TECHNOLOGY OBSERVATION PROTOCOL

Observer Reference Guide

Excel Version 1.0

June 2018

This project is funded by the National Science Foundation, grant #1438396.
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How to use this Reference Guide

If you want to start using the *Technology Observation Protocol (TOP)-Science* Excel workbook immediately, jump to section 8.0 of this reference guide for instructions on how to use the tool. If you want to start with more background on how the protocol was developed and what each portion entails, begin with section 1.0.

1.0 Introduction to *Technology Observation Protocol (TOP)-Science*

1.1 *TOP-Science* Protocol Development

The Technology Observation Protocol for Science, or *TOP-Science*, is a validated research tool that can be used to observe and describe the quality of technology implementation in high school science classrooms. With funds from the National Science Foundation (NSF), our team from the Education Development Center and University of Maryland Center for Environmental Science developed this tool because few protocols directly measure quality of technology integration and most consider science content, or technology use, or specific instructional practices, separately; they do not consider all of these together. *TOP-Science* is unique in that it defines quality as the use of technology to support instruction that is student-centered, contextualized and targets science and engineering practices (as described in the Next Generation Science Standards). This definition of quality is based on the Classroom Technology Implementation Framework (CTIF; Parker, Stylinski, Bonney, Schillaci, & McAuliffe, 2015), which we constructed from reviewing technology-intense teacher training projects (part of the NSF ITEST program) and from extensive review of recent literature of technology integration and student-centered pedagogical practices in science classrooms. Thus, *TOP-Science* aligns with theories of effective student learning and high-quality instruction.

TOP-Science provides a data gathering tool for researchers and program evaluators to characterize the type and quality of technology use in high school science classrooms. It can be used to address broad, field-based, applied research questions, or evaluate specific technology program effectiveness.

Additionally, although not designed for this purpose, it may be used by teachers to engage in formative reflection on their use of technology in their teaching practices. However, it is very important to note that *TOP-Science* **should not be used to assess teachers, is not appropriate for high-stakes evaluation purposes, nor should it be used to measure student outcomes**.

> ***Note:* TOP-Science *focuses only on digital technologies which use processors to process data in a digital format, specifically software applications and the contextual settings in which specific technology applications are most commonly used. See Appendix A for more discussion of technology definitions.***

1.2 *TOP-Science* Protocol Overview

A *TOP-Science* observation consists of

- pre-observation teacher response data
- all 10-minute interval data for that observation
- post-observation teacher response data
- post observation summary

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Typically, an observer will conduct multiple observations depending on their unit of analysis. For example, if the unit of analysis is "high school science teacher," a given observer might observe lessons taught by five different high school science teachers (n=5). In this example, each lesson takes place over three 30-minute class periods (i.e., one 30-minute class per day for three days). Thus, the observer will make five observations (one per teacher); for each observation, the observer will gather/enter pre-observation data of a particular teacher, complete nine 10-minute intervals (3 on day 1, 3 on day 2, 3 on day 3) for that teacher, and then gather/enter the post-observation data for that particular teacher.

The *TOP-Science* tool consists of four elements:

1. **Pre-Observation Teacher Questions**. These questions are sent to teachers via email to be completed before the observation, and serve to prepare the observer for what kind of class will be observed, what kinds of technology might be used, and the instructional practices the teacher might use during the class. Responses to these questions help frame the observation around the intentionality of instructional practices that might be observed.

2. **Classroom Observation Information**. This section includes information about the observation (e.g., date of observation, name of observer, course name, number of students), as well as observations made in 10-minute intervals using the Classroom Technology Implementation Framework.

3. **Post-Observation Teacher Questions**. Teachers are asked these questions after the observation period is complete (either in person or via telephone/email). They allow the observer to follow up with the teacher with any questions they have about the observed class, identify any unexpected challenges with respect to technology use that came up during the observation, and clarify the intentionality of the observed teaching practices.

4. **Post-Observation Code Summaries**. Observation data are aggregated by type (i.e., "PrePost Data" and "Interval Data"). The observer can download the aggregated observation data to perform his/her own analyses, or use the optional *TOP-Science Post Observation Summary* template (a separate document) to summarize the observation data.

The *TOP-Science* protocol is available in three formats—Microsoft Word, PDF and macro-enabled Excel. These tools and their supporting documents are available at the following websites:

- http://topscience.edc.org/index.php/resources/
- http://research.al.umces.edu/cat-stylinski/top-science/

This reference guide is for the macro-enabled Excel format version 1.0. (A separate guide is available for the Word/PDF formats.) Below are requirements for using the Excel workbook; note that while this guide provides specific guidance to use the workbook, a basic understanding of Excel is needed to take full advantage of the instructions.

Technology Requirements

- Windows 7 Professional, Windows 10, and Apple IO X 10.11.16 and above
- Microsoft Excel version 2007 and above
- Minimum screen resolution is 900 x 1600

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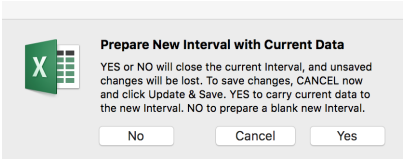
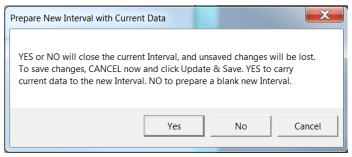
Computing Platform Differences

This reference guide gives many helpful examples using screenshots of pop-ups and interface features extracted from running the tool on an Apple IO X 10.11.16 computer. Because of differences with Microsoft Windows and Apple IO user interfaces, some of the examples screenshots may be slightly different from what an observer will see on a Window computer. For example, the following two pop-up examples of the message "Prepare New Interval with Current Data" illustrate that the order of Yes-No-Cancel buttons are different (Windows 7 Professional on the left, and Apple IO X 10.11.16 on the right).





Security Risk

In order to use the *TOP-Science* Excel workbook, you must enable the use of macros within Excel. This presents a security risk because macros are an easy way for hackers to add malicious code segments to a file. Only use the *TOP-Science* Excel workbook provided by the *TOP-Science* team. If you suspect your version may have been compromised, save the data in CSV files, discard the workbook, and download a new copy (see websites listed on the previous page).

The Workbook is designed so that worksheets and certain cells are protected, so it is not possible to change any macros. Observers can only input and modify information in the entry forms designed for observation data.

When using the *TOP-Science* Excel workbook, all observations for one (and only one) observer are saved in one workbook. Thus, the observer's data for all five teachers in the above "high school science teacher" example would be stored in one workbook. Different observers must use different workbooks. If a second observer was paired with the first, they would enter data in their own workbook.

TOP-Science Excel Workbook and Reference Guide Organization

The *TOP-Science* Excel macro-enabled workbook contains four tabs (also called "worksheets") for entering, storing, viewing and editing pre-observation, interval and post-observation data. A fifth tab in the *TOP-Science* Excel workbook provides an explanation of the content in each of those tabs. Note that the workbook cannot be adapted.

The next five sections of this reference guide describe each of the five tabs in the *TOP-Science* Excel workbook. Section 7 describes how to summarize the data gathered in the workbook. Section 8 provides step-by-step instructions on how to use the *TOP-Science* Excel Workbook. Section 9 provides guidance on troubleshooting the *TOP-Science* Excel Workbook. Section 10 provides step-by-step instructions on how to use the *TOP-Science* Post-Summary Workbook.

If you do not have a working knowledge of Excel, do not meet the minimum technology requirements, or do not want to enable macros, we recommend that you use the Microsoft Word or pdf version of the *TOP-Science Observation Protocol*.

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2.0 PrePost Tab

Teachers' responses to pre- and post-observation questions as well as general classroom information are recorded in the **PrePost** tab. The **PrePost** tab of the *TOP-Science* Excel workbook consists of the following five sections. Below is an explanation of each section as you read from top to bottom of the **PrePost** tab.

2.1 PrePost Toolbar

This section is where the observer loads the PrePost data. The observer can "load" an existing PrePost record from the scrollable list. They can also "clear" data from the PrePost and Interval tabs (i.e., before entering new data). Finally, they can also "update and save," which will copy date from this tab to the **PrePost Data** tab and save the whole workbook; this should be done frequently.

2.2 Observer

This section is where the name of the person ("observer") conducting the observation is entered. The Observer Name is required, permanent and will be encoded in every observation in the workbook. It must be entered and the workbook saved using *Update & Save* before entering any other information. Once entered, this information cannot be changed.

2.3 Class Info

This section is where information on the class to be observed is entered:

- Teacher name
- School name
- Course name
- Observation date(s)
- Number of students
- Student Grade Level (9th, 10th, 11th, or 12th)
- Observation Code (required)

The observer will gather this information from the teacher before the observation as described in Section 1.2.

The *Observation Code* is the only required class information as it is used in the automated creation of the *Observation ID*.

2.4 Pre-observation Teacher Q&A

This section is where responses to the pre-observation teacher questions are entered. These questions allow the teacher to explain their intended technology integration for the observed classroom.

> ***Tip: Observers should email the questions to the teacher approximately one week before they plan to conduct their classroom observation, so the responses may be received prior to the observation.***

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Each question posed to the teachers is aligned with our framework and is designed to provide context to the observation and insight into the intentionality of the teacher. Observers may choose to ask additional questions, but it is not possible to add them to the Workbook.

1. **What are the big ideas (e.g., content, skills, competencies) that students will understand from this lesson or unit?**

   This question helps the observer understand the teacher's targeted learning outcomes.

2. **Please provide a description of how you will use technology to support understanding these big ideas.**

   This question can prepare the observer for how the teacher will use technology and thus will provide insight into how technology might support SEPs, as well as student-centered and contextualized teaching practices. Answers to this question also help observers understand how teachers define technology for the lesson.

3. **What specific technology hardware and software will you or your students be using (e.g., learning management systems, Vernier probes, Excel, GPS/GIS)?**
   This question can also prepare the observer for what kinds of technology applications will be observed.

4. **If this lesson is part of a larger unit or project-based learning, briefly describe what you have done previously and what you plan to do later in terms of science content, science and engineering practices, and technology use.**

   This question provides background on how the observed lesson fits in with what students have been learning, and may also provide information about student-centered and contextualization intentions from the teacher. Because observers rarely have an opportunity to observe more than one or two class periods and teachers often design their instruction across multiple days or even weeks, this question helps observers understand teachers' broader instructional intentions.

5. **Why have you chosen to use technology with this lesson?**

   This question provides insight into how the teacher thinks the lesson will be enhanced by technology, including possible connections to student-centered and contextualized teaching practices.

6. **To what extent is this lesson personalized or differentiated for students based on their developmental needs, skills, and interests?**

   To assess student-centered teaching, observers should attend to personalized teaching, student autonomy, and competency-based teaching. Because the extent to which a lesson is personalized may be difficult to observe, this question provides insight into the extent the lesson has been personalized or differentiated for students.

7. **Please provide any materials you can before the class (e.g., attachments of handouts you will be using, web links), or provide the observer with the handouts when get to class.**

   It is very helpful for observers to be able to look at materials before, during, and/or after the observation. In the Excel workbook, the observer should list any provided materials in this box (skip if none were provided).

8. **Is there anything else we should know about the selected lesson/unit or your students?**

   This question gives teachers an opportunity to inform the observer about behavioral or structural issues in the classroom that may impact the observation.

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2.5 Post-observation Teacher Q&A

This section is where responses to the post-observation questions are entered. These questions allow the teacher to reflect on their intended versus actual technology integration in the observed classroom. provide more context for what was observed, and give the observer the opportunity to follow up with the teacher with any questions that may have arisen during the course of the observation, and clarify the intentionality of observed teaching practices. These responses will inform the post-observation summary.

> ***Tip: Teachers should be asked these questions as soon as possible after the conclusion of the observation period. If there is not time immediately following the observation to interview the teacher, arrangements should be made for a phone call or email to discuss the follow-up questions.***

1. **How representative of your usual technology use was the observed lesson/unit?**

   This question assesses the extent to which the teacher uses technology on a regular basis.

2. **In what ways did the technology observed help students understand the big ideas? Did the lesson go as planned in terms of students' understanding these ideas and engaging with the technology? If the lesson did not go as planned, what changes would you make?**

   This question provides insight into whether the teacher believes their actual use of technology supported their targeted learning outcomes; and if not, what they would change to more effectively use technology.

3. **Is there anything you would have done differently with regard to technology use?**

   This question allows the teacher to explain how they would improve their use of technology, including addressing any foreseen or unforeseen technology challenges. The teacher might also note if the student learning was impacted by these challenges.

4. **How would the lesson be different if you taught it without technology? (If you have previously taught this or a similar lesson without technology, please describe the differences.)**

   This question addresses the use of technology for this particular lesson, and the extent to which the technology is integrated in the lesson. If the teacher has taught this lesson (content or skills) before without technology, has the addition of technology enhanced or transformed the lesson?

5. **Is there anything else we should know about the observed lesson/unit?**

   This allows the teacher to report any additional insights into the observed class period. The observer may learn more about intentionality of certain teaching practices that can inform their ratings for SEP, student-centered teaching, contextualized teaching, and technology integration.

6. **Other follow up questions.**

   Observers can ask any additional clarifying questions.

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3.0 Interval Tab

Observations in 10-minute intervals are recorded in the **Interval** tab.

The **Interval** tab is set up as an interface where the observer enters each of the 10-minute intervals of a class period (e.g., six 10-minute intervals for a 60-minute class). That is, the observer enters data for an interval in this tab, saves and uploads it (into the **Interval Data** tabs), clears it, and then enters data for the next interval. The observer can also recall any interval and view it in this tab.

Note that each set of 10-minute intervals for an observation is directly linked to a single PrePost record (entered in the **PrePost** tab); that is, they all have the same Observation ID (plus the interval number).

> ***Tip: Always make sure you have the right Observation ID listed on your PrePost and Interval tabs.***

Below is an explanation of each section as you read from top to bottom of the Interval tab.

> ***Tip: The Excel workbook includes a Reference tab, which provides quick-reference definitions for each of these categories.***

3.1 Interval Toolbar

This section is where an observer can: (1) start a "new interval," (2) add a "timestamp" (start time) for a 10-minute interval, (3) "update and save" an interval (to the **Interval Data** tab), and (4) "load" an existing interval from a scrollable list.

This section also displays the Observation ID for the current interval (which links it to the PrePost data and the other intervals in an observations). When the observer loads the Observation ID in the **PrePost** tab, it will appear in this section.

3.2 Interval Description

This section is where an observer records specific information about the classroom. It includes the following four parts:

- **Activities Observed.** The observer provides a brief description of the activity(ies) (e.g., lecture, discussion, individual seatwork, hands-on activity, group work, assessment, test preparation, homework review). The list of activities provided is not meant to be an exhaustive or comprehensive. Because teachers may introduce prerequisite and relevant content or skills to students before bringing technology into the lesson, observers should record all classroom activities, even if technology is not being used.
- **Hardware Types Used.** The observer records any digital technology *hardware* used during the time period covered by the interval sheet (e.g., desktop/laptop computers, mobile devices, smartboard, probes, graphing calculator).
- **Software or Application Used.** The observer lists any technology *software* or applications used during the time period covered by the interval sheet (e.g., search engine, Google sheet, PowerPoint, PhET simulations).

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- **Technology Application Types.** The observer records the types of technology applications used. We define technology application types based on the setting in which a technology application (usually software) is most commonly used (Table 1). Additional examples of technology application types are provided in Appendix B.

> *Note:* ***The designation of the technology application type may change over time. For example, Microsoft Excel was originally designed as a professional spreadsheet tool and was most commonly used only in workplace settings. It has since become more ubiquitous, and is used in all settings including classroom, home, and workplace settings. Although an observer may see students using Excel in a way that mirrors how scientists might use the software (e.g., data analysis and graphing), it should still be coded as a ubiquitous technology type, since the more advanced use of Excel will be reflected in the SEP and SEPTech ratings (see below for descriptions of these codes).***
>
> ***It is important to review these classifications with your observation team to determine the most appropriate type for observed technology applications.***

- **Detailed Description of Technology Application.** The observer describes the technology application being used and how it is being used.

TABLE 1: TECHNOLOGY APPLICATION TYPES

Technology application categories	Examples of technology applications observed in the appropriate category
Instructional: Technology applications most commonly used in classroom or educational settings	Assessment tools (e.g., clicker software, Gradebook, Gizmo), online course management (e.g., Blackboard, Schoology, PowerSchool, Google Classroom), educational simulations (e.g., PhET), probeware for field data collection (e.g., Vernier or LoggerPro probes).
Ubiquitous: Technology applications most commonly used in all settings, whether classroom, social, or workplace settings	Word processing (e.g., Microsoft Word), social networking (e.g., Facebook, Twitter), presentation applications (e.g., PowerPoint, GoogleSlide), video (e.g., YouTube, QuickTime), data recording and analysis (Excel, GoogleSheet), Web browsers and search engines (e.g., Chrome, Firefox)
STEM Workplace: Technology applications most commonly used in STEM workplace	Computer modeling and simulations (e.g., Stella, Ecobeaker), image data analysis (e.g., ImageJ), geographic information system (e.g., ArcGIS), mapping tools (e.g., Fieldscope), computer programming or coding (e.g., Scratch, Visual Basic, Java).

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3.3 Science and Engineering Practices

The *TOP-Science* protocol is unique in that it considers authentic science inquiry in the science classroom. We define science inquiry using the science and engineering practices (SEPs), which are one of the three dimensions of science learning outlined in the Framework for K-12 Science Education and the Next Generation Science Standards. The SEPs consist of eight practices that reflect the work of scientists and engineers:

1. Asking questions (for science) and defining problems (for engineering);
2. Developing and using models;
3. Planning and carrying out investigations;
4. Analyzing and interpreting data;
5. Using mathematics and computational thinking;
6. Constructing explanations (for science) and designing solutions (for engineering);
7. Engaging in argument from evidence; and
8. Obtaining, evaluating, and communicating information.

These practices are interwoven with the 113 grade 9-12 standards of the NGSS, and it would be challenging to envision a protocol that could consider all possible combinations between them and technology. While a subset of standards could be a focus (e.g., earth science), this could significantly limit the usefulness of an observation protocol. Thus, our protocol reflects on technology integration with the eight SEPs without regard to specific conceptual references—that is, it is conceptually agnostic and can be applied within any high school science or engineering course. When using this protocol, the observer should consider the science and engineering practices in the context of the targeted content, and while determining how digital tools may support or enhance student learning and engagement with the SEPs. For example, computer simulations can help scaffold students' understanding and learning during inquiry-based activities (De Jong, 2006), and might also facilitate STEM learning by aligning with real-world practices, such as with project-based learning (Blumenfeld, Fishman, Krajcik, Marx, & Soloway, 2000). Furthermore, our protocol is not designed to align with a particular set of standards (which can vary by state); instead it focuses on science inquiry and uses the NGSS SEPs to define inquiry in the science classroom.

This section of the *TOP-Science* Excel workbook is where the observer captures the extent to which the SEPs are present during the observed activity (Table 2). Observers record the presence of each SEP (see Category section below) during the lesson, and provide in the Evidence box specific justification for their selection for the presence of the SEP and the integration of technology with SEPs.

- **Category.** The table below summarizes each science and engineering practice. Observers should familiarize themselves with the definitions, and refer to this table as they determine the extent to which teachers may be focusing on these practices with their students.

> ***Tip: In this protocol, observers should indicate how the teacher has set up the lesson (in the pre-observation questions) and what specific activities the teacher does to encourage students' engagement with SEPs. The student role in the classroom should be noted in relation to the teacher's action, especially if the student role differs from the teacher's intention.***

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TABLE 2: SCIENCE AND ENGINEERING PRACTICES	
Practice	**Summary and Examples**
Asking questions or defining problems	Teacher encourages students to: (1) ask questions about the natural or human-built world; (2) distinguish a scientific question; (3) formulate and refine questions that can be answered empirically in a science classroom and use them to design an inquiry or construct a pragmatic solution; (4) ask probing questions that seek to identify the premises of an argument, request further elaboration, refine a research question or engineering problem, or challenge the interpretation of a data set; (5) note features, patterns, or contradictions in observations and ask questions about them; (6) for engineering, ask questions about the need or desire to be met in order to define constraints and specifications for a solution.
	Example: Teacher presents an issue. Much is written about this issue (beyond the teacher's knowledge), so the teacher organizes students into groups focused on different aspects of the issue and students conduct web searches using various reputable sources to summarize current understanding of the issue. Groups share their background research and from this develop testable scientific questions on this issue.
Developing and using models	Teacher encourages students to: (1) construct drawings or diagrams as representations of events or systems; (2) represent or explain phenomena with multiple types of models; (3) discuss the limitation and precision of a model as the representation of a system, process, or design and suggest ways in which the model might be improved to better fit available evidence or better reflect a design's specifications. Refine a model in light of empirical evidence or criticism to improve its quality or explanatory power; (4) use (provided) computer simulations or simulations developed with simple simulation tools as a tool for understanding and investigating aspects of a system, particularly those not readily visible to the naked eye; (5) make and use a model to test a design, or aspects of a design, and to compare the effectiveness of different design solutions.
	Example: In a lesson about the food chain, students study the predator-prey mathematical model. They apply the model for the case of rabbits and foxes by using a computer simulation. After exploring different model parameters with the simulator, the students deduce that the predator-prey model can be applied to other resource-consumer applications, such as plant-herbivore, parasite-host, tumor cells (virus)-immune system, etc. They investigate a model and simulation with three variables (grass-rabbits-foxes) to understand extensions of models applied to larger systems.
Planning and carrying out investigations	Teacher encourages students to: (1) formulate a question that can be investigated within the scope of the classroom, school laboratory, or field with available resources and, when appropriate, frame a hypothesis (a possible explanation that predicts a particular and stable outcome) based on a model or theory; (2) decide what data are to be gathered, what tools are needed to do the gathering, and how measurements will be recorded; (3) decide how much data are needed to produce reliable measurements and consider any limitations on the precision of the data; (4) plan experimental or field research procedures, identifying relevant independent and dependent variables and, when appropriate, the need for controls; (5) consider possible confounding variables and ensure that the investigation design has controlled for them.
	Example: *Teacher has students select sampling sites in their school yard for a field investigation. Students have to identify impervious surfaces (e.g., parking lot, roofs) and pervious surfaces (lawns, natural areas) and pick two sites on each surface that they can easily access each week. Students use a mapping software and examine an aerial image of their schoolyard to help them pick two sites.*
Analyzing and	Teacher encourages students to: (1) analyze data systematically, either to look for salient patterns or to test whether data are consistent with an initial hypothesis; (2) recognize when data are in conflict with expectations

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interpreting data	and consider what revisions to the initial model are needed; (3) use spreadsheets, databases, tables, charts, graphs, statistics, mathematics, and information and computer technology to collate, summarize and display data and to explore relationships between variables, especially those representing input and output; (4) evaluate the strength of a conclusion that can be inferred from any data set, using appropriate grade-level mathematical and statistical techniques; (5) recognize patterns in data that suggest relationships when investigating further. Distinguish between causal and correlational relationships; (6) collect data from physical models and analyze the performance of a design under a range of conditions.
	Example: Teacher has students record data from investigation and explore the relationships between variables. Teacher provides access to spreadsheet (on hard drive or in cloud). Students use the spreadsheet to record data and perform the necessary unit conversions. They display the data in a table form with proper headings. They assess the data in the table and select two data columns (variables) to explore. Using the spreadsheet graphing capability, students make a scatter plot of two data columns to check whether the pattern of the data reveal any relationships between the two variables.
Using mathematics and computational thinking	Teacher encourages students to: (1) recognize dimensional quantities and use appropriate units in scientific applications of mathematical formulas and graphs; (2) express relationships and quantities in appropriate mathematical or algorithmic forms for scientific modeling and investigations; (3) recognize that computer simulations are built on mathematical models that incorporate underlying assumptions about the phenomena or systems studied; (4) use simple test cases of mathematical expressions, computer programs, or simulations--that is, compare their outcomes with what is known about the real world--to see if they "make sense"; (5) use grade-level appropriate understandings of mathematics and statistics in analyzing data.
	Example: The teacher has the students do an experiment to study the behavior of a bouncing ball. Students use a video recorder to record the ball bouncing across the floor. They use a x-y grid as background for video so they can get the x, y location of the ball in the video frame. From watching the videos, students record the x, y, and t data points on a spreadsheet. They use the spreadsheet to make calculations and plot the data and compare the graphs with the mathematical model of the bouncing ball that the teacher has provided to them.
Constructing explanations and designing solutions	For science work, teacher encourages students to: (1) construct their own explanations of phenomena using their knowledge of accepted scientific theory and linking it to models and evidence; (2) use primary or secondary scientific evidence and models to support or refute an explanatory account of a phenomenon; (3) offer causal explanations appropriate to their level of scientific knowledge; (4) identify gaps or weaknesses in explanatory accounts (their own or those of others). For engineering work, teacher encourages students to: (1) solve design problems by appropriately applying their scientific knowledge; (2) undertake design projects, engaging in all steps of the design cycle and producing a plan that meets specific design criteria; (3) construct a device or implement a design solution; (4) evaluate and critique competing design solutions based on jointly-developed and agreed-on design criteria.
	Example: In the experiment to study the behavior of a bouncing ball, the teacher has students construct an explanation to account for the decreasing heights of the ball in successive bounces. Their explanations are supported by data, plots, and mathematical model from using technology. They provide a more complete, consistent, and persuasive explanations because the technology allows them to easily analyze the data, try different scenarios, and come up with a mathematical model.
Engaging in argument from evidence	Teacher encourages students to: (1) construct a scientific argument showing how data support a claim; (2) identify possible weaknesses in scientific arguments, appropriate to the students' level of knowledge, and discuss them using reasoning and evidence; (3) identify flaws in their own arguments and modify and improve them in response to criticism; (4) recognize that the major features of scientific arguments are claims, data, and reasons, and distinguish these elements in examples; (5) explain the nature of the controversy in the development of a given scientific idea, describe the debate that surrounded its inception, and indicate why one particular theory succeeded; (6) explain how claims to knowledge are judged by the scientific community today and articulate the merits and limitations of peer review and the need for independent replication of critical investigations; (7) read media reports of science or technology in a critical manner so as to identify their strengths and weaknesses.

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	Example: In the experiment to study the behavior of bouncing balls, the teacher has student teams use different types of balls. After the teams have constructed their explanations, the teacher has them engage in discussions and arguments about why different types of balls bounced differently. Students use data and formulae that are in their spreadsheets. It is easy for them discuss their data and to try different model parameters to compare alternative models and/or explanations. For example, one team believes that another team has an incorrect mathematical model. Teams are able to use the spreadsheet to quickly try different parameters for their formulae, compare the revised model with the data and previous models.
Obtaining, evaluating and communicating information	Teacher encourages students to: (1) use words, tables, diagrams, and graphs (whether in hard copy or electronically), as well as mathematical expressions, to communicate their understanding or to ask questions about a system under study; (2) read scientific and engineering text, including tables, diagrams, and graphs, commensurate with their scientific knowledge and explain the key ideas being communicated; (3) recognize the major features of scientific and engineering writing and speaking and be able to produce written and illustrated text or oral presentations that communicate their own ideas and accomplishments; (4) engage in a critical reading of primary scientific literature (adapted for classroom use) or of media reports of science and discuss the validity and reliability of the data, hypotheses, and conclusions. Technology may be used throughout include for collaborations with off-site partners.
	Example: Teacher has students create and present a PowerPoint of their review of scientific writing on impacts of climate change on spring budburst. They integrate their own text along with figures, tables, and graphics that they took from online sources. They place them in an appropriate order in the PowerPoint slides and use PowerPoint features to present the information to other students and answer questions.

- **Level**. Observers should record an "Incidental-1" (incidental SEPs), or "Embedded-2" (embedded SEPs) when observing teachers encouraging or facilitating students' engagement with any of the eight SEPs (see Category section above for definitions and examples). Evidence of **incidental** SEPs might include a low emphasis on engaging in the practice, or a temporally brief engagement with the SEP. For example, in the planning and carrying investigation example above, students spend a couple of minutes of a ten-minute interval, forming teams consisting of their friends without factoring team members' potential contributions to content knowledge and experience with tools. Evidence of **embedded** SEPs might be exhibited by a high emphasis on or longer use of the SEP. For example, in the next two ten-minute intervals, teams plan their investigations by discussing which mapping software and soil database to use and set up a spreadsheet and assign tasks and schedules for each team member. A "No evidence-0" code (no evidence of SEPs) would indicate the absence of evidence of SEP engagement during that 10-minute interval.
- **Technology.** Technology codes describe the integration of technology tools within the activity as well as with each other. Table 3 provides examples of each level of technology integration into a given lesson. Observers should record a "Minimal-1" (minimally integrated), "Partial-2" (partially integrated), or "Full-3" (fully integrated) when observing technology use that has been integrated with SEP use in the interval. For example, if students use technology for most of the interval, but technology supports only the recall and reproduction level of cognitive processes, then the observer should record "1" (minimally integrated).
    - **No tech-0 (No technology)**: Students engage in SEP without using any digital technology, or digital technology is used but does not play a role in SEPs.
    - **Minimal-1 (Minimally integrated)**: The lesson could be done with or without technology. Technology supports simple one-step procedures such as recall, identify, recognize, calculate, tabulate, measure (e.g., convert numbers in Excel or reproduce list with Word).

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- **Partial-2 (Partially integrated)**: The technology *enhances* student engagement with SEPs and supports multi-step procedures such as summarize, identify patterns, sketch, estimated, show (e.g., record/display data in Excel or classify digital photos).
- **Full-3 (Fully integrated)**: The technology *transforms* student engagement with SEPs by allowing students to accomplish tasks and develop understanding that they could not otherwise do without technology. Technology supports critical thinking including reasoning, planning, and thinking of complex and abstract tasks such as making connections, developing arguments, citing evidence, assessing, revising, synthesizing, defining (e.g., using digital data to draw conclusions).
- **NA-99**: Students use technology, but no evidence of SEPs is observed. (By manually choosing NA-99, the observer clarifies that the lack of a code is not missing data.)

> ***Note: In some cases, minimal or partial integration of technology may be most appropriate for the lesson. A higher level of technology integration does not necessarily result in a better lesson, but the observer needs to be able to document the level of integration present in the classroom.***

- **Evidence.** Observers should record in the *Evidence* box specific justification for the selected category, level and technology integration with SEPs. If technology is not used for a particular activity, but is related to or connected to a previous activity during which technology was used, this connection should be noted.

Table 3: Science and engineering practices example using the practice "Planning and Carrying Out Investigations":

No technology (No tech-0)	Teacher sets up a chemistry lab for students to learn how changes in variables affect the timing of chemical reactions using baking soda and vinegar. Students hypothesize how and what changes will impact chemical reactions and then design and implement a study to test their hypothesis. Chemical reaction time is visually determined by when the bubbles stop forming, and measured using the classroom clock. *No tech: students observe changes in reaction time visually and use classroom clock to measure time.*
Minimally integrated (Minimal-1)	Teacher sets up a chemistry lab for students to learn how changes in variables affect the timing of chemical reactions using baking soda and vinegar. Students hypothesize how and what changes will impact chemical reactions and then design and implement a study to test their hypothesis. Chemical reaction time is visually determined when the bubbles stop bubbling, using a smartphone to record time more accurately. *Minimal: students observe changes in reaction time visually and use phones to provide more accurate time measurement.*
Partially integrated (Parital-2)	Teacher sets up a chemistry lab for students to learn how changes in variables affect the timing of chemical reactions using baking soda and vinegar. Students hypothesize how and what changes will impact chemical reactions and then design and implement a study to test their hypothesis. Chemical reaction time is measured using a Vernier Probe to assess change in pressure in a test tube and document differences in reaction times. *Partial: students measure reaction time using Vernier probes, use phones to provide accurate time measurement, look only at 'faster/slower,' not at specific rates of change. Technology use does not require or result in critical thinking such as reasoning or defining.*
Fully integrated (Full-3)	Teacher sets up a chemistry lab for students to learn how changes in variables affect the timing of chemical reactions using baking soda and vinegar. Students hypothesize how and what changes will impact chemical reactions and then design and implement a study to test their hypothesis. Chemical reaction time is measured using a Vernier Probe to assess change in pressure in a test tube. The probes are connected to computers that record the data into an excel file and allow students to graph rates of change by dependent variable (e.g., amount of baking soda, temperature of vinegar). *Full: Probes are connected to laptops, allowing digital data to be recorded and used to calculate rates of change.*

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3.4 Student-Centered Teaching

Student-centered teaching involves instructional practices that allow students to have a more self-directed experience with their learning. Maddux and Johnson (2006) note that technology implementation strategies are most successful when they are more student-centered and move away from teacher-directed instruction. For this protocol, we have adapted a definition from the Nellie Mae Education Foundation (NMEF), and define student-centered teaching as encompassing personalized instruction, student autonomy or ownership of the learning process, and competency-based instruction (NMEF & Parthenon-EY, 2015; Reif, Shultz, & Ellis, 2016). Nellie Mae's definition includes a fourth component of student-centered teaching, that learning can happen anytime, anywhere; however, this component addresses learning that happens outside the classroom, which is beyond the scope of this protocol.

Personalized instruction occurs when students' individual skills, interests, and developmental needs are taken into account for instruction. Students have autonomy over their own learning when they have frequent opportunities to take ownership of their learning process and have a degree of choice. Competency-based teaching is defined as teaching that progresses based on students' mastery of skills and knowledge, rather than being dictated by how much time has been spent on an activity or topic.

Integrating technology in a student-centered classroom can occur in a variety of ways. Technology applications may allow students to learn in a student-centered way that would not otherwise be possible without the technology. For example, access to information may allow student learning to be individualized; access to multiple modalities of learning might allow for personalization, or a learning management system might facilitate student-teacher and student-student collaboration or portfolios that promote competency-based learning. Technology might also support student-centered teaching such that students may have autonomy over what kind of technology to use for an activity, or when technology use might be appropriate. Having the conditions under which technology is used in the students' control could be a "potential enabler" of student-centered learning (NMEF & Parthenon-EY, 2015, p. 6).

This section of the *TOP-Science* Excel workbook is where the observer records the extent to which the activities during an interval are student-centered. We define student-centered teaching as including three components[1]: 1) students have autonomy over their own learning, 2) instruction is personalized, and 3) learning is competency-based (Lampert, 2015; NMEF & Parthenon-EY, 2015; see Table 4). Observers should take note of the extent to which teaching and learning in the classroom incorporates these components.

- **Category.** For each of the three components of student-centered teaching, observers should consider whether the instruction they are observing falls into one of these categories when coding for level and technology integration.
    - When students have autonomy over their own learning, they have frequent opportunities to take ownership of and have a degree of choice over their learning process, and may use formative assessments to monitor and reflect on their learning progress. Complete student autonomy is rare in classrooms, and some instances of teachers allowing student autonomy are not necessarily consequential to the learning goals of the lesson; however, the motivational affordances allowed by increased student autonomy, even if it is not consequential to learning, are important nonetheless and should be included in this code.
    - Personalized instruction is defined as teaching that takes students' individual skills, interests, and developmental needs into account. This may be difficult to observe, so

[1] The cited research also addresses a fourth component of student-centered learning: learning can happen anywhere and anytime; however, since this component describes learning that happens outside of the classroom, which is outside the scope of this protocol, it is not included in this framework.

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teachers are asked as one of the pre-observation questions the extent to which they have personalized or differentiated instruction for their students.
    - Competency-based teaching is defined as teaching that progresses based on students' mastery of skills and knowledge, and is not necessarily dictated by how much time has been spent on an activity. In a classroom, this may manifest itself as varied pacing schedules for students, so that not everyone proceeds through material at the same time.
- **Level.** Observers should record a "No evidence-0" (not student-centered), "Incidental-1" (incidental student-centeredness), or "Embedded-2" (embedded student-centeredness) when observing instances of student autonomy, personalized instruction, and competency-based teaching (see Category section above for definitions). Evidence of **incidental** student-centeredness might be the teacher controlling most of the technology in the classroom, whether it is by limiting what technology students may use, when or how it is used for a lesson. The teacher may provide a small degree of personalized instruction, student autonomy, or competency-based instruction, but it is limited. **Embedded** student-centeredness might be exhibited with most or all of the technology decisions (i.e., what, when, how) being made by students. There may be a high degree of personalized instruction, student autonomy, and competency-based instruction occurring in the lesson.

> ***Note: Activities will often span more than a single 10-minute interval, and the full potential of a lesson may not be realized until later in the observation. Ratings should be made according to what occurs during that particular interval, even if the activity began in an earlier interval. For example, students may use technology during one interval, but the technology use does not become fully integrated until a later interval. The observer should only rate the technology use as "Full-3" in the later interval, even if the technology use began earlier.***

- **Technology**. For this code, observers should note the extent (on a 0 to 3 scale) to which technology allows students to learn in a student-centered fashion, or whether the students engage with the technology in a student-centered way. For example, access to information may allow student learning to be individualized; access to multiple modalities of learning (e.g., video, written text) might allow for personalization, or a learning management system might allow student-teacher and student-student collaboration and/or student portfolios that promote competency-based learning.

  Technology might also enable student centered teaching such that it enables the collection of data to support and inform individualized learning progressions. Technology-enabled assessments might allow for an organized collection of content, practice, and measurement items, as well as produce data on what students know, how they are progressing, and provide scaffolded support. Student and teacher portals would enable a way to organize and store work, develop portfolios, and manage learning and administrative tasks; student-student or student-teacher collaborative platforms would support communication and facilitate group projects.

    - **No tech-0 (No technology)**: Students may have opportunities for autonomy, personalization or competency-based learning, but these opportunities are not related to any use of technology.
    - **Minimal-1 (Minimally integrated)**: Students have limited choice in when and how to use technology; teacher may demonstrate rather than having students do the activity; the activity could be completed without the technology and in some cases the technology interferes with student-centeredness. The technology itself does not contribute to autonomy, personalization or competency-based learning.

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- **Partial-2 (Partially integrated)**: Students have options about how and when to use technology; the technology *enhances* student-centeredness by increasing autonomy (e.g., students have more choice about how to complete a task), personalization (e.g., allows material to be individualized to meet student needs); competency-based (e.g., students are evaluated when they are ready rather than en masse).
- **Full-3 (Fully integrated)**: The technology allows students to learn in a student-centered fashion that *would not be possible* without the technology; access to information allows student learning to be individualized; access to multiple modalities of learning (e.g., video, written text) allows personalization; learning management systems allow student-teacher and student-student collaboration and/or student portfolios that promote competency-based learning. The technology promotes extensive use of individualized learning paths, assessment, organization, and collaboration systems that allow them to share their work, prepare portfolios, be assessed with adaptive systems.
- **NA-99**: Students use technology, but no evidence of student-centered teaching is observed. (By manually choosing NA-99, the observer clarifies that the lack of a code is not missing data.)

- **Evidence.** Observers should record in the *Evidence* box specific justification for the selected category, level and technology integration with student centered teaching. If technology is not used for a particular activity, but is related to or connected to a previous activity during which technology was used, this connection should be noted.

Table 4: Student-centered teaching example (Embedded student centeredness)	
No technology (No tech-0)	Students complete worksheets asking them to compare and contrast various kinetic graphs (showing relationships between time and velocity). The teacher differentiates the assignment by providing graphs of varying levels of complexity for different groups of students, and worksheets are completed in pairs or small groups that may collaborate with each other. *Embedded: Students are able to collaborate, and worksheets are differentiated.*
Minimally integrated (Minimal-1)	Students complete a paper-based lab in which they use motion detectors to replicate kinetic graphs using their own bodies (showing relationships between time and velocity). The teacher differentiates the assignment by providing graphs of varying levels of complexity for different groups of students, and labs are completed in pairs or small groups that may collaborate with each other. However, the software was not flexible enough to effectively accommodate the steps needed for all the different levels of complexity. *Minimal: Students use motion detectors, but the lack of functionalities of the technology does not allow the teacher to provide effective student centered teaching.*
Partially integrated (Parital-2)	Students complete a lab in which they use motion detectors to replicate kinetic graphs using their own bodies (showing relationships between time and velocity). The teacher differentiates the assignment by providing electronic data and graphs of varying levels of complexity for different groups of students and labs are completed in pairs or small groups that may collaborate with each other. The teacher and student teams were able to adjust the lab to account for some of the weaknesses of the motion detector. *Partial: The use of the motion detectors and digital data and graphs allow the students and the teacher to adjust some of the lab components for student-centered teaching.*
Fully integrated (Full-3)	Students complete an online lab through a Learning Management System (LMS) in which they use motion detectors to replicate kinetic graphs using their own bodies (showing relationships between time and velocity). The teacher provides digital data and graphs of varying levels of complexity for different groups of students and labs are completed in pairs or small groups that may collaborate with each other. Labs are completed and submitted through the LMS, which also allows student groups to collaborate with each

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	other and discuss various aspects of their graphs online. The teacher is also able to grade the labs and provide feedback to the student groups through the LMS. *Full: The use of motion detectors and the LMS to collaborate and complete the assignment enable a level of personalized learning that would otherwise be very difficult to accomplishment without the technology.*

3.5 Contextualized Teaching

One of the more common ways to increase the relevance of science to students includes making connections between the content and the real world in which students live. Contextualization is distinct from engagement in scientific practice such that the latter involves a focus on what students are being called on to do, whereas contextualized teaching focuses on the relevance of students' work. This idea of increasing relevance is also sometimes referred to as authentic learning (Lombardi, 2007; Reeves, Herrington, & Oliver, 2002). Grounding lessons in the local geographic context, making connections to youth culture, or matching classroom tasks and activities with those of professionals in practice are all ways in which learning can be made more relevant or authentic to students (Brophy, Klein, Portsmore, & Rogers, 2008; Hayden, Ouyang, Scinski, Olszewski, & Bielefeldt, 2011; Miller, Chang, Wang, Beier, & Klisch, 2011). Technology can be used to support and facilitate this type of authentic learning via such tools as web resources and search engines, online discussions or emails, online simulated environments, digital photography or voice recorders (Herrington & Kervin, 2007).

This section of the *TOP-Science* Excel workbook is where the observer records the extent to which the activities during an interval are contextualized. In this protocol, contextualized teaching is defined by incorporating lesson material related to the students or issues beyond the instructional setting (Table 5). Three components we consider in our framework are: 1) relevant to youth experiences, 2) linked to science careers or work, and 3) grounded in the local/geographical context.

- **Category.** The observer should note whether contextualization occurs within one of the sub-categories and document in the evidence text box if/how this occurs.
    - Relevant to youth experiences (e.g., topic and/or learning goals relate to contemporary events, youth culture, or cultural background),
    - Linked to science careers or work (i.e., connection is made to science careers, career tracks, and/or the work of scientists), and
    - Grounded in the local/geographical context.
- **Level.** Observers should record "Incidental-1" (incidental connection) or "Embedded-2" (embedded connection) when observing teachers making youth-relevant, science career, and/or local connections. If observers have not observed any occurrence of any of the three contextualized teaching types, they should record a "No evidence-0" (no connection). **Incidental** contextualization would occur when a teacher makes a brief reference or single statement, in order to connect what is being taught to youth experiences, science careers or the work of scientists, or to a local context. Evidence of **embedded** contextualization would be if the entire lesson is integrated and connected to something to which the students can relate (i.e., youth experiences, science careers or work, or their local area/geographic location), or if the teacher involves students in a more detailed discussion of the relevance of the topic. A "No evidence-0" code would indicate the observer sees **no evidence** of contextualized teaching during the interval.
- **Technology.** If technology is used to promote contextualized teaching, this should be briefly described in the evidence text box and the appropriate technology integration code should be selected.
    - **No tech-0 (No technology)**: Content is contextualized for students without the use of technology.

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- **Minimal-1 (Minimally integrated)**: The technology provides access to or information about contextualized content; this information could be communicated without technology
- **Partial-2 (Partially integrated)**: The technology provides access to or information about contextualized content; students use technology to manipulate the information, data or other resource in some way
- **Full-3 (Fully integrated)**: The technology provides access to or information about contextualized content; students use technology to manipulate the information, data or other resource in some way. Students are able to engage with the contextualized information in a complex way that would not be possible without the technology. The activity may take place over multiple days in order to be immersed in the context.
- **NA-99**: Students use technology, but no evidence of contextualized content is observed. (By manually choosing NA-99, the observer clarifies that the lack of a code is not missing data.)

- **Evidence.** Observers should record in the *Evidence* box specific justification for the selected category, level and technology integration with contextualized teaching. If technology is not used for a particular activity, but is related to or connected to a previous activity during which technology was used, this connection should be noted.

TABLE 5: Contextualized teaching example (connection to students' interest in local watershed)	
No technology (No tech-0)	In a lesson about water conservation and what towns and cities are doing about cleaning up water, the teacher provides printed reading material from their local watershed organization's website. Students read about and discuss local water conservation and cleanup efforts. They can see the local watershed data on the printed material and look for patterns in the data. *No tech: printed material.*
Minimally integrated (Minimal-1)	In a lesson about water conservation and what towns and cities are doing about cleaning up water, the teacher provides access to their local watershed organization's website. Students read about and discuss water conservation and cleanup efforts in their local watershed. They can see the watershed data online and look for patterns in the data. *Minimal: students reading teacher-provided information online which is similar to analog experience of reading on paper.*
Partially integrated (Parital-2)	In a lesson about water conservation and what towns and cities are doing about cleaning up water, the teacher provides access to their local watershed organization's website. Students read about and discuss water conservation and cleanup efforts in their local watershed. They can see the watershed data online and look for patterns in the data. The students download data for stream health and land cover in upstream watershed for their local stream site. They create scatter plots of the data to examine the relationship between stream health and land cover (i.e., percent impervious surface, percent forest, percent farmland, percent lawn). *Partial: The ability for the students to download, manipulate, and analyze the local stream site data allows the students to better understand the information and increase their interest in watershed health and needed conservation efforts.*
Fully integrated (Full-3)	In a lesson about water conservation and what towns and cities are doing about cleaning up water, the teacher provides access to their local watershed organization's website. Students read about and discuss water conservation and cleanup efforts in their local watershed. They can see the watershed data online and look for patterns in the data. The students download data for stream health and land cover in upstream watershed for multiple stream sites within their larger watershed. They create multiple scatter plots of the data to examine the relationship between stream health and land cover (i.e., percent impervious surface, percent forest, percent farmland, percent lawn), and examine how their site compares to others along the trend line. Students also gather information on cleanup efforts from the EPA web site. *Full: Students are able to obtain information not only of their local sites, but also wider geographical area so they can expand their analyses to better learn and understand how they local efforts compare with those in other regions.*

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3.6 Observer Reflection

This section is where observers can record any notes about a particular interval. This section is optional, and any evidence of selected codes should be recorded in the relevant evidence boxes.

4.0 PrePost Data Tab

The **PrePost Data** tab of the *TOP-Science* Excel workbook is where data entered into the **PrePost** tab are automatically aggregated and stored. It can be used to review data or to export data. Every classroom observation consists of one PrePost record (row), as well as multiple 10-minute intervals. Data cannot be changed in this tab. Instead, any edits must be made to the original data in the **PrePost** tab; these edits will be automatically updated in the **PrePost Data** tab when the observer clicks on *Update & Save* button.

5.0 Interval Data Tab

The **Interval Data** tab of the *TOP-Science* Excel workbook is where data entered into the **Interval** tab (i.e., all the 10-minute intervals for an observation) are automatically aggregated and stored. It can be used to review data or to export data. There is one row per interval record. As noted, every classroom observation consists of one PrePost record and multiple 10-minute intervals; these are linked by a common Observation ID (note that the Observation ID for intervals includes an interval number). Data cannot be changed in this tab. Instead, any edits should be made to the original data in the **Interval** tab; these edits will be automatically updated in the **Interval Data** tab when the observer clicks on *Update & Save* button.

6.0 Reference Tab

The **Reference** tab of the *TOP-Science* Excel workbook provides a glossary of terms and codes used in the workbook. If you prefer to simultaneously view this tab and the tab in which you are working, do the following:

- Open the *TOP-Science* Excel workbook and enable macros.
- From the *Window* menu (*View* menu on a MS Windows operating system), select *New Window* to open a second copy of the workbook that is connected to the first one (i.e., anything entered into the first copy will simultaneously be entered into the second one).
- Return to the original copy of the *TOP-Science* Excel workbook. From the *Window* menu (*View* menu on a MS Windows operating system), select *Arrange* (*Arrange All* on a MS Windows operating system), *Vertical*, and then *OK*.
- In the second window, view the **Reference** tab while working in the **PrePost** and **Interval** tabs in the first window

7.0 *TOP-Science* Post-Observation Summary Overview

Observers can synthesize their observation data using the *TOP-Science Post-Observation Summary* workbook (a separate Excel workbook) to determine quality for an observation. Instructions for using the *TOP-Science Post-Observation Summary* workbook are provided in section 10.0 of this reference guide.

The *TOP-Science* protocol results are rich in data describing technology integration in the classroom, and researchers can analyze the data in whatever way best serves to address their research questions. We

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provide here a post-observation summary form to synthesize the observations across the teacher pre- and post-questions and the multiple interval sheets that aligns with our Classroom Technology Implementation Framework. The quantitative results (summing together the numerical values of the codes) provide one indication of quality, with higher values indicating higher quality, and the qualitative results provide evidence of that quality. The flexible nature of the post-observation summary allows researchers to determine a more global synthesis code for the observation, as well as drill down into the specifics of particular categories, depending on their needs and interests.

8.0 *TOP-Science* Excel Workbook Instructions

Section 8.1 provides a brief description of the five steps to using the *TOP-Science* Excel workbook. Sections 8.2 through 8.6 provide more detailed instructions that guide you through these five steps. Prior to setting up the workbook you will use for observing classes in your investigation, it is highly recommended you first set up a practice workbook and use it with example classes or videos of classes to familiarize yourself and to experiment with workbook functions.

8.1 How to use the *TOP-Science* Excel workbook in a nutshell

STEP 1: Setting up an observation

1. Determine a convention for creating a unique 8-alphanumeric character *Observation code* for each observation. For example, you may wish to include abbreviations for the school, teacher, class and visit number as part of this code (i.e., your second observation of Jane Doe's honors biology class at John Marshall High School could be JMJDHB02).
2. Gather pre-observation information from the teacher.
3. Select the **PrePos**t tab, enter observer information to create and save a new workbook (following provided prompts), enter observation information, and click *Update & Save*.
4. NOTE:
    - The *Observation code* must be only 8 alphanumeric characters.
    - These data make up one PrePost record, which is stored in the **PrePost Data** tab and is linked to a set of 10-minute intervals.
    - If you wish to paste text from another document into this one, you must paste into the formula bar. Insert/paste additional text at the cursor at any point and time. Within the workbook, text can also be copied and pasted into the formula bar. DO NOT double-click the cell and paste directly to it, as that method would apply the formatting of the copied text, which could corrupt the workbook.
    - You can create and update and save multiple PrePost records in preparation for multiple sets of observations. You have the option of clearing before starting a new PrePost record, or keeping and editing the previous record.

STEP 2: Making observations

1. Load the appropriate PrePost record in the **PrePost** tab.
2. Select the Interval tab and
    - Confirm the *Observation ID* is correct.
    - Click on *Timestamp* to start the 10-minute interval.
    - Record interval data.
    - After 10 minutes, stop entering data and click *Update & Save* (respond to prompt).
    - Click on *New Interval* to start the second interval and repeat above steps.

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- Continue until all 10-minute intervals for an observation are completed.

3. NOTE:
   - If you forgot to click the *Timestamp* button at the beginning of the interval, you can click the timestamp more than once or type directly in the timestamp gray box to edit the timestamp. If you do this, the *Created_timestamp* and the *User_timestamp* in the Interval data will be different. For an interval record in the **Interval Data** tab, Created_timestamp is the time when the interval is created (i.e., the first time the observer clicks on the *Update & Save* button during an interval.) User_timestamp in an interval record is the time stamp that is above the green *:Timestamp* button when the user (i.e., observer) clicks on the *Update & Save* button to manually mark the time. You can save at any time during a 10-minute interval using the *Update & Save* button, but you must click *Update & Save* when you finish completing each 10-minute interval.
   - After completing and saving one interval, the observer will have the choice of clearing out the text to start fresh for the next interval, or keeping and editing the previous interval text for the new interval.
   - The data from the Interval tab is stored in the **Interval Data** tab, and each set of Interval records is linked to one PrePost record.
   - The **Reference** tab provides quick help for completing the workbook. There are also pop-up windows on other tabs to help the observer navigate the workbook.

STEP 3: Completing an observation

1. After completing all the intervals, talk with teacher to get responses to the post-observation questions.
2. Select **PrePost** tab, enter teacher's responses, and click *Update & Save*.
3. Back up the macro-enabled workbook often and ideally maintain a separate backup of each observation. If the workbook somehow becomes corrupt, you can use the last backup and will only lose the most recent observation.
4. To access a completed observation, load the observation in the in the **PrePost** tab, and then load the desired interval in the **Interval** tab.

STEP 4: Using *TOP-Science* observation data in other analysis tools

1. Import PrePost Data and Interval Data worksheets into another data analysis tool.
2. Export data as .CSV file to be used in other data analysis tools.

8.2 Setting up an observation (Step 1)

8.2.1 Prepare study and gather information from teacher via email or phone

1. Determine a convention for creating unique 8-alphanumeric character *Observation code*. You might use letters of the teacher, school and course name, as well as numbers for the date; but you are limited to 8 characters. Do no use special character.

   This *Observation code* will become part of an *Observation ID*. Each observation within a *TOP-Science* Excel workbook has a unique *Observation ID* that appears on the **PrePost** and **Interval** tabs. This ID is used to link a PrePost record with a set of 10-minute intervals. The Observation ID consist of

   - 8-alphanumeric character Observation code (provided by the observer)
   - 3 computer-generated numbers (provided by Excel)
   - 2 initials from the observer name (name provided by the observer)

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For each interval, there is an *Interval ID* that consists of the *Observation ID* and the interval number.

2. Gather the following information for the observation:
   - teacher name, school name, course name, observation date(s), number of students, and grade level(s).
   - responses to the pre-observation questions

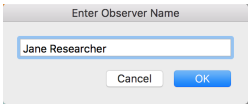
8.2.2 Create and Save a New Workbook using PrePost tab

As previously noted, each observer will have one *TOP-Science* Excel workbook for all their observations. Use the following steps to create and save this workbook.

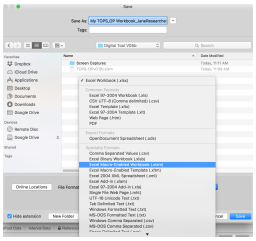
1. Open the *TOP-Science* Excel workbook, and in the pop-up window, select the option to enable macros so that the workbook functions properly. This workbook is from a trusted source, and the macros do not contain viruses that could be harmful to your computer. The workbook will open in the **PrePost** tab of the workbook.

2. In the *Observer* section, click in the orange **Enter Observer name now* text box. A pop-up window will open warning that this name will be encoded in every Observation record. This entry will be permanent. Click *OK* if/when ready to proceed. If you are not ready to proceed, click *Cancel*.

3. In the "Enter Observer Name" window that opens, type the first name, then a space, and last name of observer in the text box (e.g., Jane Researcher). Use letters and spaces only. Click *OK*.



4. In the "Save" window that opens, choose a suitable name and folder for your new custom workbook. Confirm the *File Format* you are saving it as is "macro-enabled workbook" (if not, the workbook will not function). Click *Save*. The *TOP-Science* Excel workbook will save as the name you provided in the location you selected, and you will be returned to the **PrePost** tab of the workbook. The observer's name will now appear in orange next to "*Observer name."



5. Close the workbook, or continue to the next section to enter pre-observation data.

8.2.3 Create an Observation ID and enter pre-observation data for new observation using the *PrePost* tab

1. If you are not continuing directly from the previous section, open your workbook and be sure to enable macros.

2. In the **PrePost** tab, complete the fields in the *Class Info* section. (Note: the cursor may disappear but you can identify your location by the highlighted row number on the left side of the window.)
   - Click in the *Teacher name(s)* text box, and type the name(s) of the teacher(s) being observed. Ideally, you would only enter one name but you could enter a string of names if there are multiple teachers (e.g., Brenda Fulton and Robert Crouch).

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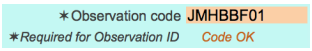
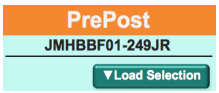
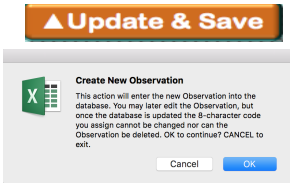
- Click in the *School name* text box, and type the name of the school being observed (e.g., John Marshall HS).
- Click in the *Course name* text box, and type the name of the course being observed (e.g., Honors Biology).
- Click in the *Observation Dates* text box, and type the dates observing this class for this particular unit of observation. Typically, you would only enter one date; however, you may enter multiple dates if, for example, you are observing one lesson over the course of multiple days.
- Click in the boxes to select the appropriate *Student Grade Level*(s).
- Notice the **Observation code* text box is orange as it is required to generate the *Observation ID*. In this text box, enter your 8-alphanumeric characters based on your coding scheme (e.g., "JMHBBF01"), and click "Enter." You should see "Code OK" after "Required for observation ID" below the Observation code. If you entered a special character or the wrong number of characters, you will see an error message under the Observation code; if necessary, re-enter the code.

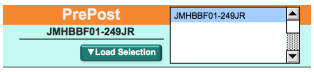


3. An *Observation ID* (e.g., "JMHBBF01-249JR") will be generated using the Observation code you entered, a computer-provided three-digit number from 100-999, and the observer's initials. This *Observation ID* will appear in the upper left corner of the *Pre-Post Toolbar*.



4. Save this observation data in the workbook.
   - Click the *Update & Save* button in the *Pre-Post Toolbar*.
   - A "Create New Observation" pop-up window will open warning that this will enter the new observation into the database, and <u>you will not be able to change the 8-character observation code or delete the observation</u>.
   - Confirm the *Observation code* is correct.
     - If the code is not correct, hit *Cancel*, edit the code, and then click *Update & Save* again.
     - If/when the code is correct, click *OK* to save the workbook.
   - The *Observation ID* will now appear in the scrollable list in the *Pre-Post Toolbar*, and the entire Observation Workbook is now saved.
   - A new row for this PrePost record is created in the **PrePost Data** tab and populated with the data entered.





> ***Tip: You MUST use the Update & Save button provided within the tab, NOT the Excel File Save options (i.e., icon, menu option, or keystroke), to save changes. As described, Update & Save (1) transfers the record to the PrePost Data and Interval Data tabs AND (2) saves the entire workbook on computer. Using the Excel File Save options as you work could result in the observer saving the workbook without updating the PrePost Data and Interval Data databases, especially if user quits immediately after manually saving in this scenario.***

5. Enter the teacher's responses under the appropriate rows in the *Pre-observation Teacher Q&A* section. To copy external text to the workbook, copy conventionally. Next, select the desired workbook cell, then select and paste <u>into the formula bar</u>. Insert/paste additional text at the cursor at any point and time. Within the workbook, text can also be copied and pasted <u>into the formula bar</u>. <u>DO</u>

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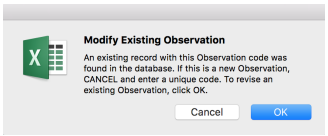
NOT double-click the cell and paste directly to it, as that method would apply the formatting of the copied text, which could corrupt the workbook.

> ***Note: Pasted text with more than about 300 characters or lots of line breaks will extend beyond the visible cell after entry; thus, you should use the formula bar to view text. Expanding the formula bar by dragging its lower edge will help. If the text is long, the observer will need to navigate up or down the formula bar with the scroll bar.***

6. Click *Update & Save* button the workbook (see Step 4 of this section if necessary). A "Modify Existing Observation" pop-up window will ask you to confirm that you wish to modify an observation record already in the database. To proceed with updating and saving these changes, click *OK*. The row for this PrePost record in the **PrePost Data** tab will be updated with the data entered.



7. Close the workbook if you are not immediately going to perform the observation. You may use the Excel File *Save* options (i.e., icon, menu option, or keystroke) at this time as prompted when closing the workbook; however, we advise against using it during the observation. Instead, during the observation, use the *Update & Save* button provided within the tab in which you are working to avoid saving the workbook to disc without updating the database. This is advised to reduce the risk of losing data by inadvertently using the Excel File *Save* function without first using the workbook's *Update & Save* function.

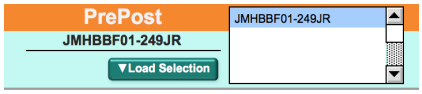
8.3 Making an observation (Step 2)

8.3.1 Load the desired observation in the PrePost tab

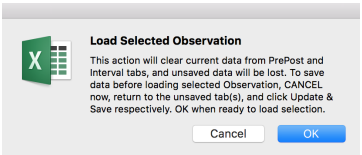
To start the first interval of an observation (or update an existing interval), you must first load its PrePost record using the **PrePost** tab.

1. If necessary, open your workbook.

2. Locate the desired observation's Observation ID in the scrollable list in the PrePost toolbar at the top of the **PrePost** tab. Click on the desired Observation ID.



3. Click the *Load Selection* button. A "Load Selected Observation" pop-up will warn that unsaved data will be lost.
   - If you have unsaved data, click *Cancel*. *Update & Save* the current observation, and then select the desired observation from the list again and click *Load Selection*.
   - If/when you are certain your current observation is saved click *OK* to load the desired observation.
   - All the data for this Observation ID (PrePost and Interval) will be added to the appropriate tabs where it can be reviewed and updated as directed in the following sections.



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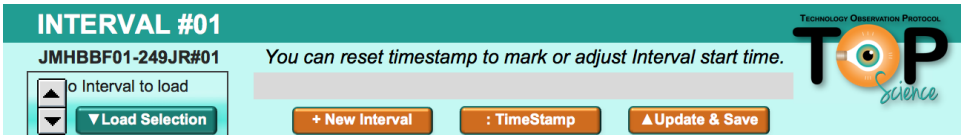
> ***Note: If you are entering data for an observation and wish to look at data from a previous observation, Update & Save the observation you are currently working on before switching to the other observation. Failure to do so can result in loss of data.***

8.3.2 Enter and save intervals of an observation using the Interval tab

An "interval" is a 10-minute time period within an observation. The observer must manually and consistently keep time.

1. Go to the **Interval** tab. Confirm the desired *Observation ID* is listed at the top of the page; if it is not, repeat/perform the steps in section 8.3.1. Notice, in the upper left of the page, "Interval #01" listed in the header; also "#01" has been added to the Observation ID, indicating this is the first interval for this observation.



2. To begin recording observation data for the first interval, hit the *:TimeStamp* button at the top of the page.
   - This marks the current time both in the Interval Toolbar in the **Interval** tab and in the first row of interval data for this observation in the **Interval Data** tab.
   - You will need to determine a targeted end time (10 minutes from the start time), and keep track of the time.

> ***Tip: If you forgot to click the Timestamp button at the beginning of the interval, you can click the timestamp more than once or type directly in the timestamp gray box to edit the timestamp. If you do type directly in the timestamp gray box, the User_timestamp in the Interval data will reflect the time you provided.***

3. Complete the interval form.
   - Work quickly to record all ratings and evidence during a particular 10-minute interval. Trying to recall ratings and evidence after an observation can lead to missing or erroneous data.
   - To do a "hard return" (to start a new line or paragraph) in an evidence box, hit "alt" and "return" keys at the same time.
   - When entering category codes, you should check at least one of the multiple sub-categories or select "No evidence - 0" under *Level*. More than one category code may be selected, but only one level code and one technology integration code may be selected. The level and technology integration codes should be selected based on what best reflects the entirety of the 10-minute period.
   - If you have any questions about key terms, look them up in the **Reference** tab.

4. You may save your work any time during the 10-minute interval - and you MUST save it at the end of the interval - by clicking the *Update & Save* button at the top of the **Interval** tab.

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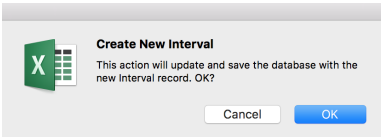
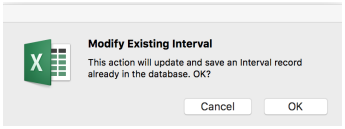
- The first time you click *Update & Save* in the **Interval** tab, a "Create New Interval" pop-up will warn "This action will update and save the database with the new interval record. OK?"
- Click *OK* to complete a new record (row) in the **Interval Data** tab with the data you entered into the interval form and save the entire workbook.



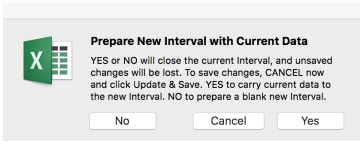
Interval_ID	Created_timestamp	User_timestamp	Int_num	Observation_ID	Activities_observed	Hardware_types	Software_app	TA_type_instructional	TA_type_iquitous
JMHBBF01-249JR#01	5/24/18 4:11 PM	5/24/18 4:05 PM	1	JMHBBF01-249JR	Test	Test	Test		

- You may *Update & Save* the interval data multiple times during a given 10-minute observation period. After the first time, subsequent saves will result in a "Modify Existing Interval" pop-up warning "This action will Update & Save an Interval record already in the database. OK?" Click *OK* to update that record and save the entire workbook.



> ***Reminder: You MUST use the* Update & Save *button to save your work in the* TOP-Science *Excel workbook in order to have data from PrePost and Interval tabs aggregated in the PrePost Data and Interval Data tabs, respectively. Simply using an Excel* Save *function will NOT accomplish this.***

5. To begin the next interval, click the *+New Interval* button in the *Interval* toolbar. A "Prepare New Interval with Current Data" pop-up will open with three options (the order of the buttons for these options varies between a Mac and a MS Windows operating system).



   - Click on the button for your choice:
     - Yes: If the activities in this new interval are a continuation of the activities in the previous interval, click *Yes* to carry the current data to the new interval (you may edit it as needed once you begin the new interval).
     - No: If the activities in this new interval will be new and you'd like to start the new interval with a blank worksheet, click *No*.
     - Cancel: If you have not updated and saved the current interval, click *Cancel. Update & Save* it as directed in the previous step before clicking on the *+New Interval* button again.
   - Once you start the new interval, notice, in the upper left of the page, "Interval #02" listed in the header. Also notice "#02" has been added to the record's observation ID to indicate this is the second interval for the observation.
   - Notice the timestamp is also automatically updated. You can reset the timestamp to mark or adjust the Interval start time by clicking *:TimeStamp*.

6. Repeat steps 4 through 6 - recording observations for 10-minute intervals, updating and saving interval data in the **Interval Data** tab, and then loading new intervals - until the class is over. You can create as many intervals as needed.

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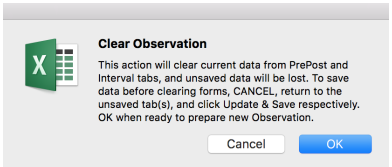
> ***Note: The observer can return to any interval at any time to edit or add more text and re-save. To do so, use the up/down arrows to select the desired interval from the scrollable list at the top of the Interval tab, and click Load Selection; you will get a warning asking if you want to save the current data. You can then review and add more text, clicking the Update & Save button when finished.***

8. After updating and saving the final observation, back up the macro-enabled workbook with another filename (e.g., add "backup" to the current workbook filename). Ideally you should maintain a separate backup of each observation. If the workbook somehow becomes corrupt, you can use the last backup and will only lose the most recent observation.
9. Close the *TOP-Science* Excel workbook. Again, you may use the Excel File *Save* options (i.e., icon, menu option, or keystroke) at this time as prompted when closing the workbook.

8.3.3 Making subsequent observations

Each observer will make multiple observations for a given study. While the observations themselves are performed in the same way, there are a couple steps to prepare the workbook for a new observation.

1. As with the first observation, gather information from teacher via email or phone.
2. Open the workbook in which the first observation was recorded.
3. Go to the **PrePost** tab, and click *0 Clear*. A "Clear Observation" pop-up will open.
   - If you are continuing directly from the previous observation, be sure you updated and saved that data. If you did not, then click *Cancel* and *Update & Save* the workbook.
   - If you are certain the previous observation has been updated and saved, click *OK* to clear the current data from **PrePost** and **Interval** tabs.



> ***Note: Data from the previous observation will remain in the PrePost Data and Interval Data tabs.***

4. Repeat sections 8.2.3 through 8.3.2 of these instructions to enter and save PrePost and Interval data for this observation.
5. Data recorded for each observation will again be compiled in the **PrePost Data** and **Interval Data** tabs.

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8.4 Completing an observation (Step 3)

8.4.1 Record responses to post-observation teacher questions using the PrePost tab

Use the *Post-Observation Teacher Q&A* questions to interview the teacher and enter their responses in the **PrePost** tab.

1. If you have not already done so, open the appropriate *TOP-Science* Excel workbook and load the desired observation in the **PrePost** tab (see section 8.3.1).

2. Under *Post-Observation Teacher Q&A, e*nter the teacher's responses to questions. As a reminder, if you are copying external text to the workbook, you must paste it into the formula bar. DO NOT double-click the cell and paste directly to it, as that method would apply the formatting of the copied text, which could corrupt the workbook.

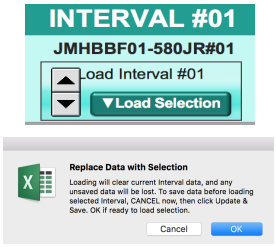
3. Click *Update & Save* button to save the workbook and update the PrePost Data record. Close the *TOP-Science* Excel workbook.

8.4.2 Accessing specific PrePost and Interval data in the workbook

Once observation data is saved, an observer can go back and view and edit that data.

1. Open the workbook and load the data for the desired observation (see section 8.3.1). You can view data in the **PrePost**, **Interval**, **PrePost Data**, and **Interval Data** tabs, but you can only edit data in the **PrePost** and **Interval** tabs.

2. Load the data for the desired interval in the workbook.
   - In the **Interval** toolbar in the **Interval** tab, use the scrollbar to locate and select the desired interval.
   - Click the *Load Selection* button. A "Replace Data with Selection" pop-up will warn that unsaved data will be lost.
     - If you have unsaved data, click *Cancel*. *Update & Save* the current observation, and then select the desired observation from the list again and click **Load Selection**.
     - If/when you are certain your current observation is saved click *OK* to load the desired observation.



3. Update & save any changes.

8.5 Using *TOP-Science* observation data in other analysis tools (Step 4)

One of the advantages of using the *TOP-Science* Excel workbook is that stored data can be exported and manipulated for further analysis in automated data analysis tools. For example, for a study involving multiple observers, the data from their individual workbooks can be exported and merged into one database.

For analysis tools that have Excel worksheet import capacities, observers can use the tools' mechanisms to import data from the PrePost Data and Interval Data worksheets. The names of the data fields are in the first row of the data worksheet.

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For analysis tools that use CSV files, observers can export the data from the PrePost Data and Interval Data worksheets (one at a time) by using Excel's export or save as functions.

Following are some information about the organization and data in the CSV data files:

- The first row contains the name of the data column.
- The Observation IDs (column A in the PrePost CSV file and column E in the Interval CSV file) can be used to link PrePost and Interval records.
- In cells for data entered via checkboxes, FALSE or no entry means the box was not checked, and TRUE means the box was checked.
- In cells for data in the SEP Level, SCT Level, and CT Level columns, the meaning of the values are: 0 = No evidence, 1 = incidental, 2 = embedded, Blank = no option was selected.
- In cells for data in the SEP Tech, SCT Tech, and CT Tech columns, the meaning of the values are: 0 = No Tech, 1 = Minimal, 2 = Partial, 3 = Full, 99 = NA (i.e., technology was not applicable as there was no evidence of SEP, SCT or CT observed), Blank = no option was selected.

9.0 Troubleshooting the *TOP-Science* Excel Workbook

Again, we encourage observers to back up their observation data in macro-enabled workbooks. If your *TOP-Science* Excel Workbook is corrupted for any reason, download a new copy from one of the following websites:

- http://topscience.edc.org/index.php/resources/
- http://research.al.umces.edu/cat-stylinski/top-science/

To recover data from a corrupted *TOP-Science* Excel workbook, you may try to save the workbook as a CSV file. While you will not be able to import these data into a new uncorrupted macro-enabled *TOP-Science* Excel workbook, you should be able to open the CSV data in another Excel workbook to view it.

If you find you have an erroneous row of data in your **Interval Data** tab, there is no way to delete that interval from your *TOP-Science* Excel Workbook as doing so would compromise the integrity of the data and could affect workbook function. You can work around this by typing, for example, "Invalid Record" in the first text field in the **Interval** tab for an erroneous interval. When analyzing the observation data, records marked in this way could be deleted or ignored either manually or with a script.

10.0 *TOP-Science* Post-Observation Summary Workbook Instructions

The *TOP-Science* Post-Observation Summary Workbook is available at the following websites:

- http://topscience.edc.org/index.php/resources/
- http://research.al.umces.edu/cat-stylinski/top-science/

DO NOT start the post-observation summary until the entire observation and pre- and post-observation data are complete. Section 10.1 provides a brief description of how to use the *TOP-Science* Post-Observation workbook. Sections 10.2 through 10.4 provide more detailed instructions that guide you through these five steps.

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10.1 How to use the *TOP-Science* Post-Observation workbook in a nutshell

1. Open the *TOP-Science Post-Observation Summary* workbook (this is a separate Excel workbook) and save it with an appropriate name.

2. Open the observation workbook.
3. Summarize the qualitative description of the classroom by using the observation workbook **PrePost** and **Interval** tabs to respond to the questions in the *Content* section of the *TOP-Science Post-Observation Summary* worksheet. For each, write a 1-3 sentence summary of evidence or examples.

4. In the SEP, SCT, and CT sections of the *TOP-Science Post-Observation Summary* worksheet, insert the necessary number of interval rows (corresponding to number of intervals observed); and then insert the Excel formula AVERAGE to calculate the average *Level* and *Tech* scores for each category (i.e., *SEP*, *SCT*, and *CT*) in the *[calculate average]* cells. NOTE: "99" means "NA-99" (i.e., not applicable) was recorded for a particular interval, so that "99" should be changed to a blank cell (NOT a "0").

5. Use the observation workbook **Interval** tab to respond to the questions regarding how technology contributed to each category. For each, write a 1-3 sentence summary of the evidence for how technology contributed to the category.

6. Using your results in the *TOP-Science Post-Observation Summary* worksheet, select the Interval with the overall highest ratings in each of the three categories. Enter the results from that sheet in the section "Highest Interval Sheet," and synthesize the most relevant evidence that summarizes the highest interval sheet.

7. Save the *TOP-Science Post-Observation Summary* workbook.

8. To summarize additional observations, duplicate the summary worksheet in additional tabs in the *TOP-Science Post-Observation Summary* workbook.

10.2 Summarizing the qualitative description of a classroom

The first part of the post-observation summary provides a way to describe the overall characteristics of the classroom. The observer should use the identified data source to complete the brief description for each row. This section provides prompts to describe key technology components of the classroom and provides a standardized description of each classroom that focuses on teacher intentionality in technology integration.

Content	Data source	1-3 sentence description
Name of course and grades of students	Pre-questions	
Big ideas students are working on and how teacher has designed technology to support those ideas	Pre- and post-questions	
Specific technology use in the lesson (e.g., hardware, software, technology application types, activities students engaged in)	Pre-questions and interval data	

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How this lesson fits in with other technology use; coherence of content and technology use	Pre-questions and interval data	
Challenges in lesson and how teacher addressed them (e.g., technology glitch, classroom management)	Interval data and post-questions	

To complete the first part of the post-observation summary:

1. Open the *TOP-Science Post-Observation Summary* workbook (this is a separate Excel workbook) and save it with an appropriate name.

2. Open the observation workbook.

3. Use data in the observation workbook **PrePost Data** and **Interval Data** tabs to respond to the questions in the *Content* section of the *TOP-Science Post-Observation Summary* worksheet.
   - For each question, read over all the relevant evidence, summarize the evidence for that question in 1-3 sentences, and then type the evidence or examples in the appropriate cell in the *TOP-Science Post-Observation Summary* worksheet.
   - Do NOT simply copy/paste all the evidence from the *TOP-Science* Excel workbook into the *TOP-Science Post-Observation Summary* worksheet. If you find the need to copy/paste a common piece of evidence, you will not be able to copy from the formula bar. Instead, you will have to click on the cell, copy it, and then paste the entire contents into the *Post-Observation Summary* worksheet.

> ***Tip: To view evidence in the* PrePost Data** and **Interval Data** tabs, *click in the desired cell and then click on the arrow at the far right side of the formula bar to expand the formula bar and display all of the text from the cell. You may need to use the scroll bar to view all of the text.***

10.3 Summarizing the interval data by framework category

The summary provides space for both the quantitative codes and the qualitative evidence. The quantitative code values can be copied onto the sheet and then summed and averaged. The sum and the average only provide one aspect of the observation, and the evidence from each of the interval sheets is equally important. Use the text from the "Evidence" section of each interval sheet to complete the Evidence section of the summary. Once all the evidence has been listed, synthesize the key evidence to provide an overall description of technology integration for each of the SEP, SCT, and CT categories. It is recommended to include both the specific SEP, SCT and CT aspect observed as well as the evidence recorded on the interval sheet.

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Science and Engineering Practices (SEPs)

	SEP Level	SEP Tech	How technology contributed to student use and/or understanding of SEPs (Key evidence and 1-3 examples; note specific SEP as relevant)
Sample row	*[copy from Interval Data tab]*	*[copy from Interval Data tab]*	*[Synthesize from evidence box on Interval Data tab]*
Interval 1			
Interval 2			
Interval 3 … (add rows as needed)			
Average science and engineering practices score	*[calculate average]*	*[calculate average]*	*[Observer synthesizes from justification on this summary sheet to provide an overall description of how technology contributed to student use and/or understanding of SEPs]*

Student-centered teaching (SCT)

	SCT Level	SCT Tech	How technology contributed to student-centered teaching (Key evidence and 1-3 examples; note autonomy, personalization, competency-based as relevant)
Sample row	*[copy from Interval Data tab]*	*[copy from Interval Data tab]*	*[Synthesize from evidence box on Interval Data tab]*
Interval 1			
Interval 2			
Interval 3 … (add rows as needed)			
Average student-centered teaching score	*[calculate average]*	*[calculate average]*	*[Observer synthesizes from justification on this summary sheet to provide an overall description of how technology contributed to student-centered teaching]*

Contextualization (CT)

	Context Level	Context Tech	How technology contributed to contextualization (Key evidence and 1-3 examples; note youth-focused, science-focused; time/place relevance as relevant)
Sample row	*[copy from Interval Data tab]*	*[copy from Interval Data tab]*	*[Synthesize from evidence box on Interval Data tab]*
Interval 1			
Interval 2			
Interval 3 … (add rows as needed)			
Average contextualization score	*[calculate average]*	*[calculate average]*	*[Observer synthesizes from justification on this summary sheet to provide an overall description of how technology contributed to contextualization]*

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To summarize the interval data in the post-observation summary:

1. In the SEP, SCT, and CT sections of the *TOP-Science Post-Observation Summary* worksheet, insert the necessary number of interval rows (corresponding to number of intervals observed).

2. Use data in the observation workbook **Interval Data** tab to enter the *Level* and *Tech* scores for each interval in the SEP, SCT, and CT sections of the *TOP-Science Post-Observation Summary* worksheet. NOTE: "99" means "NA-99" (i.e., not applicable)" was recorded for a particular interval, so that "99" should be changed to a blank cell (NOT a "0")

3. In the *TOP-Science Post-Observation Summary* worksheet, in the *[calculate average]* cells, insert the Excel formula AVERAGE to calculate the average *Level* and *Tech* scores for each category (i.e., *SEP*, *SCT*, and *CT*).

4. Use the observation workbook **Interval Data** tab to respond to the questions regarding how technology contributed to each category. To do this,
   - For each interval in each category, read over all the evidence for how technology contributed to the category, and then write 1-3 statements that summarize the evidence for that interval. Type the evidence or examples in the appropriate cells in the *TOP-Science Post-Observation Summary* worksheet.
   - For each category, synthesize all the evidence for all the intervals in 1-3 statements. Type the evidence or examples in the appropriate cells in the *TOP-Science Post-Observation Summary* worksheet.

10.4 Determining the highest interval rating

The last section of the summary provides an opportunity to focus on the interval sheet that describes the highest overall levels of the codes. This allows researchers to highlight particular moments of the class that illustrate high quality technology integration. The information for this section of the post-observation summary should come from a single interval, as it will describe the ten-minute period when the teacher incorporated the most elements of high-quality teaching. In some observations, the highest interval rating will be self-evident, while in others high quality technology integration in SEPs might have happened in one interval and high quality technology integration in SCTs in another. In those cases, the researcher should use his/her best judgement to choose the interval, or he/she may decide that no single interval included sufficient high quality technology integration to be included, and thus would only use the averages and summaries above.

Highest Interval # ____	**Level**	**Tech**	**How technology contributed to each (Key evidence and 1-3 examples)**
Sample row	*[copy from Interval Data tab]*	*[copy from Interval Data tab]*	*[Synthesize from evidence box on Interval Data tab]*
SEP			
SCT			
Contextualization			
Summary	NA	NA	*[Observer synthesizes most relevant evidence that summarizes interval sheet]*

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By providing the average scores across interval sheets as well as the highest-level interval for an observation, the post-observation summary allows the protocol to be flexible in how researchers can use the summary data, depending on their own qualitative or quantitative analyses. Multiple post-observation summaries across multiple observations can provide a description of similarities and differences across observations. This particular way of summarizing the data highlights quality of technology integration at the observation level; research that includes many observations may choose to summarize in other ways that provides less detail about each observation. The classroom observation data can also be summarized in any way that researchers find useful.

To calculate the highest interval rating in the post-observation summary:

1. For each of the three categories, using your results in the *TOP-Science Post-Observation Summary to*
   - select the Interval with the overall highest ratings in each of the three categories,
   - enter the results from that sheet in the section "Highest Interval Sheet," and
   - synthesize the most relevant evidence that summarizes the highest interval sheet.

2. Save the *TOP-Science Post-Observation Summary* workbook.

3. To summarize additional observations, duplicate the summary worksheet in additional tabs in the *TOP-Science Post-Observation Summary* workbook. We suggest using the observation IDs for the name of the summary worksheet tabs.

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Appendix A.

Technology Definitions

The *TOP-Science* protocol defines technology as the hardware and software involved with digital technology. We are more interested in the software, or technology applications, that may be used in high school science classrooms, but also consider the hardware that runs the particular digital software.

Digital technology includes machines and equipment that utilize processors which store or transmit information in digital format (Pullen, Baguley, & Marsden, 2009). Conway, Harris, Smith, Brackett, and Hayes (2016) define digital technology as "any information used on a computer or disseminated on a computer… [which] can enhance the level of creativity and distribution of information" (p. 206). A computer is any electronic device that accepts and processes data, usually in binary form (Computer, n.d.). While this is most commonly assumed to encompass desktop and laptop computers, it also includes such devices as mainframes, tablets, and smartphones. Consistent with these definitions of digital technology, examples may include computer programs and software, websites, databases, and digital media. Examples of equipment that should not be considered digital technology might include thermometers, hot plates, calculators (excluding scientific or graphing calculators), *unless* these instruments are connected to a computer that processes data communicated to it.

We understand that the term technology in the context of education and instruction has many varied definitions, and considered them when determining what we ultimately included in our own definition. Some of the definitions we reviewed are listed below:

- Instructional technology (Seels & Richey, 2012): "In its more familiar sense it means that media born of the communications revolution which can be used for instructional purposes alongside of the teacher, textbook and blackboard...the pieces that make up instructional technology: television, films, overhead projectors, computers and other items of 'hardware' and 'software'..." (p. 17).
- Educational technology (Januszewski & Molenda, 2013): Technology "resources, the hardware and software entailed in teaching… The pool of resources has expanded with technological innovations and with the development of new understandings regarding how these technological tools might help guide learners. Resources are people, tools, technologies, and materials designed to help learners. Resources can include high-tech ICT systems, community resources such as libraries, zoos, museums, and people with special knowledge or expertise. They include digital media, such as CD-ROMs, Web sites, WebQuests, and electronic performance support systems (EPSS). And they include analog media, such as books and other print materials, video recordings, and other traditional audiovisual materials" (p. 11-12).
- Instructional/educational technology (Newby, Stepich, Lehman, & Russell, 2000): Application of scientific knowledge about human learning to the practical tasks of teaching and learning.
- Educational technology integration (van't Hooft, 2009): "The process of utilizing digital technologies for teaching and learning" (p. 456).
- Technology applications (Ololube, 2015): "The application of technology tools and devices in the teaching and learning processes. It involves the usage, knowledge, skill and competence in the use of technology in solving problems or performing specific functions during and after academic activities" (p. 130).

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Appendix B.

Technology Examples

Instructional

- Gradebook (Engrade, LearnBoost)
- Concord Consortium Water Model
- Gizmo quiz program
- Edmodo
- Schoology
- Powerschool
- Google Classroom
- desmos scientific and graphic calculator
- Socrative
- Vernier Sensors, Probes, and lab software (LabQuests)
- PhET simulations
- Scratch
- NearPod

Ubiquitous

- email
- Web browsers
- Writing applications
- Spreadsheets
- Basic presentation software (e.g., Presi, PowerPoint)
- Google drive
- Internet Search Engines
- YouTube
- iMovie
- FaceBook chat
- OneDrive
- Wikis

STEM Workplace

- ArcGIS
- Microsoft Visio
- ImageJ
- Wolfram Mathematica
- STELLA

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