Title: Using the LifeGrid Interview Technique in Science Education Research

Authors: Ashley A. Rowland\textsuperscript{1}, Dimitri R. Dounas-Frazer\textsuperscript{2,3,4}, Laura Ríos\textsuperscript{2,3}, H. J. Lewandowski\textsuperscript{2,3}, Lisa A. Corwin\textsuperscript{1}

Affiliations: \textsuperscript{1}Department of Ecology and Evolutionary Biology, University of Colorado, Boulder, Boulder CO 80309; \textsuperscript{2}Department of Physics, University of Colorado, Boulder, Boulder CO 80309; \textsuperscript{3}JILA, National Institute of Standards and Technology and University of Colorado Boulder, Boulder CO 80309; \textsuperscript{4}Department of Physics and Astronomy, Western Washington University, Bellingham WA 98225

Corresponding author: Lisa A Corwin, Department of Ecology and Evolutionary Biology, 1900 Pleasant St., 334 UCB, Boulder CO 80309
Abstract

Qualitative interviewing is an essential tool utilized by Science, Technology, Engineering, and Mathematics (STEM) education researchers to explore and describe the experiences of students, educators, or other educational stakeholders. Some interviewing techniques use co-creation of an artifact, such as a personal timeline, as a unique way to elicit a detailed narrative from a respondent. Here, two groups of education researchers from physics and biology come together to describe an interview artifact called a LifeGrid. First used and validated in medical sociology to conduct life course research, the LifeGrid was demonstrated to reduce recall bias and facilitate an interview. We apply the LifeGrid interview technique to two educational contexts: 1) students in an advance degree program reflecting on their entire undergraduate career as a biology major, and 2) students in an undergraduate physics program reflecting on a multi-week lab project. Specifically, we elaborate on how the LifeGrid facilitates respondents’ agency, establishes rapport between interviewers and respondents, affects the depth of the respondents’ narratives, and constructs accurate accounts of events. We situate our experiences with respect to those attributes and compare and contrast them with the experiences detailed in literature. We conclude with recommendations for future use of the LifeGrid technique in undergraduate STEM education research. Overall, we find the LifeGrid to be a valuable tool to use when conducting interviews about phenomena with a chronological component.

Keywords: qualitative research, interviews, DBER, biology education, physics education, undergraduate, LifeGrid
I. Introduction

Qualitative research methodologies are foundational in STEM education research because they can elucidate educational mechanisms and provide detailed insights into how and why learning happens through rich and nuanced data collection. Qualitative approaches also allow educators to develop a better understanding of both student and educator experiences as well as examine the effects of institutional structure on educational experiences. Indeed, many breakthrough studies in STEM education have been accomplished using qualitative approaches. For example, McGee and Martin (2011) employed interviews to better understand how stereotype management among Black students facilitates success in mathematics and engineering contexts. They demonstrated that, while Black students maintain a perpetual awareness that their racial identities are undervalued, their motivations to achieve evolve over time, which suggests that stereotype threat may not be deterministic (McGee & Martin, 2011). Laursen and colleagues (2010) conducted extensive interviews (nearly six hundred over five years) with students, their mentors, undergraduate research program directors, administrators, and staff to describe the outcomes of participation in undergraduate research in the sciences. Their work brought to light how scientific research outcomes are achieved, and what the outcomes mean for both students and research mentors (Laursen, Hunter, Seymour, Thiry, & Melton, 2010).

Interviewing, specifically, is a technique that, despite being time and resource intensive, is particularly suited for exploring and unpacking individuals’ experiences in STEM. Interviews can provide detailed descriptions, characterize processes and mechanisms, and elucidate how events are interpreted by the interview respondent (Weiss, 1994). These in-depth descriptions make it possible for the researcher to produce a report that allows readers to put themselves in
the respondent’s shoes and develop a deeper understanding of the respondent’s experience (Weiss, 1994).

Interviewing is a challenging skill that requires researchers to consider how their interview methodology will ensure that the portrayal of the phenomena under investigation accurately represents an individual’s experiences. For example, if proper considerations are not made, recall bias may be introduced, poor rapport can prevent development of detailed narratives, and an interviewer’s own personal background and objectives can influence the “restorying” of a respondent’s narrative. One way to mitigate these issues is to design the interview to promote collaboration between the interviewer and the respondent, enabling the respondent to assert ownership over their narrative (Creswell & Poth, 2016). A respondent is made to feel empowered when the interview is emphasized as a shared task between the interviewer and the respondent (Gubrium & Holstein, 2001). Thus, in order to best achieve research goals, it is often worth considering how modifications to more standard interview techniques might support collaboration by making it clear that all participants in the interview can effectively raise questions related to the topics under consideration.

To promote collaboration and help elicit detail during narrative interviews, artifacts can be used to build and direct conversation. Artifacts can be printed materials, photos, memorabilia, or other objects that serve as a visual cue or talking point discussed during an interview (Creswell & Poth, 2016). Using artifacts during interviews can give respondents agency in the research process. A card sorting exercise, for example, is an artifact-based technique that enables respondents to guide and interpret a conversation. In a study of engineers’ identities, student engineers were provided 126 cards inscribed with terms corresponding to different engineering identities (Tonso, 2006). Students were asked to sort the most frequently elicited terms into
“categories that make sense to you” and to “tell me why you put terms together in each group and to describe how the categories differ.” The exercise allowed the researcher to characterize student engineer identities and demonstrate how they arise and are related. Moreover, using artifacts created by respondents themselves can improve the depth and accuracy of interviews. For example, the visual presence of laboratory notebooks while interviewing graduate students was used to explore students’ experiences when learning how to effectively use a notebook for scientific documentation (Stanley & Lewandowski, 2016). In another study, researchers conducted structured interviews with physics professors using the professors’ own teaching materials to investigate their beliefs and values about teaching and learning (Henderson, Yerushalmi, Kuo, Heller, & Heller, 2007; Yerushalmi, Henderson, Heller, Heller, & Kuo, 2007). The visual artifacts were used to direct conversation, increase respondent engagement, and prompt richer, more accurate narratives. Yet, despite these examples, descriptions of best practices when using artifacts during interviews, and the specific contexts in which such artifacts should be applied, are uncommon in the literature.

Here, two discipline based education research (DBER) groups, one of biology education researchers (BER) and one of physics education researchers (PER), have collaborated to describe a qualitative interview technique that makes use of an artifact called a LifeGrid (LG). We identified this technique from the field of medical sociology, where it was first piloted in health research and shown to reduce recall bias. We have utilized the LG as a visual tool in two STEM DBER contexts to facilitate collaboration in an interview. We describe the structure of a LG and the history of its use, and elaborate on the unique BER and PER applications. Lastly, we detail the 4 attributes of the interviews that we felt were supported by the LG: agency of the respondent, rapport between interviewer and respondent, depth of recall, and accuracy of recall.
II. What is a LifeGrid?

A. Anatomy of a LifeGrid

A LG is a visual grid (i.e., spreadsheet) that is an artifact used during the interview process. There are three key features of every LG:

1. The entries in the grid represent dimensions of the respondent’s life experiences over a specific period of time.
2. The grid row headings are discrete periods of time and the column headings are dimensions of the respondent’s life. All headings are determined by the researcher in accordance with the research questions.
3. The majority of grid spaces are left intentionally left blank, to be filled out collaboratively by the interviewer and respondent during the interview.

Abbreviated examples of the LG interview tool are shown in Tables 1 and 2, while the full LGs examples can be found in Supplemental Tables 1 and 2.

A researcher must consider the context of the study and the research questions to select which time periods and life dimensions to include in the grid. The life dimension columns are divided into indirect and direct indicators. Indirect indicators are typically highly memorable events. They serve to orient the respondent to the frame of mind relevant to the study. Indirect indicators are not directly related to the research questions but can lead to discussion of topics that are directly related and are often factual in nature. They can be personal for the respondent, such as place of residence or events that they participated in, or external to the respondent’s life, such as historical, cultural, or social events. Grid entries for indirect indicators may be partially filled in by the researcher in advance of the interview using other ancillary data collected from
the project, such as a reflection prompt or transcript. Direct indicators serve to generate rich discussions around the different dimensions of a person’s life. They are selected carefully to guide the interview dialogue to topics that are central to addressing the research questions. The direct indicators should refer to events that occurred over the same period of time as the indirect indicators.

The completion of the LG is a collaborative process where the interviewer and respondent work together to construct a complete picture of the life experiences within the time relevant to the study. Cross-referencing between columns can promote a more complete and accurate timeline of selected indicators. For example, a study interested in respondents’ extracurricular engagement may ask “You did a research internship your junior year; was that also the time when you were living in an off-campus apartment with friends? (pointing to the LG)” (Supplemental Table 1). A respondent may choose to correct their account or be prompted to remember additional important details. The LG also functions to focus the topics of conversation to the direct indicators relevant to the research questions. It is the visual nature of the LG that facilitates this collaboration, cross-referencing, and guiding of the interview to relevant topics. LG interviews can be conducted on paper or electronically, either in-person or via video-call.

B. History of the LifeGrid

Life course research aims to examine how past events have affected an individual’s current state or decisions with a focus on the role of time, context, and process. Specifically, life course research consist of 4 elements: 1) the intersection of age, period, and cohort, 2) the development of the individual, 3) history and culture, and 4) social relations (Giele & Elder,
A LG interview comprises some aspects of each of these elements, and as such falls under the umbrella of life course research.

The LG, as we have described above with direct and indirect indicators, was first piloted by Blane (1996) as they sought to identify the causal and non-causal variables of chronic obstructive airway disease (Blane, 1996). Berney and Blane (1997) then tested the LG technique to see if it could reduce recall bias compared to traditional interview techniques (L. R. Berney & Blane, 1997). They used archived material of the respondents' social circumstances recorded 50 years previously and identified archive items that could be included as indicators on the LG. They interviewed respondents about social circumstances during their youth and childhood and compared their account with the archive material. They found that a substantial majority of subjects recalled simple socio-demographic information after a period of 50 years with accuracy. Since this validation study, several studies have published findings on the use of the LG (Abbas, Ashwin, & McLean, 2013; Bell, 2005; L. Berney & Blane, 2003; Groenewald & Bhana, 2015; Harrison, Veeck, & Gentry, 2011; Holland et al., 2000; Nico, 2016; Parry, Thompson, & Fowkes, 1999; Porcellato, Carmichael, & Hulme, 2016; Richardson, Ong, Sim, & Corbett, 2009; Wilson, Cunningham-Burley, Bancroft, Backett-Milburn, & Masters, 2007). Parry and colleagues (1999) set out to illustrate some of the more indeterminate aspects of LG interviewing in a study of smoking behavior among elderly respondents who have a smoking related illness. They described how the LG initiated discussion around topics relevant to the study, established researcher-respondent rapport, made it easier to return to important topics since the grid established certain events as markers in time, helped to clarify and confirm the accuracy of dates, allowed respondents to assert influence over their own biographical accounts, and encouraged
the respondent to discover associations between different events in their lives that they had not previously considered (Parry et al., 1999; see section IV for additional details).

To date, we are aware of only a single study that used the LG to conduct education research. Abbas, Ashwin, and McLean (2013) use the LG to explore the relationship between university rank (i.e., quality in teaching/learning) and inequality between students. The LG indicator columns included topics such as housing, friends and significant others, leisure, parents’ employment, etc. and time period was based on the educational milestones of the English education system (e.g. pre-school, primary school, high school). They found that the LG enabled easier comparative checks of data collected at multiple points in a longitudinal study, and they felt that they built a relationship with the respondents, gaining useful knowledge of respondents’ lives (Abbas et al., 2013). In the next section, we extend prior explorations of the LG research with additional descriptions of how we have used LGs in undergraduate science education research.

**III. Applications of LifeGrid technique within DBER**

The two research groups collaborating here conduct DBER in the disciplines of biology (BER) and physics (PER) as a part of the biology and physics departments at the University of Colorado at Boulder, a large, public, PhD-granting institution. Individual DBER projects were conducted by each team utilizing the LG technique to conduct retrospective interviews that explored event chronologies. The methodological approaches for each teams’ BER and PER LG applications are described below including the research questions, reasons for using a LG, study respondents, LG structure and design, interview set-up, interview implementation, and procedural outcomes of the interviews. We then address notable differences between the BER and PER applications.
A. Biology education application

The BER team consists of authors AAR and LAC. We used the LG technique as part of a retrospective interview study to investigate the research question: How do disciplinary interests and career goals influence undergraduates’ pursuit of critical experiences that enable entry to advanced degree paths (e.g., medical or graduate school)? Critical experiences are activities or interactions that students engage in during their undergraduate tenure that are not part of normal curricula and that enable access to advanced degrees because they are of value to program gatekeepers (i.e., admissions). For example, students applying to medical school are required to have more than just a high GPA, they often need to engage in volunteer work, research, and/or teaching experiences (Association of American Medical Colleges, n.d.-a, n.d.-b). We were curious to know whether students who enter college with a strong disciplinary interest in biology content and highly specific career goals were more likely to (a) pursue critical experiences earlier and more frequently, and (b) maintain biology career goals throughout their undergraduate career. These questions necessitated construction of a timeline of each student’s critical experience pursuits and participation during their undergraduate tenure. In addition to carefully crafting an accurate timeline of critical experiences, we were interested in capturing rich narratives that described how and why students accessed such experiences.

We found the LG technique in the medical literature when searching for techniques to reduce recall bias. We were initially attracted to this technique for two primary reasons. First, we were looking at a timeline of four or more years and wanted to reduce recall bias. Second, our research question necessitated that we construct an accurate and complete timeline of when students pursued and participated in extracurricular activities. A third benefit, which did not become apparent until our initial pilot of the LG technique, was that it allowed us to easily probe
for details about each critical experience and answer our questions of how and why students pursued and accessed critical experiences.

**Study respondents**

We conducted interviews with former undergraduate students that majored in biology and had graduated, or were on-track to graduate shortly, from one of two large, public, PhD-granting institutions in the South-eastern and Western United States of America. The students had applied and been accepted to either medical school or graduate school for biology, including masters and Ph.D. granting programs. This included students who were still enrolled in undergraduate programs (often seniors), those who took several years between undergraduate and advanced degree programs, and those who were nearing the end of their advanced degree program. Respondents were asked to reflect on their time during their undergraduate career. Considering this, respondents were sometimes asked to recall time periods up to 10 years in the past.

**LifeGrid structure and design**

We arranged the timeline of the grid (rows) by semester (e.g. Year 1 Fall, Year 1 Spring, Year 1 Summer, Year 2 Fall, etc.) for up to 6 years during the respondent’s undergraduate tenure. The LG also included rows for pre-undergraduate and post-undergraduate years enabling the respondent to mention significant events for these periods. The columns of the LG consisted of 4 indirect indicators and 6 direct indicators (column headings). The indirect indicators included large moves/changes in residence, family events and relationships, non-academic events and activities, and financial support (Supplemental Table 1). We chose these indicators because they reflect things that might change and shift throughout a student’s undergraduate trajectory, thus helping us to ground the timeline in other memorable events. Direct indicators included academic interests, career goals, participation in research activities, interactions with STEM
faculty or advisors, internships/volunteer positions/work related to academics, and participation in professional societies, organizations, or academic living-learning communities. We chose these direct indicators because they related to our research questions (e.g., interests and career goals) and reflected the variety of critical experiences desired by advanced degree programs (Association of American Medical Colleges, n.d.-b, n.d.-a). We provided students with examples of the indirect and direct indicators at the beginning of each interview (Supplemental Table 1).

Prior to using the LG in our study, we conducted pilot interviews with graduate students. Based on these interviews, we slightly edited the indirect and direct indicators to reflect commonly referenced life changes and activities. The pilot interviews also informed how we initially described and made recommendations to respondents to facilitate filling in the LG. For example, we found that, to encourage a more detailed narrative from the respondent, it was important to tell a respondent that few words would be written on the grid itself but that we would record the interview to capture all of their valuable thoughts. A truncated version of the BER LG is shown in Table 1, and the full version is available in the supplemental material (Supplemental Table 1).

| Year 1   | Residence          | Family events and Relationships | Interests and Career Goals | Activities (research, volunteering, clubs, etc.) |
|----------|--------------------|---------------------------------|---------------------------|-----------------------------------------------|
| Fall     | Lived in Dorms     | Ended relationship from high school. | Declared a biology major. Wanted to be a doctor. |                                                |
| Spring   | Lived in dorms with new roommate | Grandmother passed away. | Took immunology and loved it. | Joined the Pre-Health club. Volunteered for the Health Fair. |

**Legend.** Column 1 shows times that are relevant to the study. Columns 1 and 2 (italicized) represent indirect indicators. Columns 3 and 4 (bolded) represent direct indicators. Fictitious representative responses shown in italics. Blank spaces exist and are expected in the BER LG application.
Interview set-up

We conducted the majority of the interviews online using a videoconferencing software (Zoom), thus respondents viewed the LG as it was filled out electronically by the interviewer in a table in a Microsoft Word document. We took care to ensure that respondents could see both the face of the interviewer and the LG as it was filled out, using a screen-share function. Occasionally, we conducted interviews in-person, and in these cases, we provided a printed grid in landscape view on 8.5 x 11 in paper with all column headings fitted horizontally and 2 years fitted vertically on a single page. The interviewer and respondent were positioned on the same side of the table so that the entire grid could be viewed as it was filled out by the interviewer. We determined in pilot interviews that it was important that the interviewer, not the respondent, write on the grid so that the respondent could focus on their thoughts and construct a complete narrative.

Implementing the LifeGrid interviews

When implementing the LG interviews, we first introduced the structure of the LG, including the timeline and each column heading. We made it clear to the respondent that the LG could be filled out in any order (event-centered or chronological), but suggested that the interview begin by filling out the first few columns (indirect indicators) to help the respondent enter the right “frame of mind” and establish a timeline. We found it important to note that not every square in the grid would be filled out. This was intentional to both streamline the interview process and alleviate any anxiety about filling out the grid. Lastly, we made it clear that most spoken details would not be entered on the grid, but were nonetheless incredibly valuable to the research study. We asked to record the interview so that we could capture more of the respondent’s thoughts than would be possible using only notes.
As the LG was filled out, we noted each instance when a critical experience was mentioned by the respondent, as this was central to our research question. Whenever this occurred, we employed a set of follow-up questions:

1. What led to your participation in (activity)?
2. Did an interest in biology lead you to participate in (activity)?
3. Did you develop an academic interest in biology during (activity)?
4. Did you have career goals that led you to participate in (activity)?
5. Did you develop any career goals during that (activity)?

Without these questions, our LG would comprise only a chronological sequence of events and lack details about how and why things happened. We additionally probed respondents’ statements related to their participation in specific critical experiences. To do this, we used generic probes such as “Can you tell me more about that?” and “Please explain [what you just said] in more detail.” Our goal when using such probes was to develop rich narratives explaining why students pursued (or did not pursue) critical experiences and how that affected their interests and career goals and vice versa. At the end of each interview, we asked respondents to review the LG in entirety and assess it for accuracy and completeness. We asked if there was any additional information that the respondent would like to add. This helped to ensure the accuracy of the timeline and allowed us to “catch” any relevant experiences that had not been previously covered. Lastly, we asked a few additional questions that were either unrelated to the grid or captured information about critical experiences in which the respondent did not participate. For example, we asked “Was there a critical experience during your undergraduate career that you wanted to participate in but could not? Please describe what prevented you from doing so.”

Procedural outcomes
We conducted 35 interviews that lasted on-average 90 minutes. We analyzed the interview timing from 10 of these interviews and found that between 3 to 4 were spent on obtaining consent and introducing the interview topic and technique. We spent 2-3 minutes introducing the LG specifically. While filling in details for indirect indicators took a large portion of interview time (between 8 and 15 minutes), we often jumped over to the direct indicator columns to fill in critical experiences during this period. For example, a student may live in another state for one summer (indirect indicator) in order to do research as part of a research experience for undergraduates program (direct indicator). In an effort to allow a complete narrative to form, respondents were allowed to talk about experiences when they felt naturally compelled. Cross-referencing was occasionally a challenge in cases when indirect indicators did not change for a respondent. For example, a student may have lived at home during all years of undergrad and did not experience any significant family events or changes in relationships. In these cases, we encouraged respondents to consider other indirect indicators that may not have been represented by the columns on the grid. Blank spaces on the grid were allowed and common because it was unlikely for a single individual to participate in all critical experiences during all semesters of their undergraduate career.

B. Physics education application

The PER team consists of authors DRDF, LR, and HJL. We used the LG as part of a multi-year, cross-institutional study of teaching practices in physics lab courses that implement multi-week final projects. In part, we were focused on how those teaching practices can foster or inhibit students’ engagement in experimental modeling and their development of a sense of project ownership. “Experimental modeling” refers to the recursive process through which scientists construct and revise models and apparatus in order to achieve agreement between
predictions and data (Dounas-Frazer & Lewandowski, 2018). “Project ownership” refers to a student’s feelings of agency, responsibility, investment, and pride with respect to their project (Dounas-Frazer, Stanley, & Lewandowski, 2017). We were also interested in uncovering connections between modeling and ownership: who proposes revisions to an experiment, who enacts them, and how does that impact students’ development of project ownership over time? These questions were best answered by reconstructing timelines of student participation in key events over the course of the project. Because there are many complex social factors that contribute to ownership, we were also interested in collecting rich narratives that described students’ interpersonal interactions with peers and instructors during different phases of the project (e.g., choosing a project topic, carrying out the experiment, and presenting results to others).

The PER team was introduced to the LG by the BER team. We were initially encouraged to use LG because the surface features of the data collection instrument matched the data analysis methods we used in a previous investigation. Namely, during a multiple case study of students’ final project experiences, we created detailed chronological case logs with a grid structure similar to a LG (Dounas-Frazer et al., 2017). Thus, one major benefit of using the LG technique was its ability to support respondents’ recollection and reconstruction of their final project experiences in a structure that made chronological and thematic sense to the research team. Another benefit was that LGs resulted in rich and nuanced narratives, which would aid us in developing an understanding of the dynamics of modeling, ownership, social interactions, and other features of final projects in upper-division labs. A third potential benefit was that the LG technique would foster a positive rapport between interviewer and respondent, increasing the
likelihood that respondents would describe unproductive interactions with peers or instructors. Thus, the LG appeared well-suited to addressing our research goals.

Study respondents

We conducted interviews with undergraduate students currently enrolled in physics programs at doctoral, master’s, and baccalaureate colleges in the West, Midwest, and Southwest portions of the US. The students were enrolled in upper-division lab courses that incorporated multi-week projects. The LG was designed to probe respondents’ engagement in modeling and feelings of ownership during final projects. The longest time period that respondents were asked to recall was the latter half of a single semester (7 weeks) prior to the interview.

LifeGrid structure and design

LG rows corresponded to periods of time in units of weeks (e.g., Week 1, Week 2, etc.). The number of rows was determined by the length of the project; a four-week project necessitated a four-row grid. Columns corresponded to dimensions of respondent experiences on the project. The leftmost column focused on the details of respondents’ technical progress on their project and was meant to provide indirect indicators of modeling and ownership. The second and third columns were direct indicators for modeling of experimental systems. These focused on respondents’ revisions to apparatus or models and changes in overall experimental project goals or subgoals. The remaining columns focused on respondents’ memorable moments, personal contributions, and experiences working with other students and professors during the project, which are direct indicators of ownership. A truncated version of the LG is shown in Table 2, and the full version is available in the supplemental material (Supplemental Table 2).
Prior to using the LG with our undergraduate student respondents, we piloted the LG with physics graduate students. During pilot interviews, we asked graduate student respondents to focus on the last four weeks of their dissertation research. The pilots allowed us to familiarize ourselves with technological considerations of online LG interviews, gain insight into the order in which the LG should be filled out, and develop a rough idea of the time required to fill out the grid. For example, we observed in pilot interviews that there was a tradeoff between a larger LG with more indicators that would allow for more information, but create a potentially intimidating grid, and a smaller grid that was more manageable for both respondents and interviewers. Thus, we aimed to keep the grid small, while still incorporating meaningful direct indicator columns.

Table 2. Abbreviated PER Grid.

| Week | Experimental progress | Changes to experiment | Personal contributions |
|------|-----------------------|-----------------------|-----------------------|
| 1    | Assigned to team/project; Interested in design aspects | Did you make changes to your equipment or theories? | What ideas, skills, or work did you personally contribute? |
| 2    | “We went through all the projects and discussed them. I picked this because it was the most engineering related.” | “Drew some initial designs, and then made changes as necessary when designing in software.” | “We all contributed pretty equally.” |

Legend. Row 1 represents what students see pre-interview and Row 2 represents what the grid might look like post interview. Column 1 shows times that are relevant to the study. Column 2 (italicized) represents the indirect indicator. Columns 3 and 4 (bolded) represent direct indicators. Examples of actual responses shown in quotes. Blank spaces exist and are expected in the PER application.

Interview set-up

We conducted interviews online using a process logistically identical to that used by the BER team for their online interviews. LG interviews were conducted at the end of the semester,
after projects were completed. During the semester, students completed weekly free-response surveys that asked them to describe their interests, goals, challenges, and successes while working on the projects. For each respondent, these weekly survey responses informed the LG in two ways. First, we included short phrases from students’ survey responses in the first column of their LG. These phrases were anchor points that could help students reconstruct a personal timeline of the project, including interactions with peers and instructors. Additionally, we hoped that the anchor points would demonstrate to respondents that the interviewer had read their survey responses, conveying a sense of investment in the respondent and building rapport with the interviewer. Second, for each respondent, we used their survey responses to generate a ‘ShadowGrid’ that only the interviewer could see. The ShadowGrid was a paper version of the LG. Prior to interviewing each respondent, the interviewer read their survey responses. The interviewer then added information corresponding to the various LG columns to the ShadowGrid. During the LG interview, the interviewer would sometimes refer to the ShadowGrid to jog the respondent’s memory or ask follow-up questions. Note that the ShadowGrid was developed as a unique addition to the LG technique by the PER authors of this paper and its features are discussed in the attributes section below.

**Implementing the LifeGrid interviews**

When conducting LG interviews, we first described the grid and framed the process of filling it out as a collaborative activity. Next, we told the respondent that we had read their survey responses to prepare for the interview and had written key phrases in the first column to help jog the respondent’s memory. Based on our experiences in the pilot interviews, we then instructed the respondent to discuss the first three columns chronologically before switching to a
non-chronological approach. Finally, we told the respondent that they could leave some grid entries blank.

During the interview, we filled out the grid while the respondent spoke. The respondent could see the grid as it was being filled out. We occasionally asked follow-up questions of the form, “How did you feel when this event happened?” These questions were designed to elicit information about respondents’ emotional responses while making revisions to their experiment or experimental goals, which could help us identify links between modeling and ownership. We chose to ask about emotions via follow-up questions to grid entries rather than via an explicit LG column because we wanted this information to come up naturally, and in context, rather than in a more compartmentalized fashion.

Toward the end of the LG interview, we asked each respondent to reflect on the completed grid, including empty entries, to see if there was any additional information they wanted to include. After completing the grid, we asked a few additional questions that were not directly connected to the LG. For example, the interviewer asked how the respondent would define student ownership.

**Procedural outcomes**

We conducted 15 interviews that lasted 55 to 80 minutes, including the description of the LG (about 5 to 10 minutes) and additional questions after the grid was filled out (also about 5 to 10 minutes). We used the ShadowGrid to ask follow-up questions in several interviews. Across all interviews, between 10% and 40% of grid entries were left empty. Some blank entries reflected the fact that nothing notable occurred for the given week number and project dimension. Other blank entries reflected that the respondent described a pattern that occurred throughout the project for a particular column, and it did not correspond to a particular week. For
example, when describing interactions with their instructor, one respondent said that the “strongest thing that I remember” about professor interactions was that “[my professor] was very explicit and adamant that getting data is not the important part; learning experimental physics was the goal.” The respondent was describing their instructor’s overall framing of the projects. Because the instructor repeated and reinforced this framing in many daily interactions, it did not map onto a single week. Nevertheless, the interviewer wrote it down in the topmost row (Week 1) of the column titled, “Interactions with professors.” The other entries in this column were left blank.

In addition to project-wide patterns, the topmost row contained another type of information that did not correspond to Week 1. Some respondents described events that were relevant to their project but that pre-dated the first week of the project portion of their course. For example, one respondent said that he chose his group and project topic prior to the start of the course. The interviewer added this information to the topmost row of the column titled, “Interactions with students.” In future work, the LG could be modified to include two additional rows above the row for Week 1: one for project-wide patterns, and another for information that predates the first week of the project.

C. Differences between BER and PER Methods

The BER and PER implementations satisfied the three key features of a LG: they each used a visual grid comprising entries that represent dimensions of the respondent’s life experiences over a specific period of time; row (times) and column (life dimensions) labels were determined by the interviewer in accordance with research questions; and grid entries were filled in during the interview via a collaborative process that involves both interviewer and respondent. Nevertheless, the implementations were distinct due to differences in research
questions and access to background information for respondents. In addition, the PER team incorporated supplementary tools (namely, reflections and a ShadowGrid) to aid in respondent’s recall and to inform targeted follow-up questions. These differences resulted in creating LGs with unique temporal scopes and structures.

The BER project was focused on understanding students’ perceptions of critical experiences during their undergraduate career that resulted in acceptance to graduate or medical school. Thus, the BER LG was constructed to elicit information on the timescale of 4 to 6 years. In contrast, the PER project was focused on students’ experiences during their final projects for a lab course, with a timeframe ranging from 4 to 7 weeks. Also, in the case of the BER team, their LG data was often collected years after the time interval of interest (i.e., 1-2 years after graduation from college). The PER team collected LG data immediately after the time interval of interest (i.e., during the last portion of the respondent’s final project). Due to the difference in temporal scope and timing, the BER team had more variability in respondents with respect to ages/cohorts, whereas the PER group was interviewing people who were all enrolled in the lab concurrently. Ultimately, the shorter time period employed by the PER team resulted in a more directed and specific interview, which allowed detailed information about a single experience to emerge, while the longer time period employed by the BER team resulted in a broader more open-ended exploration of students’ experiences.

Another notable difference was regarding availability of information about respondents prior to the interview. Researchers in the PER team were able to collect data from respondents both during and after their projects in weekly reflection surveys. Thus, the research team was able to use students’ weekly reflections to inform the design of the LG and the ShadowGrid. The BER team surveyed respondents for basic demographic (e.g., race, ethnicity, gender, age) and
academic information (e.g., GPA, major, relevant coursework taken) prior to the interview, but otherwise were only able access to details surrounding critical experiences from the LG interview (occasionally respondents would refer to their transcripts or resumes to assist in recall). One implication of this was that the PER group could draw upon their additional knowledge to ask targeted questions about specific events they knew to have occurred.

Together, the temporal scope of interest and the auxiliary information available to the researchers resulted in each team constructing a different template for the structure of their LG. Specifically, the nature of the indirect indicator columns was significantly different. The BER team’s indirect indicator columns were broader in scope and designed to capture memorable life events occurring over multiple years to ground other life decisions. The BER team’s columns could easily applied to all respondents with no prior knowledge of their past. In contrast, the PER team’s indirect indicators did not access educational or personal events outside the final project. The salient events were entirely contained within the time interval in the LG, and for each interview, a few indirect indicator cells were pre-filled with known events. The shorter timeline and prior knowledge allowed highly specific and detailed information to emerge during interviews.

This difference in temporal scope and auxiliary information also contributed to differences in how the interviewers used the LG. The BER team approached the LG interview with the expectation that the sheer amount of information discussed would not fit on the grid, since the grid spanned a long time period. In the BER application, short, factual notes and descriptors were jotted down on the LG, but the interviewer did not strive to capture all of the respondent’s spoken points in the LG grid. This approach was logical for the BER team since they did not expect that a respondent would have something to say about each cell in the grid and
since they viewed the grid primarily as a guide to facilitate an audio-taped discussion. In contrast, the PER team wrote continuously throughout the interviews, striving to capture as much detail as possible on the grid. They took this approach in order to convey to the respondent that all of their additions or descriptions regarding their project were of equal importance. However, the PER interviewers found that this presented an added cognitive strain on them during the interview. While there are potential benefits to each approach, there are drawbacks as well. The PER interviews may be more strenuous, but generate a more detailed interview artifact as a result, which may facilitate future analysis.

These considerations illustrate ways in which the LG design and process is flexible and can accommodate distinct, specific research questions and available auxiliary resources. When using this technique, we encourage researchers to consider how it may be adapted to best serve their research interests.

IV. Attributes of the LifeGrid technique

Our experiences have led us to conclude that the LG interview technique is well-suited for collecting rich qualitative information about phenomena that evolve over a discrete period of time. Drawing from the existing literature and our personal experiences, we describe four attributes of the LG technique that make it a unique and effective interviewing tool for studies of undergraduate science education. With thoughtful framing of the interview, we found that the LG technique can a) help to facilitate respondents’ agency, b) establish rapport between interviewer and respondent, c) affect the depth of the respondent’s narrative, and d) construct a more accurate account of events. We define agency, rapport, depth, and accuracy as follows.

*Agency* refers to the capacity, condition, or state of exerting power over a situation, process, or object. In the context of LG interviews, agency is evident when respondents exert power over
the interview process, LifeGrid entries, or their own narrative. For example, respondents may choose the order in which the grid is filled out, or they may direct the interviewer to edit a grid entry.

*Rapport* refers to a positive, friendly relationship or connection between two people most often characterized by general agreement, mutual understanding, or empathy that makes communication fluid and easy. In the context of LG interviews, rapport between interview and respondent is evident when common life experiences are discovered and shared between the interviewer and respondents.

*Depth* refers to a high level of detail, information, and connections between ideas that a person includes in a verbal recounting of their experiences. In the context of LG interviews, depth is evident when respondents describe relationships between events in different grid entries, or when they elaborate upon their recollection of events after a grid entry is made.

*Accuracy* refers to the correctness and completeness of a person’s description of events. In the context of LG interviews, accuracy is evident when respondent uses a partially completed grid to help them reconstruct the temporal ordering of events or cross-reference events to recall others that occurred at the same time.

These attributes are a result of the relationship between the interviewer, respondent, and the LG as both an artifact and task. Below, we elaborate on the importance of each attribute and draw on relevant literature as well as our own experiences to demonstrate how the LG addresses each attribute. In doing so, we demonstrate how the LG technique can be applied to DBER contexts.

Facilitating respondents’ agency
Modern interviews seek to secure the constructive voices of the respondents by providing respondents agency to direct construction of their narrative in concert with the interviewer. Gubrium and Holstein (2001) argue that interviews should not be conducted as a discreet neutral set of question and ensuing responses, and instead should be seen as co-constructed and informed by the cultures and experiences of both the interviewer and respondent. Because the interviewer is inherently more agentic at the start of an interview, the respondent’s agency should be privileged and steps should be taken to ensure a respondent’s sense of identity (Gubrium & Holstein, 2001). This interview philosophy is supported by use of the LG technique.

Compared to a more classic semi-structured interview approach, where the interviewer directs the flow of conversation using questions and follow-ups, the LG approach allows more choice and direction to come from the respondent. As an artifact, the LG’s visual presence and use in questioning allows the respondent to question, contradict, or re-direct the conversation because they can see and make reference to what the interviewer is writing. Prior LG researchers have described this as “productive interference” during the interview (e.g., Nico, 2016), which increases respondents’ agency by allowing them to exert power over and redirect their narrative. They argue that this, in turn, enhances the accuracy and relevance of information (Parry et al., 1999; Sheridan, Chamberlain, & Dupuis, 2011). In addition, they describe how the collaborative task of constructing the LG puts the respondent on more equal footing with the interviewer than traditional interviews, allowing more agentic moves by the respondent (Groenewald & Bhana, 2015; Parry et al., 1999; Wilson et al., 2007). Since the LG allows respondents to exert a high degree of control over the pace, structure, and emphasis of the interview, respondents can draw more attention to personally salient events (Parry et al., 1999) or avoid topics that cause them discomfort or stress (Richardson et al., 2009).
Our experiences corroborate these findings. Similar to prior LG users, we felt that respondent agency arose because respondents were afforded the power and opportunity to guide the discussion during the task of grid completion. Specifically, we noted agentic instances when respondents a) directed the interview in a way that was unanticipated by the interviewer and b) guided the interview to discuss topics that shaped the respondent’s experiences under investigation, but were not directly related to any grid columns or interviewer questions. Often, the details added by the respondent were temporally linked to the LG and served to form a more complete image of the individual and their narrative. The following example from the BER application illustrates how Sarah (all respondent names are pseudonyms) interacted with the LG to bring up an important, somewhat sensitive, experience that shaped her undergraduate career, but was not directly related the interview indicators under discussion. This occurred after the interviewer asked Sarah if there were other events she wanted to add to a column on the grid.

Sarah: Oh, one other thing did happen, sorry, I’m sure it happens a lot but, I got an MIP (minor in possession), like, right when I got to college.
Ashley: Oh, your freshman year?
Sarah: There’s no column for it (laughing)
Ashley: Well, it’s a non-academic event, we’ll say. (laughing)
Sarah: “interactions with the law” (laughing). Yeah, I got an MIP and after that I was really nervous, but it got sealed.
Sarah: [describes the incident] …
Sarah: I always was nervous that [the MIP] might surface and thought that I might not be able to get into medical school if I have an MIP.
Ashley: Okay, was that part of the reasons you said you were considering like nursing and other trajectories you were interested in?
Sarah: Yeah and I think that’s one of the reasons that I did so well in school, ‘cause I didn’t give myself wiggle room with my GPA to compensate for that.
Sarah’s agency became apparent as she utilized the temporal nature of the grid to discuss an event that was important for that time period of her life, but was not explicitly represented on the LG and was unanticipated by the interviewer. Another BER application example from Miguel illustrates how the visual nature of the LG enabled him to reflect on the entire grid and elaborate on or clarify his story.

Ashley: Do you have anything else that you would like to add? [gestures to grid]
Miguel: No, I think that's good.
Ashley: Awesome.
Miguel: [looking at grid] One thing that we really didn't talk about much was how I think, for a lot of people, it’s important to be able to cope with things that come up in your pursuit of whatever career you have.
Ashley: Yeah.
Miguel: I think for me, like I talked about this a lot with my postdoc [referring to a cell on grid that refers to research mentor interactions] because we were studying stress and the mechanisms, and I believe my faith was a big way that I was able to sort of detach from the stress and think of it in perspective and learn about things that are, you know, that don't have to do with school and there's a bigger picture.

Despite the majority of our personal experiences and published studies describing how the LG technique facilitates respondents’ agency, there are potential caveats to consider. In a study on adolescent substance abuse, Wilson (2007) described how one respondent reacted to the blank LG with discouragement, stating that they knew that their complex story would not “fit” within the bounds of the grid. This lack of “fit” may have resulted in this respondent feeling unable to act to sufficiently express his story (i.e., he may have felt a lack of agency). Therefore, we recommend that researchers interested in this technique consider how they will introduce the grid to the respondent and actively facilitate discussion to support respondent agency.
A. Establishing rapport between interviewer and respondent

Building positive rapport is a critical component of an effective interview. Kvale and Brinkmann (2009) describe how a skilled interviewer creates a positive relationship that leads to the production of significant knowledge. They, like Gubrium and Holstein (2001), describe an interview as a co-constructive process involving both parties rather than a monologue recorded by an interviewer (Kvale & Brinkmann, 2009).

The collaborative construction of the LG by the interviewer and respondent, as described in section II, often fosters a relationship in which positive feelings arise and the interviewer better understands the feelings and needs of the respondent. In other words, positive rapport is developed (Wilson et al., 2007). Specifically, LG co-construction facilitates an indirect, less confronting way of eliciting information, which supports rapport building. This is in contrast to direct questions often used in more traditional interview techniques, which can feel combative and make the implicit interviewer-respondent hierarchy more apparent (Groenewald & Bhana, 2015; Harrison et al., 2011; Parry et al., 1999; Wilson et al., 2007). Furthermore, co-construction and completion of the LG can foster a sense of satisfaction and accomplishment among both the interviewer and respondent (Richardson et al., 2009). This shared sense of accomplishment may inspire lasting positive relationships and rapport, which can be leveraged over multiple interviews. This benefit is described by Abbas, Ashwin, and McLean (2013), who used initial LG interviews to help build rapport and facilitate lasting relationships with respondents over three years of interviews.

Our interviews displayed similar patterns as previous literature with regard to rapport. Specifically, we noted instances of positive rapport when respondents expressed positive emotions related to their co-construction of the grid or when expressions of agreement, mutual
understanding, or empathy emerged during an interview. In the PER study, the interviewer asked each respondent how it felt to see the completed grid. Some respondents expressed happy surprise: “It’s kind of crazy. [...] It feels good!,” and, “There's a lot more here than I thought!” Others described the grid as a helpful or logical way to structure their narrative: “It's an interesting way to lay things out. [...] a helpful way to break things down,” and, “It's a fairly logical progression.” Similar sentiments were shared by the interviewer, and hence implementation of the LG technique yielded many instances of mutual satisfaction among respondent and interviewer.

Also, similar to findings by Parry and colleagues (1999), the BER team found that discussing topics of interest to the research became easier after working through the initial indirect indicators, which provided opportunities to develop rapport. For example, indirect indicators often allowed the interviewer to find commonalities with the respondent that were unrelated to the study, allowing the interviewer to express understanding or empathy and build rapport. In the quote below, the BER interviewer, Ashley, identified a commonality between themselves and respondent Emily during discussion of indirect indicators.

Emily: And I was still on the [sport] team.
Ashley: You did [sport name]?
Emily: Uh-uh (affirmative).
Ashley: All right, I [did that sport] in college also. Did you do that from your freshman year? I should write that on here [referring to the grid].
Emily: Yep.
Ashley: So, you [participated] all four years?
Emily: Well, I [did it] for the first two, and then I switched to [another sport] for the second two-
Ashley: Oh.

Emily: ... because I [had a bad injury].

Ashley: Oh my God.

Emily: So my coach was like, "Are you really sure that you want to continue with this?"

Ashley: Sounds like some of my friends [that had similar injuries].

Emily: Yeah.

As seen here, working through indirect indicators (Non-academic events in the example above) frequently fostered mutual understanding or highlighted shared experiences and facilitated personal exchanges between interviewer and respondent. This is likely in part because the indirect indicators were general enough to allow connections to be made.

In contrast to the BER group, the PER interviewers used reflections to fill out some indirect indicators prior to the interviews, personalizing their grid to the respondent and creating highly specific indirect indicators. They also created the ShadowGrid to inform follow-up questions during the interview. This may have demonstrated to respondents that the interviewer was invested in their story, contributing to positive rapport. Overall, despite slightly different approaches, the use of LG indirect indicators facilitated rapport building exchanges for a majority of students in both the PER and BER study. Therefore, careful considerations of which indirect indicators to include or which information to pre-fill in advance is likely to be important in facilitating this function of the LG. Future work could explore whether and how aspects of each implementation contributed to rapport building between interviewers and respondents.

B. Affecting the depth of the respondent’s narrative

Kvale and Brinkmann (2009) enumerate various aspects of qualitative interviews including that they are descriptive and specific. A descriptive interview involves encouraging the
respondent to describe as precisely as possible what they experience and feel. The specificity of the interview refers to eliciting detailed descriptions of situations and actions, rather than general opinions, to inform meaning (Kvale & Brinkmann, 2009). We refer to this high level of detail, information, and connections as “depth” and find that it is supported by the LG interview technique.

Several researchers have found that the LG approach can facilitate collection of rich, qualitative narratives during the interview (Groenewald & Bhana, 2015; Nico, 2016). They cite the development of rapport and facilitation of respondents’ agency as two aspects that contribute to this attribute. Specifically, increased agency allows surprising connections between the research topics and other, seemingly unrelated, areas of the respondent’s life to be made (Nico 2016) and rapport increases respondents’ comfort and thus their willingness to share their narrative (Groenewald & Bhana, 2015; Parry et al., 1999). Beyond these aspects, the LG as an artifact can be used to ask questions in creative ways that elicit more information than traditional interview techniques. For example, instead of asking a respondent a direct question such as “Describe your experiences engaging in undergraduate research.” and then following up with “What were your reasons for engaging in these experiences,” an interviewer can point to the “Research Experience” column on the grid and simply state “let’s begin filling out this column.” This focus on the LG artifact is less confrontational and allows respondents to elaborate on their stories since they are indirectly discussing life experiences via the LG (Nico, 2016). Considering the grid as an artifact also facilitates greater detail. When sufficient fluidity is allowed during the interview (e.g., movement freely around the grid during discussion), the grid structure can allow respondents to visualize and discuss connections between seemingly unrelated events (Blane, 1996; Parry et al., 1999). Fluidity also facilitates return to prior events when new connections are
made (Nico, 2016). Thus, the grid combines the historical occurrence of events with the respondent’s own interpretation and subjective experience, enriching and extending the narrative (Nico, 2016).

However, eliciting depth and nuance does not arise solely through incorporation of a LG in an interview. Specific facilitation techniques enable this process. Nico (2016) specifically cites that flexibility in filling out the grid should be used to facilitate connections. Allowing respondents to move backwards and forwards through time enhances the detail and connections that can be made and allows more recall to occur. Likewise, they describe that the grid should be visible and comprehensible to respondents (e.g., abbreviations should be avoided) during the interview to facilitate respondents’ use of the LG to direct their own narrative. Nico (2016) describes that introduction of the LG and description of how it should be used is critical to facilitate these features and enhance interview depth. We also found that a thoughtful introduction of the LG at the start of an interview to be an important step in eliciting depth.

In both BER and PER studies, we introduced the LG as a tool to help build a narrative, encouraged respondents to backtrack and fill in the grid as appropriate, and paused to ask respondents follow-up questions frequently during the interview. Specific instances of added depth and description occurred when respondents cross-referenced information in different columns of the grid and provided insights into the reasons why they took certain actions, engaged in specific tasks, or felt different emotions. Added depth also emerged during participants’ explanations regarding how they had used the grid to build their narrative during the interview. In an example from the BER application, an interaction between the interviewer, Ashley, and the respondent, Megan, illustrates how the visual nature of the grid allowed greater
temporal clarity and more detail regarding how living conditions (an indirect indicator) influenced Megan’s academic major and advising (related to direct indicators).

Ashley: So did your advisors help you plan your classes, your schedule? (referring to a direct indicator column on the grid)
Megan: Not really. I had a friend who [did], one of my roommates was incredibly organized and so she sat down [and looked at] my schedule every semester, and just like, "Does this the sound interesting?" I was like, "Yeah, sure, I'll take that."
Ashley: Wow. Is that a friend that you had met in the dorms (pointing to the indirect indicator column on the grid)?
Megan: Yeah. No, she was my roommate sophomore junior (pointing to a different row on the grid). Well actually she lived across the hall from me in my freshman year, and she was the one that figured out that I could technically be an Anthropology major (referring to another direct indicator column on the grid).
Then we lived together sophomore junior and senior year. So I think I only had help my senior year from my major advisor (pointing to a different direct indicator column).

After being prompted from Ashley, Megan references the LG as she describes how her living arrangement with a roommate influenced her chosen course of study. She also clarifies that academic advising did not have a role to play in her early undergraduate choices. These techniques added details and facilitated new connections, while also supporting respondents’ agency (see quotes from Miguel and Sarah above).

Prompting reflection on blank grid entries was another mechanism through which the LG facilitated deep and detailed interviews. Similar to what Nico (2016) describes as challenging respondents to fill ‘omissions’ within their narrative, the PER interviewers asked respondents whether or not information might belong in empty spaces present at the end of the interview. Most respondents indicated that the spaces should be blank. Several provided rationale for
leaving some entries unfilled. Several others added information to their narrative. Consider the following excerpt from an interview with Sophie, a respondent who was working on an acoustic levitation project:

Dimitri: Zooming out, big picture, there are a few blank spots, and I wanted to take some time just to look over them. It's okay if we have blank spots. We don't have to fill out every grid entry. I just wanted to make sure you're okay with leaving these spots blank. Or, if there's something, when looking at them, that you wanted to fill out.

Sophie: Mhm. I guess that the last "interactions with professors" column, it was fun to show our professors it [the project] working. It was fun in general to show people the project working, because it's the sort of thing that, it's cool to see something floating in the air, it's cool to see something levitating. So, kind of at the end of the day, it was fun to show off. Kind of like affirming to have a professor be like, "Wow, that's cool!" (laughs) [...] Dimitri: Anything else?

Sophie: (5 second pause) Um, I don't think so. I think the "personal contributions" column is, like, pretty empty because my group was working on things together most of the time. So, I’m sure that, like, I and my group members all had personal contributions in any given time we [were] working on it together, but none of them really stands out because they were, like, brainstorming or troubleshooting as a group. So, it wouldn't be like, "Ah, yes my contribution was this."

Here, Sophie used this opportunity to add depth to her narrative in two ways. First, she described an affirming interaction with a professor after her apparatus became functional. Second, she provided rationale and context for leaving multiple entries blank in the column designed to probe students' personal contributions to the project. According to Sophie, blank entries in this column were due to the presence of collaborative problem solving, not the absence of individual effort.
Thus, the LG as an artifact facilitated additions to Sophie’s narrative by giving her the opportunity to see and reflect upon blank entries.

In addition to asking follow-up questions, the PER team used the ShadowGrid to support respondents in the shared task of filling out the grid and enhancing the detail of grid entries. For example, when Carlos was trying to recall interactions with his professor, he described patterns of interaction that spanned his project experience, but he initially could not think of any specific interactions. The interviewer used the ShadowGrid to jog the respondent’s memory:

Carlos: I'm trying to think if there's a specific example. Um. Yeah. I can't think of a specific example right now, but I liked the combination of [instruction] being generally hands-off but also checking with us so that if we were reaching a problem, the professor would talk to us. [...] 

Dimitri: I have a couple examples from your surveys that you had filled out [examining the ShadowGrid]. So, one, you'd mentioned that the professor was the one who suggested that the heat of the laser might be altering the beam intensity. Do you remember that interaction?

Carlos: Um. Yeah, yeah. I'm trying to think of the (trails off). So yeah, that was, again, when we were sitting down looking at how the different trials were not consistent and we were kind of befuddled by that. Trying to come up with reasons. Most of the reasons we were thinking about were some issue with our, basically everything about the apparatus except the laser. We had just assumed the laser was consistent. And so, then the professor coming in and taking this idea that the laser was inconsistent serious, that helped us realize that that could be the problem.

After Carlos elaborated on a specific interaction with his professor, the interviewer asked a clarifying question to help situate that interaction in the context of the pattern of interactions that Carlos had previously described:
Dimitri: Was this an example of where you all were trying to solve a problem and the professor came in to check in, or did you reach out to her?

Carlos: We did not reach out to her. I mean, looking in hindsight, we should have. But again, we were so focused on a problem, sometimes it's hard to pick your head up. And so having the professor check in every once in a while, was helpful. And that was a great example of how that works.

Thus, the combination of the ShadowGrid and clarifying questions helped the interviewer and respondent co-construct a detailed account of student-professor interactions, including both abstract patterns of interaction and “great example[s]”.

Overall, we found that using the LG to facilitate rich descriptions of respondent narratives was perhaps the most important function of the LG in both the BER and PER studies. However, one study from another researcher reported a contrasting experience. In using the LG technique, Bell felt that the linear and event-centered structure of the grid discouraged respondents from providing rich details about their experiences. Bell (2005) asserted that the grid caused respondents to focus only on facts without elaborating on feelings, context, and other relevant details. He found that LG interview respondents tended to work chronologically from the top-most to the bottom-most row, and that respondents were hesitant to go “backward” to discuss previously covered rows. Thus, in Bell’s study, interviews were relatively quick and devoid of detail. Therefore, he recommended that the LG technique be used only to generate factual data and be avoided for more affective and attitudinal topics (Bell, 2005). We suspect that the incongruity of Bell’s results as compared to ours and other studies is caused by differences in grid structure and facilitation techniques. The grid used in the Bell (2005) study included 50 rows to capture details of long-term marriages dating as far back as 50 years. The large size and temporal scope of this grid may have been prevented respondents from providing detail, and
instead, directed focus toward completing the task at hand. We made sure to limit the size of the grid to avoid intimidating respondents or creating time pressure. Bell also selected very broad direct indicators such as “Marriage and Family” and “Relationship issues”. In contrast, we used more specific direct indicators to encourage detailed narratives from respondents attempting to recall factual events. Finally, we aimed to provide flexibility and actively encouraged participants to backtrack, cross-reference, and return to blank spaces, all recommendations made by Nico (2016) to elicit more detail. We conclude that the way in which researchers introduce and use the grid is highly likely to influence the depth and characteristics of their data.

C. Construct a more accurate account of events

All retrospective data have the potential for bias because of their reliance on memory (Dex, 1995). Recall bias is systematic error that arises in reports of past events due to differences in the accuracy or completeness of recollections. Recall bias is problematic in that it can introduce inaccuracies during temporal narratives which, at their worst, may change the interpretation of events’ causes and consequences.

A classic and frequently cited benefit of the LG approach is reduction in recall bias in retrospective research, which was the main motivation for using this approach in early studies (L. R. Berney & Blane, 1997; Blane, 1996). Enhancing recall continues to be a benefit of use of the LG in more recent studies (Groenewald & Bhana, 2015; Porcellato et al., 2016). The primary characteristics of the LG approach that give rise to this benefit are the presentation of a visual timeline used to ground events and the use of indirect indicators. As described in Section II, indirect indicators are highly memorable events that allow the respondent to ground events of interest to the study (listed in the direct indicator columns) in their timeline. Indirect indicators can reflect major societal events, like wars or natural disasters (e.g., Parry et al., 1999; Porcellato
et al., 2016), or personally relevant events, like sports or hobbies (e.g., Wilson et al., 2007). Indirect indicator columns can be filled out by the interviewer prior to the interview using information that the interviewer suspects will be memorable to respondents (e.g., Parry et al., 1999) or using previously known information about the respondent (e.g., such childhood health records, see Holland et al., 2000). Alternatively, these columns can be filled out during the interview based on events that are personally relevant to the respondent (e.g., Richardson et al., 2009; Wilson et al., 2007). Deliberate selection of indirect indicators grounds the discourse in events that are relevant and memorable to the respondent and may even uncover surprising relationships between life-events and study-relevant information.

Both the BER and PER team found the grid helpful for enhancing accuracy of recall. To improve recall, the BER team used indirect indicators likely to be relevant to college-age students: semester classes taken, changes in living situations, changes in relationship (romantic or friend) status, and large family events (births, deaths, marriages, etc.). Indirect indicator columns were filled out at the start of the interview and subsequently used as markers to ground study-relevant information. The following excerpt illustrates cross-referencing for temporal accuracy.

Ashley: That's cool. When did that happen?
Kristin: I guess that was fall of my senior year. Yeah, yeah, fall of my senior year.
Ashley: Fall of your senior year. Okay, so that was ... Let's see. So that was after you had finished working [searching the grid], you'd already done the research that time and then you were working for [company name] when you were traveling?
Kristin: Mm-hmm (affirmative), yeah.

In some cases cross-referencing resulted in correction of previously mentioned information.

Sarah: Yeah, there are two semesters, it was physiology 1 and physiology 2.
Ashley: Okay, so you had moved into the apartment by then [referencing the grid], you were out of the [other living arrangement]?
Sarah: Yeah, I think they make you finish physics and stuff.
Ashley: Do you think that’s around the time of your car accident, then, that you were in your second semester?
Sarah: Uh, you put it under summer, but the it was in the fall.
Ashley: Got it. (corrected the LG entry)

Earlier, Sarah had listed an experience relevant to the study in the summer. In this quote, she corrects her earlier statement and moves the experience to the fall.

The PER team used respondents’ progress on their project as an indirect indicator, and the corresponding column of the LG was filled out by the interviewer based on respondents’ responses to weekly surveys. Thus, each respondent was presented with a unique LG during their interview, which assisted with recall. The interviewer also often used the ShadowGrids to guide follow-up questions when filling out columns of indirect and direct indicators, thus facilitating recall while avoiding imposing too rigid a structure at the start of the interview (see the example from Carlos above). When asked to reflect on the completed grid, one respondent, Francisco, drew a connection between the structure of the LG and his ability to recall events:

Dimitri: So, just looking over the grid, how does it feel seeing the project laid out this way?
Francisco: Going through it from top left to bottom right and going column by column makes a lot of sense. [...] It jogs the memory as you go, and it's a fairly logical progression of, you know, what happened this week, this week, this week, this week.

In summary, all of the attributes described above contribute to the utility of the LG technique in facilitating a positive experience for the respondent (agency and rapport) and in
enhancing the detail and accuracy of the narrative. However, the mere presence of the LG does not ensure these attributes. We found that how the LG is structured, introduced, and used during interviews is paramount in realizing the benefits described above. In addition, respondents’ unique identities and comfort levels affect interviews regardless of the interview technique, resulting in variable experiences. Overall, we have found that the LG technique is highly useful in collecting detailed data and nuanced narratives describing a discrete period of time in a students’ academic career.

V. Conclusions

In this paper, we have described the LifeGrid technique, explored two specific contexts in which the LG approach was applied in DBER research, and described attributes of LG use that may add to its utility as an interview technique. Additionally, this work addresses recent calls in DBER for research to go beyond simply demonstrating that something works and to additionally characterize how it works and explain moderating effects of different educational contexts (Tanner, 2011; Dolan, 2015). These calls recognize the need to draw upon theory and methodologies from other fields (e.g., cognitive science, sociology, psychology, etc.), much in the way that we adapted the LG from the field of medical sociology, in order to advance STEM DBER. This section synthesizes the information above to suggest how the LG approach can be used more broadly across education research endeavors.

Our experience and review of the literature related to the LG approach suggests that this technique is most useful to address questions with a substantial temporal component. These include questions similar to those presented here, which investigate experiences over the course of a project or academic career, and may extend to questions that ask about time periods before or after specific academic events. Constructs that undergo development or are subject to process
are inherently well-suited to studies using the LG technique. For example, life events, development of identity, career clarification, and development of expertise might all be appropriate topics for LG work. In addition, our experiences combined with examples from the literature also illustrate the plasticity of the LG technique. It can be used for time intervals that span weeks to years, and grid rows and columns can be modified to meet the needs of specific studies. These aspects may make the grid an attractive option for the study of a variety of temporal phenomena in educational contexts.

Despite the many potential uses of the LG technique, it is not appropriate in all instances. Research questions that are not temporal in nature will not benefit from this technique. For example, a research question asking about how an individual perceives a school policy or the culture of a department would not be answered using a LG. Temporal questions that span a small amount of time (i.e., less than four weeks) might also not necessitate the use of an LG as they would be easily discussed without a grounding artifact. Also, due to the more open-ended nature of the LG, which allows respondents to guide much of the direction of the interview, highly specific research questions that aim to target very specific details may not benefit from this technique. Instead, techniques such as semi-structured or structured interviews may be used for these types of questions.

Notably, the precise application of the BER and PER LGs varied in a few ways that demonstrate its flexibility, including the timescale under investigation (i.e., years or weeks), use of prior knowledge of the participant (i.e., student reflections and demographic information), and the structure of the grid (i.e., size and use of a ShadowGrid). Despite these differences, we feel that several specific components of the LG anatomy are consistently useful for facilitating the LG attributes we describe above. These components include the row headings that designate
discrete periods of time, column headings that are direct and indirect indicators relating to
dimensions of the respondents’ life, and grid spaces left primarily blank to be filled out
collaboratively during the interview. Also, we found that thoughtful facilitation of the LG is
important for achieving positive outcomes. While we feel that these defining LG components
contribute to the results we observed, relationships between specific LG components and LG
attributes have not yet been tested, aside from improved recall. Therefore, we cannot yet say
which components are essential for facilitating the different LG attributes. An important next
step in determining the utility of this technique would be to test which components of the LG are
essential for it to function as described. Here, we present the historical uses of LG alongside two
diverse uses of the LG in STEM education to serve as exemplars that we hope generate ideas
about how to approach interviews in STEM education research and future research on LG use
and function.

Summary

Originally developed to minimize recall bias in quantitative medical research studies (L.
R. Berney & Blane, 1997; Blane, 1996), we have shown that LGs are also useful for qualitative
DBER studies. In particular, LGs are suitable for investigations that focus on the development of
a phenomenon over a period of time and require rich descriptions of students’ experiences. LGs
are appropriate for time periods that range from weeks to years or even decades. For example,
we used the LG in two DBER studies: one on the effects and evolution of biology students’
disciplinary interest and career goals during college (4-6 years), and another on the development
of physics students’ sense of ownership of final projects (4-7 weeks). To the best of our
knowledge, the LG technique has been used in only one other education research study (Abbas et
al., 2013). Applications of the LG technique are sparse, and we believe that our work constitutes
the first applications of the LG technique to DBER contexts. Based on our experiences, we conclude that LGs are a valuable addition to the toolkit of qualitative DBER methods.
VI. List of abbreviations

BER – Biology education research

DBER – Discipline based education research

LG - LifeGrid

PER – Physics education research

STEM – Science, Technology, Engineering, and Mathematics
VII. Declarations

A. Availability of data and materials

The de-identified interview datasets used to inform this work are not currently publicly available because other studies analyzing the data are not yet complete and published, but the data are available from the corresponding author on reasonable request.

B. Competing interests

The authors declare that they have no competing interests.

C. Funding

This material is based upon work supported by the National Science Foundation (NSF) under Grants No. DUE-1712160, No. DUE-1611868, No. DUE-1726045, and No. PHY-1734006. The NSF did not contribute to the study design, data collection and analysis, interpretation of the data, or writing of the manuscript. This manuscript solely represents the views of the authors and does not represent the views of the NSF.

D. Author’s contributions

AAR conceived and designed the work, lead manuscript writing and project organization, directed the literature review, performed interviews related to the BER project, and synthesized and interpreted exemplar data.

DRDF and LR contributed to manuscript writing and literature review, performed interviews related to the PER project, and synthesized and interpreted exemplar data.

HJL contributed to manuscript writing and literature review and synthesized and interpreted exemplar data.
LAC conceived and designed the work, contributed to manuscript writing, project organization, and the literature review, and synthesized and interpreted exemplar data.

The initial draft of the manuscript was written via a collaborative writing process that was organized by AAR and LAC and in which all five coauthors participated roughly equally.

E. Acknowledgements

We are grateful for useful input on this manuscript by Angela Little, Laura Wood, Vashti Sawtelle, and Sarah Maestrales from the Advancing Narratives about Student Experiences through Research (ANSER) group at Michigan State University. This material is based upon work supported by the NSF under Grants No. DUE-1712160, No. DUE-1611868, No. DUE-1726045, and No. PHY-1734006.
VII. References

Abbas, A., Ashwin, P., & McLean, M. (2013). Qualitative life-grids: A proposed method for comparative European educational research. *European Educational Research Journal, 12*(3), 320–329. doi:10.2304/eerj.2013.12.3.320

Association of American Medical Colleges. (n.d.-a). Getting Experience. Find ways to get experience in the medical field before you attend medical school. Retrieved from https://students-residents.aamc.org/applying-medical-school/preparing-med-school/getting-experience/

Association of American Medical Colleges. (n.d.-b). What Medical schools are looking for: Understanding the 15 core competencies. Retrieved from https://students-residents.aamc.org/applying-medical-school/article/med-schools-looking-for-15-competencies/

Bell, A. J. (2005). “Oh yes, I remember it well!” Reflections on using the life-grid in qualitative interviews with couples. *Qualitative Sociology Review, 1*(1), 51–67.

Berney, L., & Blane, D. (2003). The lifegrid method of collecting retrospective information from people at older ages. *Research Policy and Planning, 21*(2), 13–22.

Berney, L. R., & Blane, D. B. (1997). Collecting retrospective data: Accuracy of recall after 50 years judged against historical records. *Social Science & Medicine, 45*(10), 1519–1525. doi:10.1016/S0277-9536(97)00088-9

Blane, D. B. (1996). Collecting retrospective data: Development of a reliable method and a pilot study of its use. *Social Science & Medicine, 42*(5), 751–757. doi:10.1016/0277-9536(95)00340-1
Creswell, J. W., & Poth, C. N. (2016). *Qualitative Inquiry and Research Design: Choosing Among Five Approaches*. Thousand Oaks, CA: SAGE Publications.

Dex, S. (1995). The reliability of recall data: A literature review. *Bulletin de Méthodologie Sociologique [Bulletin of Sociological Methodology]*, 49(1), 58–89. doi:10.1177/075910639504900105

Dounas-Frazer, D. R., & Lewandowski, H. J. (2018). The modelling framework for experimental physics: Description, development, and applications. *European Journal of Physics*, 39(6), 064005. doi:10.1088/1361-6404/aae3ce

Dounas-Frazer, D. R., Stanley, J. T., & Lewandowski, H. J. (2017). Student ownership of projects in an upper-division optics laboratory course: A multiple case study of successful experiences. *Physical Review Physics Education Research*, 13(2), 020136. doi:10.1103/PhysRevPhysEducRes.13.020136

Giele, J. Z., & Elder, G. H. (1998). *Methods of Life Course Research: Qualitative and Quantitative Approaches*. Thousand Oaks: SAGE Publications, Inc. doi:10.4135/9781483348919

Groenewald, C., & Bhana, A. (2015). Using the lifegrid in qualitative interviews with parents and substance abusing adolescents. *Forum Qualitative Sozialforschung*, 16(3). doi:10.17169/fqs-16.3.2401

Gubrium, J., & Holstein, J. (2001). Handbook of Interview Research. Thousand Oaks CA: Sage Publications.

Harrison, R. L., Veeck, A., & Gentry, J. W. (2011). A life course perspective of family meals via the life grid method. *Journal of Historical Research in Marketing*, 3(2), 214–233.
doi:10.1108/1755750111132154

Henderson, C., Yerushalmi, E., Kuo, V. H., Heller, K., & Heller, P. (2007). Physics faculty beliefs and values about the teaching and learning of problem solving. II. Procedures for measurement and analysis. *Physical Review Special Topics - Physics Education Research, 3*(2), 1–12. doi:10.1103/PhysRevSTPER.3.020110

Holland, P., Berney, L., Blane, D., Davey Smith, G., Gunnell, D. J., & Montgomery, S. M. (2000). Life course accumulation of disadvantage: Childhood health and hazard exposure during adulthood. *Social Science & Medicine, 50*(9), 1285–1295. doi:10.1016/S0277-9536(99)00375-5

Kvale, S., & Brinkmann, S. (2009). *InterViews: Learning the Craft of Qualitative Research Interviewing, 2nd ed.* (2nd ed.). Thousand Oaks, CA, US: Sage Publications, Inc.

Laursen, S., Hunter, A.-B., Seymour, E., Thiry, H., & Melton, G. (2010). *Undergraduate Research in the Sciences: Engaging Students in Real Science.* New York, NY: John Wiley Sons.

McGee, E. O., & Martin, D. B. (2011). “You would not believe what I have to go through to prove my intellectual value!” Stereotype management among academically successful black mathematics and engineering students. *American Educational Research Journal, 48*(6), 1347–1389. doi:10.3102/0002831211423972

Nico, M. L. (2016). Bringing life “back into life course research”: Using the life grid as a research instrument for qualitative data collection and analysis. *Quality & Quantity, 50*(5), 2107–2120. doi:10.1007/s11135-015-0253-6

Parry, O., Thompson, C., & Fowkes, G. (1999). Life course data collection: Qualitative
interviewing using the life grid. *Sociological Research Online, 4*(2). Retrieved from http://www.socresonline.org.uk/4/2/parry.html

Porcellato, L., Carmichael, F., & Hulme, C. (2016). Using occupational history calendars to capture lengthy and complex working lives: A mixed method approach with older people. *International Journal of Social Research Methodology, 19*(3), 269–286. doi:10.1080/13645579.2014.988005

Richardson, J., Ong, B. N., Sim, J., & Corbett, M. (2009). Begin at the beginning … using a lifegrid for exploring illness experience. *Social Research Update, (57)*, 1–4. Retrieved from http://sru.soc.surrey.ac.uk/SRU57.pdf

Sheridan, J., Chamberlain, K., & Dupuis, A. (2011). Timelining: Visualizing experience. *Qualitative Research, 11*(5), 552–569. doi:10.1177/1468794111413235

Stanley, J. T., & Lewandowski, H. J. (2016). Lab notebooks as scientific communication: Investigating development from undergraduate courses to graduate research. *Physical Review Physics Education Research, 12*(2), 1–11. doi:10.1103/PhysRevPhysEducRes.12.020129

Tonso, K. L. (2006). Student engineers and engineer identity: Campus engineer identities as figured world. *Cultural Studies of Science Education, 1*(2), 273–307. doi:10.1007/s11422-005-9009-2

Weiss, R. S. (1994). *Learning from Strangers: The Art and Method of Qualitative Interview Studies*. New York, NY: Free Press.

Wilson, S., Cunningham-Burley, S., Bancroft, A., Backett-Milburn, K., & Masters, H. (2007). Young people, biographical narratives and the life grid: Young people’s accounts of
parental substance use. *Qualitative Research*, 7(1), 135–151.

doi:10.1177/1468794107071427

Yerushalmi, E., Henderson, C., Heller, K., Heller, P., & Kuo, V. (2007). Physics faculty beliefs and values about the teaching and learning of problem solving. I. Mapping the common core. *Physical Review Special Topics - Physics Education Research*, 3(2), 1–31.

doi:10.1103/PhysRevSTPER.3.020109
## Supplement Table of Contents

| Table | Description | Pages |
|-------|-------------|-------|
| Supplementary Table 1: BER LifeGrid | | 2-6 |
| Supplementary Table 2: PER LifeGrid | | 7 |
| **Pre-undergrad time** | **Large Moves / Changes in residence (for yourself or people you are close to)** | **Family Events** (marriage, celebrations, births, illnesses, deaths, etc.) & **Relationships** (friendships, dating, etc.) | **Non-academic events and activities** (Awards, achievements, sports, hobbies) | **Financial Support** (Paid employment, scholarships, loans) | **Academic Interests** (origin and changes, intensity of interest, major declaration) | **Career Goals** (what did you want to be and did that change—specificity of goal) | **Participation in undergrad research** (lab work, authoring a publication, presenting poster or talk at a conference) | **Interactions with STEM faculty or Advising officers** (mentorship other than research) | **Internships, volunteer positions, work related to academics** | **Participation in professional society, organizations, or academic living-learning community** |
|------------------------|-----------------------------------------------------------------|-------------------------------------------------|-------------------------------------------------|-------------------------------------------------|-------------------------------------------------|-------------------------------------------------|-------------------------------------------------|-------------------------------------------------|-------------------------------------------------|-------------------------------------------------|
| **Year(s):**            |                                                                 |                                                 |                                                 |                                                 |                                                 |                                                 |                                                 |                                                 |                                                 |                                                 |
| Undergrad Semester | Large Moves / Changes in residence (for yourself or people you are close to) | Family Events (marriage, celebrations, births, illnesses, deaths, etc.) & Relationships (friendships, dating, etc.) | Non-academic events and activities (Awards, achievements, sports, hobbies) | Financial Support (Paid employment, scholarships, loans) | Academic Interests (origin and changes, intensity of interest, major declaration) | Career Goals (what did you want to be and did that change—specificity of goal) | Participation in undergrad research (lab work, authoring a publication, presenting poster or talk at a conference) | Interactions with STEM faculty or Advising officers (mentorship other than research) | Internships, volunteer positions, work related to academics | Participation in professional society, organizations, or academic living-learning community |
|--------------------|---------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------|-------------------------------------------------|--------------------------------------------------------------------------------|----------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------|
| Year 1: Fall       |                                                                            |                                                                                                               |                                                                          |                                                 |                                                                                       |                                                                            |                                                                                                                                     |                                                                                                                                     |                                                                                                                                     |                                                                                                                                 |
| Year 1: Spring     |                                                                            |                                                                                                               |                                                                          |                                                 |                                                                                       |                                                                            |                                                                                                                                     |                                                                                                                                     |                                                                                                                                     |                                                                                                                                 |
| Year 1: Summer     |                                                                            |                                                                                                               |                                                                          |                                                 |                                                                                       |                                                                            |                                                                                                                                     |                                                                                                                                     |                                                                                                                                     |                                                                                                                                 |
| Year 2: Fall       |                                                                            |                                                                                                               |                                                                          |                                                 |                                                                                       |                                                                            |                                                                                                                                     |                                                                                                                                     |                                                                                                                                     |                                                                                                                                 |
| Year 2: Spring     |                                                                            |                                                                                                               |                                                                          |                                                 |                                                                                       |                                                                            |                                                                                                                                     |                                                                                                                                     |                                                                                                                                     |                                                                                                                                 |
| Year 2: Summer     |                                                                            |                                                                                                               |                                                                          |                                                 |                                                                                       |                                                                            |                                                                                                                                     |                                                                                                                                     |                                                                                                                                     |                                                                                                                                 |
| Undergrad Semester | Large Moves / Changes in residence (for yourself or people you are close to) | Family Events (marriage, celebrations, births, illnesses, deaths, etc.) & Relationships (friendships, dating, etc.) | Non-academic events and activities (Awards, achievements, sports, hobbies) | Financial Support (Paid employment, scholarships, loans) | Academic Interests (origin and changes, intensity of interest, major declaration) | Career Goals (what did you want to be and did that change—specificity of goal) | Participation in undergrad research (lab work, authoring a publication, presenting poster or talk at a conference) | Interactions with STEM faculty or Advising officers (mentorship other than research) | Internships, volunteer positions, work related to academics | Participation in professional society, organizations, or academic living-learning community |
|-------------------|-----------------------------------------------------------------|-----------------------------------------------------------------|-----------------------------------------------------------------|-----------------------------------------------------------------|-----------------------------------------------------------------|-----------------------------------------------------------------|-----------------------------------------------------------------|-----------------------------------------------------------------|-----------------------------------------------------------------|-----------------------------------------------------------------|
| Year 3: Fall      |                                                                 |                                                                 |                                                                 |                                                                 |                                                                 |                                                                 |                                                                 |                                                                 |                                                                 |                                                                 |
| Year 3: Spring    |                                                                 |                                                                 |                                                                 |                                                                 |                                                                 |                                                                 |                                                                 |                                                                 |                                                                 |                                                                 |
| Year 3: Summer    |                                                                 |                                                                 |                                                                 |                                                                 |                                                                 |                                                                 |                                                                 |                                                                 |                                                                 |                                                                 |
| Year 4: Fall      |                                                                 |                                                                 |                                                                 |                                                                 |                                                                 |                                                                 |                                                                 |                                                                 |                                                                 |                                                                 |
| Year 4: Spring    |                                                                 |                                                                 |                                                                 |                                                                 |                                                                 |                                                                 |                                                                 |                                                                 |                                                                 |                                                                 |
| Year 4: Summer    |                                                                 |                                                                 |                                                                 |                                                                 |                                                                 |                                                                 |                                                                 |                                                                 |                                                                 |                                                                 |
| Undergrad Semester | Large Moves / Changes in residence (for yourself or people you are close to) | Family Events (marriage, celebrations, births, illnesses, deaths, etc.) & Relationships (friendships, dating, etc.) | Non-academic events and activities (Awards, achievements, sports, hobbies) | Financial Support (Paid employment, scholarships, loans) | Academic Interests (origin and changes, intensity of interest, major declaration) | Career Goals (what did you want to be and did that change—specificity of goal) | Participation in undergrad research (lab work, authoring a publication, presenting poster or talk at a conference) | Interactions with STEM faculty or Advising officers (mentorship other than research) | Internships, volunteer positions, work related to academics | Participation in professional society, organizations, or academic living-learning community |
|-------------------|-----------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------|-----------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Year 5: Fall      |                                                                              |                                                                                                             |                                                                     |                                                                     |                                                                                                                                                                                  |                                                                                                                                                                                                  |                                                                                                                                                                                                  |                                                                                                                                                                                                  |                                                                                                                                                                                                  |                                                                                                                                                                                                  |
| Year 5: Spring    |                                                                              |                                                                                                             |                                                                     |                                                                     |                                                                                                                                                                                  |                                                                                                                                                                                                  |                                                                                                                                                                                                  |                                                                                                                                                                                                  |                                                                                                                                                                                                  |                                                                                                                                                                                                  |
| Year 5: Summer    |                                                                              |                                                                                                             |                                                                     |                                                                     |                                                                                                                                                                                  |                                                                                                                                                                                                  |                                                                                                                                                                                                  |                                                                                                                                                                                                  |                                                                                                                                                                                                  |                                                                                                                                                                                                  |
| Year 6: Fall      |                                                                              |                                                                                                             |                                                                     |                                                                     |                                                                                                                                                                                  |                                                                                                                                                                                                  |                                                                                                                                                                                                  |                                                                                                                                                                                                  |                                                                                                                                                                                                  |                                                                                                                                                                                                  |
| Year 6: Spring    |                                                                              |                                                                                                             |                                                                     |                                                                     |                                                                                                                                                                                  |                                                                                                                                                                                                  |                                                                                                                                                                                                  |                                                                                                                                                                                                  |                                                                                                                                                                                                  |                                                                                                                                                                                                  |
| Year 6: Summer    |                                                                              |                                                                                                             |                                                                     |                                                                     |                                                                                                                                                                                  |                                                                                                                                                                                                  |                                                                                                                                                                                                  |                                                                                                                                                                                                  |                                                                                                                                                                                                  |                                                                                                                                                                                                  |
| Post-undergrad time | Large Moves / Changes in residence (for yourself or people you are close to) | Family Events (marriage, celebrations, births, illnesses, deaths, etc.) & Relationships (friendships, dating, etc) | Non-academic events and activities (Awards, achievements, sports, hobbies) | Financial Support (Paid employment, scholarships, loans) | Academic Interests (origin and changes, intensity of interest, major declaration) | Career Goals (what did you want to be and did that change—specificity of goal) | Participation in undergrad research (lab work, authoring a publication, presenting poster or talk at a conference) | Interactions with STEM faculty or Advising officers (mentorship other than research) | Internships, volunteer positions, work related to academics | Participation in professional society, organizations, or academic living-learning community |
|---------------------|------------------------------------------------------------------|-------------------------------------------------|-------------------------------------------------|-------------------------------------------------|-------------------------------------------------|-------------------------------------------------|-------------------------------------------------|-------------------------------------------------|-------------------------------------------------|-------------------------------------------------|
| Year 1 Post-Graduation | | | | | | | | | | |
| Year 2 Post-Graduation | | | | | | | | | | |
| Year 3 Post-Graduation | | | | | | | | | | |
| Year 4 Post-Graduation | | | | | | | | | | |
| Year 5 Post-Graduation | | | | | | | | | | |
| Year 6 Post-Graduation | | | | | | | | | | |
| Experimental progress | Changes to experiment | Goals and subgoals | Memorable experiences | Personal contributions | Interactions with students | Interactions with professors |
|-----------------------|-----------------------|--------------------|----------------------|------------------------|---------------------------|----------------------------|
| **Wk 1**              |                       |                    |                      |                        |                           |                            |
| **Wk 2**              |                       |                    |                      |                        |                           |                            |
| **Wk 3**              |                       |                    |                      |                        |                           |                            |
| **Wk 4**              |                       |                    |                      |                        |                           |                            |
| **Wk 5**              |                       |                    |                      |                        |                           |                            |
| **Wk 6**              |                       |                    |                      |                        |                           |                            |
| **Wk 7**              |                       |                    |                      |                        |                           |                            |
| **Wk 8**              |                       |                    |                      |                        |                           |                            |