7/11/2018

Dear Matthew Koehler, Jennifer Schmidt, Lisa Linnenbrink-Garcia, and Christina Schwarz,

I am writing with a memorandum of understanding regarding the required revisions requested to my dissertation and the specific changes that I have made in response to these requests. For the revisions I describe below, I highlighted (in yellow) the portions of the manuscript to which I made substantial changes. Thank you very much again for this very valuable feedback and the opportunity to improve my work. Thank you, too, for serving on my dissertation committee.

Sincerely,

Joshua Rosenberg

**Introduction**

1. *Improve the argument for the need for this particular study. Include this powerful rationale for the study in the abstract and literature review as well as throughout the manuscript (i.e., in the need for study section).*
   1. In the introduction, I outline three reasons why work with data should be the focus of study for STEM education research. In particular, I argue work with data:
      1. Empowers learners by turning learners from consumers of knowledge to creating knowledge. In particular, I added the following sentences: “Work with data turns learners from consumers of knowledge to creating knowledge (Hancock, Kaput, & Goldsmith, 1992; Lehrer & Schauble, 2015; Lee & Wilkerson, 2018; Finzer, 2013). Practice with such work empowers learners to ask questions and to answer them with arguments and explanations that draw from data as evidence (McNeill & Krajcik, 2007). This work, then supports learners to create new knowledge in learning environments and classrooms which is an aim of recent reform efforts that cast a vision of learning that emphasizes participation in the practices of STEM disciplines (e.g., NGSS Lead States, 2013; National Governors Association Center for Best Practices, Council of Chief State School Officers, 2010).”
      2. Provides a capability that can be used across content areas, particularly in advanced coursework. I added the following sentences to the paragraph on work with data cutting across STEM domains: “Work with data provides a capability that can be used across content areas, particularly in advanced coursework. Aspects of work with data are recognized as core competencies across recent curricular documents for STEM subject area learning. They are found, for example, in the Next Generation Science Standards and the Common Core State Standards. These standards highlight the role of authentic work with data as part of engaging in scientific and engineering and mathematical practices, respectively. These capabilities may be particularly useful in STEM domains because advanced coursework in these domains often involves demanding and abstract work with data, work that may be more accessible to more learners when they encounter it earlier in their education.”
      3. Can be a relevant context for learning, apart from contexts such as robotics and coding. In the section on why this study is in outside-of-school STEM programs, I added the following sentences: “One promise of work with data in outside-of-school settings is that relevant sources of data can be inherently interesting to learners. Such sources of data can be used as a context for learning about the world, allowing youth to ask and answer personally and socially meaningful questions, whereas many outside-of-school programs are focused around commercial aims, such as developing mobile device applications.”
   2. In addition, I argue that work with data *may* be more engaging than other activities to learners by comparing it to past research on similar (laboratory) activities and to research on activities that youth perceive to be challenging, such as work with data. In particular, I added the following sentences to the introduction: “Work with data is similar to hands-on, laboratory work which research has shown to be engaging to students (Schmidt, Rosenberg, & Beymer, 2018). In addition, work with data is demanding and requires sustained effort and focus (Lehrer & Schauble, 2015; National Research Council, 2015), and past work has shown that when learners are more challenged (and competent), they are more likely to be engaged (Schneider et al., 2016; Shernoff et al., 2016).”

**Literature Review**

1. *Clarify from what sources the five aspects of work with data came from.*
   1. I connect each of the five aspects of work with data to past research. In particular, I added the following paragraph to the literature review: “Wild and Pfannkuch (1999) consider the process in terms of identifying a problem, generating a measurement system and sampling plan, collecting and cleaning the data, exploring the data and carrying out planned analyses, and interpreting the findings from the analysis. Such a process is common in STEM content areas and is instantiated in standards for some (especially mathematics) curricula. Franklin et al.’s guidelines focus on the Framework for statistical problem solving: formulating questions, collecting data, analyzing data, and interpreting results (2007). The goals of this framework and its components are similar to Hancock et al.’s (1992) description of data modeling, the process of “using data to solve real problems and to answer authentic questions” (p. 337). Hancock et al. (1992) focus in on two goals, data creation and analysis, arguing that the former (data creation) is under emphasized in classroom contexts. Scholars have subsequently expanded Hancock et al.’s definition of data modeling to include six components: asking questions, generating measures, collecting data, structuring data, visualizing data, and making inferences in light of variability (see Lehrer & Schauble, 2004, for using this conceptualization of data modeling applied to the task of understanding plant growth). The last of these components is crucial across all of the visions of data modeling reviewed here and distinguishes these processes from other aspects of data analysis: Accounting for variability (or uncertainty) is central to solving real-world problems with data and the process of data modeling.”
2. *Re-order research questions #2 and #3 on p. 17.*
   1. I made this change by re-ordering the research questions in this way.
3. *When the programs are described on p. 18, refer the reader to the appendix.*
   1. I added a sentence to refer the reader to the appendix (in what is section 3.1).

**Method**

1. *Add a coding frame for the STEM-PQA with the names of the variables, possible values (i.e., present or not present), descriptions and examples.*
   1. I added a coding frame (Table 3.3) to the method section with the names of the variables, possible values, descriptions of the variables, and examples from this study.
2. *Add a coding frame for the open-ended, qualitative coding with the themes, descriptions, and examples.*
   1. I added a coding frame (Table 3.5) with the topics for the open-ended, qualitative coding as well as descriptions of these topics in terms of what the aim of coding for these topics was.
3. *Clarify how the STEM-PQA aligns with the aspects of work with data.*
   1. I moved the alignment information from the Appendix into the text to section 3.4.2. I also added the following two sentences to better explain the alignment: “While I chose to match the five aspects of work with data to the STEM-PQA code(s) that I interpreted as aligning most closely (in the cases of generating data and interpreting and communicating findings, choosing to use two STEM-PQA items as codes), there are other ways that these could be matched. For example, in the NGSS (NGSS Lead States, 2013), asking questions highlights coming up with questions that can be answered through an investigation, whereas the STEM-PQA code used to indicate asking questions emphasizes exploring possible solutions to problems and testing hypotheses.”
4. *Report the reliability of the pre-interest measure.*
   1. I added information on the reliability of the pre-interest measure in the following two sentences to section 3.4.3: “The individual interest measure represented the mean of interest items across all relevant domains. Thus, for some students, the mean was based on 3 items, while for others it was based on as many as 9 items representing all three domains (with Cronbach alpha values ranging from .77 - .86 for each domain-specific interest scale)”

**Results**

1. *Provide more information about work with data and why it may be engaging to youth (in the abstract; on p. 38 with respect to the use of statistical and mathematical models versus the development of these models; and on p. 58 with respect to data modeling).*
   1. As noted in revision point 1B, I describe two possible reasons for why work with data may be more engaging to learners in the abstract. I also integrate these reasons into these two specific parts of the manuscript requested.
   2. In particular, with respect to the use of statistical and mathematical models, I added the following paragraph: “This type of work with data differs from descriptions of data modeling as the equations provided to youth did not often involve modeling variability, a key component of work with data (see section 2.1). Instead, when youth solved equations, there was one often correct answer that the activity leader sought to guide youth to. Additionally, using equations differed from definitions of data modeling because learners were not developing statistical models themselves, a key part of data modeling (Hancock et al., 1992; Lehrer, Kim, & Schauble, 2007; Lehrer, Kim, & Jones, 2011). Using already-created equations may be less engaging than activities that challenge youth to use and develop data models from scratch, work which may be more engaging, especially when youth perceive themselves to be good at such activities (Schneider et al., 2016; Shernoff et al., 2016).”
   3. I also added this paragraph with respect to why data modeling may be particularly engaging: “Modeling may be especially engaging to youth because such work positions learners as the creators of new information, in addition to using models created by others to learn about authoritative sources of information. This is one of the affordances of modeling in teaching and learning contexts (Berland et al., 2016; Schwarz et al., 2009). Moreover, when learners create new knowledge through activities such as modeling, they can begin to shape the process of constructing new knowledge in a domain, a challenge in science education contexts (Miller et al., 2016) and likely in other STEM content areas, we well.”
2. *In the descriptive analysis, include the correlations between the aspects of work with data and the individual variables used to create the profiles.*
   1. I included the correlations between the aspects of work with data and the individual variables used to create the profiles. I also made changes to the discussion of these correlations in the Discussion section, as I previously mentioned using these correlations as part of a future direction: “One way to consider such an alternate explanation is to use the data used in this study as part of correlational analyses, other analyses that use the variables used to create profiles of engagement but do not use the profiles themselves. An analysis in this spirit was reflected in the correlations including the aspects of work with data (presented in Table 4.2). These indicated very modest relations with engagement, indicating that work with data and the individual variables used to create the profiles are not related. Because of this, it is not surprising that the (more complex) mixed effects models used to explore the relations between work with data and engagement showed minimal relations.”
3. *Include Table 7.3 in the document instead of in the Appendix, but modify it to include only the AIC, BIC, SABIC & entropy, cell sizes, and BLRT.*
   1. I moved Table 7.3 from the Appendix to the section on the results for research question #2, modifying it to include only the AIC, BIC, SABIC, entropy statistic, cell sizes, and the BLRT.
4. *Regarding how the six-profile solution as selected, move some of the discussion from the appendix. (See Lisa’s published work for example; mention I carried out analysis of six versus seven profiles in-text.)*
   1. Using Linnenbrink-Garcia, Wormington, Snyder, and Perez (2018, JEP) as an example (or “model”), I re-wrote the paragraph at the beginning of the section of the results for research question #2, mentioning that I did analyses for subsequent research questions using both the six- and seven-profile solutions. I wrote that finding them to be nearly identical, I chose to use the six-profile solution on the basis of the fit indices and other statistics as well as concerns of parsimony and interpretability. Specifically, I added this paragraph: “For solutions associated with model 1, the decrease (indicating a preferred model) in the information criteria (AIC, BIC, SABIC) becomes smaller as the number of profiles increases from 5 to 6 and 6 to 7. The BLRT suggests that, until the log-likelihood is not replicated, every more complex model be selected. The six and seven profile solutions are compelling because both show profiles that are distinguished by dimensions of engagement and its conditions (challenge and competence) and have lower values on the information criteria than the solutions with fewer profiles. For solutions associated with model 2, only those associated with 2-5 profile solutions were associated with log-likelihoods that were replicated. For these four models, the log-likelihood decreased in a mostly consistent way, such that changes in the decrease are not as evident as those associated with model 1. The BLRT suggest that the more complex model be selected and so did not provide clear information about which solutions are to be preferred. Taken this information into consideration, either a model one type, six profile solution or a model one type, seven profile solution was found to be most reasonable. The seven profile solution, described in Appendix D, was used for the analyses for research questions 4 and 5. The results from these analyses were comparable to those for the six profile solution, and so the six profile solution was chosen on the basis of parsimony and its greater interpretability.”
5. *Provide a richer description of the six profiles. Use a MANOVA to determine which variables differ across the profiles (and for which profiles). Use subscripts in a table with the mean values to indicate which differ.* 
   1. I provided a richer description of the six profiles in section 4.4 by adding information about statistically significant differences between the variables used to the profiles, the size of the profiles, and additional interpretation (in substantive terms, i.e. what the profiles suggest about youth engagement) for each of profile.
   2. I added a MANOVA to section 4.4 to determine whether the variables’ values differed across the profiles. Having determined they did, I also included follow-up ANOVA analyses. I added this information in the following sentences: "The MANOVA was statistically significant (Pillai-Bartlett = 0.633, p < .001). The table with the raw values, with subscripts indicating values the mean values that were not statistically significantly different is presented in Table 4.5. Note that the F -test associated each ANOVA was also statistically significant”
   3. I presented the results of the ANOVA analyses in a table with subscripts indicating variables values that were the same across profiles.
6. *In the descriptions of the six profiles, report the percentage of responses in each profile. Related, state that entropies are high, so it is reasonable to extract the most likely profile membership.*
   1. In the descriptions of the six profiles, I added the percentage of responses associated with each profile to the descriptions of the profiles. I also added the following sentences: “Note that for the profiles (and their presentation in Figures 4.2 and 4.3 and Table 4.5), each response is associated with the probability of profile membership at a particular moment. Because, across all responses, the highest probability for each response was on average quite high (the entropy statistic was .888), the probability was appropriate to use to classify each response into one profile. These classifications were subsequently used to calculate the number and percentage of responses in each profile. They were also used for the analyses comparing the mean levels of each variable across profiles (with a MANOVA and with the follow-up ANOVAs).”
7. *Improve Table 4.5, so that the betas and standard errors are labelled for each model; format the column (presently too wide) for the Engaged and Competent but not Challenged profile.*
   1. To improve Table 4.5 with results for research questions #4 and #5, I added labels for the beta and standard error for each model and shortened the name for the Engaged and Competent but not Challenged profile, so the appearance was more streamlined.
8. *Mention that any of the aspects of work with data versus none of the aspects of work with data and the interactive effects of youth characteristics and the aspects of work with data were examined but not found to be statistically significant (but do not include these in a table).*
   1. I added this sentences to the section on the results for research question #4: “Instructional episodes that involved work with data were compared to those without work with data. Like for the other models, these models were specified with the dependent variable as the probability of a response being associated with a profile for each of the six profiles. However, there was no difference in terms of the regression () coefficients associated with this variable for any of the six profiles.”
   2. I also added this sentence for the section on the results for research question #5: “Note that interactions between the individual aspects of work with data and youth characteristics were also specified. However, none of these interactions were found to be statistically significant.”

**Discussion**

1. *Discuss more broadly what it means that this is happening in the context of a summer program, specifically in the limitations section.*
   1. I added information on the importance of the summer STEM program context in the Discussion section. In particular, I added this paragraph: “Note that outside-of-school STEM programs have distinct features that provide affordances and limitations. One feature is the substantial, but still limited period of time, which was around four weeks. Another feature concerns the nature and quality of the teaching and learning that is afforded. The contexts (including in field settings) in which youth were engaged could spark their engagement and could support work with data better than some K-12 learning environments. They also have limitations, such as the chance that youth considered their time in them to be fun and to be social, rather than educational, in nature. Of course, this is not unreasonable or unexpected on the part of youth, but it may mean that the ways that youth engaged in the programs as documented in this study could be unique to outside-of-school STEM programs. In particular, engagement as reflected in the engaged and competent but not challenged profile may be unique to the experiences of youth in summer STEM programs: It may not be common in K-12 classrooms. This limitation is in addition to and in the context of those documented in earlier parts of this section, particularly, that the limited variability at the instructional episode level may also be due to the lower stakes that learners in these contexts may perceive.”
2. *Speculate about why some of the anticipated findings were not found, particularly by discussing reasons for why the activity does not matter very much: methodological, summer context, under-represented youth and equity issues, and work with data just is not very engaging.*
   1. In order to add information about the null findings, I added the following three paragraphs to the Discussion: “Why might these relations be so minimal? First, and foremost, the little variability at the instructional episode level was noteworthy because it means that few relations between variables at the instructional episode were expected. In particular, there were small ICCs at the instructional episode level for all six profiles. This suggests that there was very little systematic variability at the particular level that the variable for work with data was at. Additionally, the ICC values found in this study were smaller than those found in the one other past study that employed the same analytic approach (Strati et al., 2017). The relative absence of variability at the instructional episode level may be due to the summer STEM setting: Perhaps youth are less likely to engage differently from instructional episode to instructional episode (compared to in K-12 educational settings) because there is less variability in what took place across the episodes or because youth perceive there to be lower stakes for the programs' activities and therefore do not perceive the changes in the instructional episode as a salient factor in terms of their engagement. This consideration is described in greater detail in the limitations section.”
   2. “There are other possible reasons, though, too, for the minimal relations. One may be that work with data is not, as carried out in these summer STEM programs- very engaging, even accounting for the small amount of variability at the instructional episode level. The comparison between the five individual aspects of work with data and not working with data as well as the comparison of instructional episodes that involved any of the aspects of work with data and those that contained none showed minimal relations. This suggests that work with data is not more engaging than other activities carried out in summer STEM programs.”
   3. “Another noteworthy possibility is that the novel analytic approach or the measures used also had impacts; but, again, the small variability at the instructional episode level is likely a greater factor than these, and a review of the correlations between the aspects of work with data and the variables used to create the profiles showed minimal relations. This and the previous potential explanation are explored even further in the next section, on limitations to the present study and recommendations for future research. Taken together, it seems that the major reason for limited relations between work with data and youth engagement is that youth simply did not engage very differently from instructional episode to instructional episode.”

**Throughout the Manuscript or Overall**

1. *Be careful about language use when discussing profiles; change any instances of profile membership to probability of profile membership at a particular moment.*
   1. I made changes to the research question #2 results section to reflect this language (as also described in revision point 14). I also searched for other examples of this but did not find any instances.
2. *Use the past verb tense throughout the methods, results, and discussion section. Use the first-person verb conjugation in these sections.*
   1. I have made changes to use the past tense and the first-person conjugation throughout the manuscript
3. *Carefully copy edit the manuscript or have the manuscript copy-edited. Check figure, table, and appendix numbers and the citations and references given the revision made to the manuscript.*
   1. I read through and copy-edited the entire manuscript. Given the changes made, I also checked and revised the figure, table, and appendix numbers and the citations and references.
4. *Acknowledge that this is a secondary analysis of existing data, citing the STEM-IE NSF grant number (1421198).*
   1. I acknowledged that this is a secondary analysis and added the grant number to the acknowledgements section through the addition of the text added for revision point 24.
5. *Include NSF blurb relating to their independence from the findings of this research as an author’s note (“This material is based upon work supported by the National Science Foundation under Grant No. 1421198. Any opinions, findings, conclusions, or recommendations expressed in this material are those of the authors and do not reflect the views of the National Science Foundation.”* 
   1. I added this text to the acknowledgements section.