected on what was missing and what supports/resources they wish had been provided. Eleven percent of teachers indicated they needed more time. In the other instance, teachers explained why they did not attempt a microcredential, and 17% of the teachers indicated that they needed more time, while 13% of teachers indicated they needed to resubmit microcredential responses. In focus group interviews, wireframe interviews and development platform interviews, time was often discussed. Teachers frequently pointed out that their time was extremely limited and that having an estimate of time needed to engage with specific resources would help them in selecting resources given any time restrictions.

Impact on Self-efficacy to Teach DS&S

We investigated the impact of the InSTEP professional learning experience by examining the mean pre-, post- and gains. Before the professional learning experience, teachers rated their overall confidence to teach statistics as somewhat confident (score of 3.38, see Table 1), and they concluded their experience between confident (score of 4) and very confident (score of 5) in their self-efficacy to teach statistics with an average gain of just over 1 Likert point (1.14 gain). All teachers, except three, improved in their confidence to teach statistics with two teachers improving their average by three Likert points. Using a matched-pairs t test, the gains in confidence between pre- and post- survey are statistically significant.

Similar trends can be seen in all three sub-scale scores. Level A had the highest pre- and post- scores with average confidence starting slightly below teachers being confident (score of 3.89) to teach Level A statistical content and ending the experience with teachers' average confidence growing to just a little below very confident (score of 4.87). Interestingly, level B and level C topics saw similar gains with an increase in 1.22 and 1.17 Likert points of confidence, respectively. Teachers began the professional learning experience slightly more than somewhat confident (3.48) and ending at an average a little below very confident (4.70) for level B content. Level C content, on average, began at a lower confidence level (just below somewhat confident, 2.92) and ended at confident to teach level C statistical ideas (4.09). However, the higher standard deviation for the gains scores at level C indicates more variability in gains by the teachers. All three sublevels had statistically significant gains when tested with a matched pairs t-test (Table 2).

Table 1: Descriptive Statistics of Likert scale items

		Pre	Post	Gains
Overall	Mean	3.38	4.51	1.14
	Standard Deviation	1.16	0.99	0.83
Level A	Mean	3.89	4.87	0.98
	Standard Deviation	1.02	0.90	0.90

Level B	Mean	3.48	4.70	1.22
	Standard Deviation	1.14	0.95	0.87
Level C	Mean	2.92	4.09	1.17
	Standard Deviation	1.39	1.26	0.98

Table 2: Matched Pairs t -Test

	Test Statistic	p-value
Overall	8.8072	6.589e-11
Level A	6.9611	2.125e-8
Level B	8.9656	4.082e-11
Level C	7.6373	2.468e-9

Discussion

We found that some portals in the InSTEP platform were more effective in supporting teachers' professional learning related to teaching DS&S than others. Engaging in data investigations, using technology tools and using microcredentials as an opportunity to reflect on practice were the most effective portals in the InSTEP platform. Teachers who reflected on their practice through microcredentials indicated they would provide or were already providing opportunities to engage students with relevant, real, large data using a data investigation process or phases of a data investigation process. This is similar to findings by Lee et al. (2017) and Mojica et al. (2018) where teachers also increased their beliefs and practices related to using real data and investigative approaches, as well as their confidence to teach statistics. In our work, teachers also significantly increased their confidence to teach statistics. Yet, other portals in the InSTEP platform were less effective in supporting learning, such as discussion forums. One surprising finding is that teachers did not value or utilize discussion forums. This is in contrast to other work on teachers' learning, where there is evidence that interactions in discussion forums supported their professional learning (e.g., Park, 2015; Revere & Kovach, 2011).

Our results have several implications for DS&S professional learning and designing DS&S learning environments. Key features that supported online learning that we identified could be used to design other online learning environments. The internal grammar, or the way we structured elements of the InSTEP platform, such as personalized recommendations and tracking features, which teachers found effective, can be applied to other professional learning contexts, whether online or not.

While we were encouraged that a little over half of the teachers engaged with data investigations and resources in learning modules for 10 and 20 hours of professional learning, those teachers were provided with monetary incentives and certificates of completion where they were able to earn professional development hours or Continuing Education Credits (CEUs). Since InSTEP is freely available to the public, we will need to find new ways to encourage engagement in the platform. Time was identified as an important factor in teachers' engagement. With the public launch in March 2023, there are no plans to close the platform. Perhaps this will provide sufficient time for teachers to engage with the platform in ways that fulfill their needs. There is also a concern about ways to increase the number of teachers who engage with

microcredentials since this involved a small subset of teachers who were receiving incentives.

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References

Bargagliotti, A., Franklin, C., Arnold, P., Gould, R., Johnson, S., Perez, L., & Spangler, D. (2020). Pre-K-12 Guidelines for assessment and instruction in statistics education II (GAISE II). American Statistical Association and National Council of Teachers of Mathematics. https://www.amstat.org/asa/files/pdfs/GAISE/GAISEIIPreK-12_Full.pdf

Ben-Zvi, D., Gravemeijer, K., & Ainley, J. (2018). Design of statistics learning environments. In D. Ben-Zvi, K. Makar, & J. Garfield (Eds.), International handbook of research in statistics education (pp. 473–502). Springer. https://doi.org/10.1007/978-3-319-66195-7_16

DeCuir-Gunby, J. T., Marshall, P. L., & McCulloch, A. W. (2010). Developing and using a codebook for the analysis of interview data: An example from a professional development research InSTEP. Field Methods, 23(2), 136-155. https://doi.org/10.1177%2F1525822X10388468

Finzer, W. (2013). The data science education dilemma. Technology Innovations in Statistics Education 7(2), 1-9.

Franklin, C., Kader, G., Mewborn, D., Moreno, J., Peck, R., Perry, M., & Scheaffer, R. (2007). Guidelines for assessment and instruction in statistics education (GAISE) Report: A Pre-K-12 curriculum framework. American Statistical Association. https://www.amstat.org/asa/files/pdfs/GAISE/GAISEPreK-12_Full.pdf

Gee, J. P. (2005). Semiotic social spaces and affinity spaces. In D. Barton, & K. Tusting (Eds.), Beyond communities of practice (pp. 214–232). Cambridge University Press.

Glaser, B. J. & Strauss, A. (1967). The discovery of grounded theory: Strategies for qualitative research. Aldine.

Groth, R., & Meletiou-Mavrotheris, M. (2018). Research on statistics teachers' cognitive and affective characteristics. In D. Ben-Zvi, K. Makar & J. Garfield (Eds.), International handbook of research in statistics education (pp. 327-355). Springer. https://doi.org/10.1007/978-3-319-66195-7_10

Harrell-Williams, L. M., Lovett, J. N., Lee, H. S., Pierce, R. L., Lesser, L. M., & Sorto, M. A. (2019). Validation of scores from the high school version of the self-efficacy to teach statistics instrument using preservice mathematics teachers. Journal of Psychoeducational Assessment, 37(2), 194-208. https://doi-org.prox.lib.ncsu.edu/10.1177/0734282917735151

Jones (February 19, 2018). Big Data classes a big hit in California high school. EdSource. https://edsource.org/2018/big-data-classes-a-big-hit-in-california-high-schools/593838

Justice, N., Zieffler, A., Huberty, M., & delMas, R. (2018). Every rose has it's thorn: Secondary teachers' reasoning about statistical models. ZDM—The International Journal on Mathematics Education, 50(7), 1253–1265. https://doi.org/10.1007/s11858-018-0953-1

Kwasny, M. J. (2015). Statistics in K–12: Educators, students, and us: Challenges and resources for K–12 educators and students. CHANCE, 28(4), 26-29.

Lee, H. S., Lovett, J. N., & Mojica, G. (2017). Characterizing impacts of online professional development on teachers' beliefs and perspectives about teaching statistics. In Galindo, E., & Newton, J., (Eds.), Proceedings of the 39th annual meeting of the North American Chapter of the International Group for the Psychology of Mathematics Education (pp. 407-414). Indianapolis, IN: Hoosier Association of Mathematics Teacher Educators. https://files.eric.ed.gov/fulltext/ED581323.pdf

Lee, H. S., Mojica, G. F., & Lovett, J. N. (2020). Examining how online professional development on teachers' beliefs and perspectives about teaching statistics. Online Learning, 24(1), 5-27. https://doi.org/10.24059/olj.v24i1.1992

Lee, H. S., Mojica, G. F., Thrasher, E. P., & Baumgartner, P. (2022). Investigating data like a data scientist: Key practices and processes. Statistics Education Research Journal, Special Issue: Research on Data Science Education, 21(2), 3. https://doi.org/10.52041/serj.v21i2.41

Lovett, J. N., & Lee, H. S. (2017). New standards require teaching more statistics: Are preservice secondary mathematics teachers ready?. Journal of Teacher Education, 68(3), 299-311. https://doi.org/10.1177%2F0022487117697918

Mojica, G. F., Lee, H. S., & Lovett, J. N. (2018). Designing spaces to support teacher learning about teaching statistics. In T. E. Hodges, G. J. Roy, & A. M. Tyminski (Eds.), Proceedings of the 40th annual meeting of the North American Chapter of the International Group for the Psychology of Mathematics Education (pp. 410-413). Greenville, SC: University of South Carolina & Clemson University. http://www.pmena.org/pmenaproceedings/PMENA%2040%202018%20Proceedings.pdf

National Council of Teachers of Mathematics. (2000). Principles and standards for school mathematics. Author

National Governors Association Center for Best Practice & Council of Chief State School Officers. (2010). Common core state standards for mathematics. Author. http://www.corestandards.org/Math/

Park, J. Y. (2015). Student interactivity and teacher participation: An application of legitimate peripheral participation in higher education online learning environments. Technology, Pedagogy & Education, 24(3), 389-406. https://doi.org/10.1080/1475939X.2014.935743

Revere & Kovach, 2011 Revere, L., & Kovach, J. V. (2011). Online technologies for engaged learning: A meaningful synthesis for educators. Quarterly Review of Distance Education, 12(2), 113-124.

Strauss, A. L. & Corbin, J. (1990). The basics of qualitative analysis: Grounded theory procedures and techniques. Sage.

Zieffler, A., Garfield, J., & Fry, E. (2018). What is statistics education? In D. Ben-Zvi, K., Makar, & J. Garfield (Eds.), International handbook of research in statistics education (pp. 37-70). Springer. https://doi.org/10.1007/978-3-319-66195-7_2