A Novel Methodology to Elicit Student Perspectives In Semi-Structured Interviews

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This paper introduces a novel methodology that was designed to enrich student perspective interview data by providing students with a more robust approach to supplying their justifications to interview questions. This methodology evokes student perspectives on a target object (e.g., their typing speed) by inviting participants to place the object along a physical dial representing a conceptual continuum (e.g., slow to fast) and justify their placement through open-ended discussion. The data presented to introduce the methodology was collected from upper-level undergraduate students in a quantum mechanics (QM) course. In this paper, we focus on two illustrative case studies, Oliver and Emma, to demonstrate the range of interpretive strategies used among students. The methodology supports multiple modes of reasoning: object-focused, scale-focused, qualitative, and quantitative. The physical dial acted as an anchor for students to provide structure to not only the interview protocol, but also how students deliver their responses to the interviewer. Through the use of a training period at the beginning of the interview, where students "learn how to play the game", students were able to give consistent responses to course perspectives interview questions. The pilot study presented here is part of a larger analysis of the methodology, but already suggests that integrating semantic differential scaling into interviews offers a promising framework for structured yet open-ended exploration of student thinking across complex scientific domains.

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I. INTRODUCTION

While there are numerous resources aimed at supporting novice researchers in physics education research (PER), including strategies for formulating effective interview questions, distinctions among various interview formats, and fundamental contrasts between quantitative and qualitative methodologies [1–3], there remains a notable gap in the literature on methodological journal articles that focus primarily on the practical execution of semi-structured interviews. Specifically, aside from generic lists of "tips and tricks", there is limited discussion on how to conduct interviews with techniques that elicit students' perspectives and perceptions.

Student perspectives on their learning context impact their learning outcomes and, as such, determine students' thoughts, feelings, and attitudes toward various aspects of their learning environment [4]. Thus, these perspectives are important for developing more effective and engaging learning experiences [4]. PER studies investigate student perspectives on specific content areas [5], challenges in learning specific content and skills [6], motivations and expectations in particular courses [7], and specific pedagogies [8], among others. Open-ended and semi-structured interviews are commonly used methodologies in studies of student perceptions.

Literature on open-ended, semi-structured, and think-aloud interviews warn that students may not always verbalize their thought processes spontaneously or in sufficient detail to meet the analytical needs of the researcher [9, 10], especially when students perceive a threat to their academic self-image [11]. "Leading the witness" [12] also inadvertently shapes student responses through overprompting, occurring in both educational [13, 14] and research [15, 16] contexts. Thus, an appropriate balance must be struck: the prompts should be designed to encourage reflection and clarity without directing or biasing the respondent [9, 10, 17, 18]. In addition, interview protocols often depend on predefined questions supplemented by prompting and probing strategies [15, 19], which can be insufficient when interviewees provide non-descriptive, rambling, or tangential responses [16, 20].

To address all of these issues, we developed and tested a novel semi-structured interview protocol that aims to elicit more focused and intentional student responses, enhance student agency in articulating thought processes, and provide interviewers with a structured yet flexible framework for probing that minimizes inadvertent shaping of interviewee responses. This approach was designed to reduce the need for intrusive probing by (1) encouraging deep, elaborate and specific [9] initial responses through structured design and (2) providing interviewers with a systematic approach to probing when necessary that emphasizes procedural neutrality and minimizes the risk of interviewer bias.

This paper discusses our novel methodology to investigate student perspectives that has two major features: (1) a dynamic, tactile adaptation of the traditional semantic differential scale on a continuous dial and (2) the introduction of a "learning to play the game" training segment of the interview where students learn how to give deep and elaborate responses before moving on to the target questions. We provide illustrative training and target questions from interviews that we conducted with upper-division quantum mechanics students. We also present two case studies as initial evidence for the potential effectiveness of the methodology.

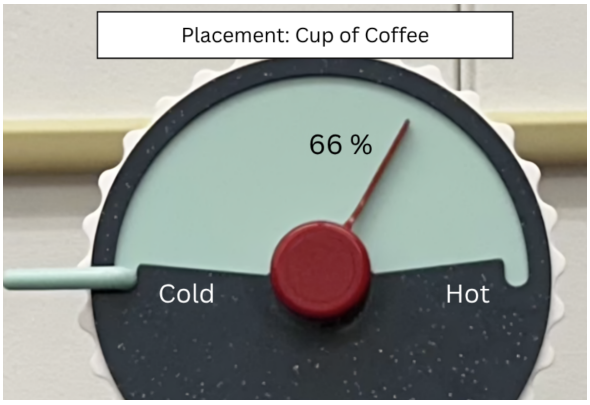

FIG. 1. This continuous dial originates from the board game "Wavelength". Students are given a customized card with two extremes where one description represents the left end, and another the right.

II. DESCRIPTION OF THE METHODOLOGY

(1) Manipulative, continuous dial: Our methodology adapts elements from conventional quantitative surveys, specifically semantic differential testing, to a qualitative interview framework. Traditional semantic differential instruments are typically depicted with "opposite" adjective pairs anchored at either end of a discrete interval scale [21–23]. For instance, a scale anchored by "cold" on one end and "hot" on the other may include seven equally spaced markers between the poles. In this example, the specific temperature unit (e.g., Celsius or Fahrenheit) is not essential, as the semantic differential focuses on relative placement along the scale rather than absolute values, assuming equal interval perception across the range. Although a related format, the Likert scale, typically consists of five-point intervals with explicit labels for degrees of agreement [24, 25], there is disagreement within the literature on the optimal number of response intervals: too few may obscure nuanced perspectives, while too many can overwhelm or confuse respondents [26, 27]. Furthermore, conventional survey formats offer limited insight into the reasoning behind respondents' selections [2, 27, 28].

We introduced a modification to this format by implementing a manipulative, continuous-response dial as shown in Figure 1. This tool allows students to select any position along a continuous spectrum, providing them with greater agency in their responses. Importantly, the emphasis shifts from interpreting predefined bins to considering the relative distance that a student positions the dial along the continuum. This flexibility reduces the potential ambiguity that arises from

instructor-defined bin sizes or interval interpretations and empowers students to respond in a manner that more accurately reflects their own perceptions. As students articulate their justifications for their placements on the dial during the interview, researchers gain valuable access to the interviewees' interpretive processes, including how the student interviewees define scale endpoints, understand interval spacing, and conceptualize neutrality on the scale.

The manipulative nature of the dial further encourages students to engage dynamically with the instrument, where participants are invited to share their initial placements and elaborate on their reasoning, including their interpretation of each end of the scale and the significance of their chosen position. The format also accommodates mid-response adjustments, as students refine their responses in real-time while verbalizing their thought processes. Thus, it enriches the data with context often lost in fixed-response instruments. Additionally, our methodology allows students to explicitly compare responses across items, reflecting on how their prior responses to previous questions inform subsequent judgments. Especially when students make minor shifts in placement in response to nuanced conceptual differences between consecutive questions, these changes are often lost in traditional bin-based formats, yet they are preserved and contextualized through the continuous dial and verbal explanations.

The manipulative dial itself serves as a conceptual anchor, encouraging students to externalize and spatially locate their thinking along a continuous scale. The inherent structure of the physical dial requires students to place answers along a bipolar continuum, naturally prompting them to consider contrasting perspectives before making a decision. However, many disconnected ideas may arise in a student's justified placement of the dial. If the organization of student ideas is important to the research question, like in the examination of student conceptions of a particular phenomenon, other manipulative methodologies like card-sorting activities [29] may be more beneficial.

(2) "Learning how to play" segment: The second key feature of the methodology is a training segment at the start of the interview. Approximately 10 minutes at the start of the interview is dedicated to a set of introductory questions targeting similar constructs (e.g., preferences, abilities) to those that will be examined in the target question set. These introductory questions served a dual purpose: (1) to familiarize participants with the interview structure and the interactive dial-based response system, and (2) to elicit preliminary responses in a low-stakes context that would prime students to articulate their justifications consistently and without the need for interviewer probing in the target segments of the interview. This introductory session functioned as a training mechanism, enabling students to practice articulating nuanced reasoning and to calibrate their expectations regarding the level of detail and justification required in their responses.

Some sample questions (used in our test study outlined in more detail in the next section) that are appropriate for the training segment are listed here:

- On a scale from cold (coldest place on Pluto) to hot (the Sun), where would you place a cup of coffee?
- On a scale from hate (worst thing in the world, zero is too many) to love (best thing in the world, could never have enough), where would you place cats?
- On a scale from slow (any single person would beat you in a race or competition) to fast (in the top 0.001% of all people), where would you place your typing skills?

These questions are intentionally content-neutral and designed to model the structure of the target questions to follow. Depending on how students justify their placement, multiple probing questions should be asked to ensure that they discuss how they are interpreting the object being placed and the end-points of the scale, and that they provide reasons for the placement in the context of those interpretations. For instance, interviewers could ask, "Can you elaborate on why you placed the coffee closer to the cold end?" or "What influenced your decision to position your typing speed closer to the middle of the scale?"

In each case, students are provided with standardized definitions for the endpoints of the spectrum to ensure consistency in interpretation. The students were then invited to describe how they conceptualized the scale, including their understanding of the midpoint and relative ends. This trial interaction also enabled the researchers to assess the students' initial interpretations of the interviewing framework and provide real-time scaffolding through probes. Repeated follow-up questions aimed at probing students' reasoning in contexts with minimal cognitive or affective stakes across these training items are intended to help students internalize both the expectations and the format of the interview before they reach the target questions. While some probing may still be necessary, interviewers can reference prior student placements or explore distances between current and previous responses (e.g. relative to endpoints or the midpoint) to elicit further explanation with more interviewer neutrality.

In summary, the training session acts as an epistemic scaffold, that contributes to elaborate and balanced responses during the targeted sections of the interview. It also provides the opportunity for building connections with the student early in the interview and allows for a settling-in period before the heavier content-related questions are asked.

III. INITIAL TESTING OF THE METHODOLOGY

The methodology was first tested in interviews with upper-level undergraduate students enrolled in a quantum mechanics course consisting of 21 dial questions categorized in five sections as shown in Table I.. All eight students in the course participated in the study; however, here, we highlight two case studies to illustrate the potential range of student responses elicited by the interview protocol. The students will be referred to by the pseudonyms *Oliver* and *Emma*.

Our initial evaluation of the methodology was to assess whether students are "playing the game" by the end of the

TABLE I. The interview structure was broken up into 5 major parts spanning a total of 21 interactive dial questions.

Interview Structure
Section 1: Learning the Game
Section 2: Perceptions of their Quantum Knowledge
Section 3: Comparison of Intermediate vs Quantum Mechanics
Section 4: Pedagogical Preferences
Section 5: Mathematical and Experimental Quantum Knowledge

TABLE II. Out of the 21 questions in this preliminary interview, a selection of questions will be discussed in this paper.

Interview Questions		
Object Placed	**Left End**	**Right End**
Q1: Cup of Coffee	Cold	Hot
Q3: Your Typing Skills	Slow	Fast
Q12: Quantum Mechanics	Easy	Difficult

training period and whether they continue to do so throughout the target questions. "Playing the game" as intended would require that students:

1. discuss how they are interpreting the object placed
2. discuss how they are interpreting endpoints of the scale
3. provide reasons for the placement in the context of those interpretations.

To take a closer look at this, we will present Oliver and Emma's responses to two training questions and one target question (shown in Table II).

In the first question of the interview, students were asked to place a cup of coffee on a cold-hot scale. The scale was defined such that the cold end represented "the coldest place in the solar system; Pluto on a winter's day," and the hot end represented "the hottest place in the solar system; the center of the Sun." Oliver and Emma demonstrated distinctly different approaches to this initial question.

Oliver: So Pluto is not close to 0 C. Definitely below freezing by a significant margin. How far down can it go? Maybe minus 100 C... I know the surface of the Sun is not as hot as we can get on Earth. But the center has got to be like really hot. I'm inclined to say that... the Sun is more hot than Pluto is cold. So I'd place coffee a bit more *(around)* here than the middle.

Interviewer: Can you talk a little bit more about your placement, and why it isn't over more this way *(hot end)*?

Oliver: Well, I'm seeing this as a linear scale. I think that the Sun, let's say it's 5000 C. And I think Pluto is only minus 100 C...Because I'm thinking in the middle is 2500 C. Hot cup of coffee is about around 100 C. Or if it just came out, if you just poured boiling water...

Here, Oliver's description is scale-focused; his justification centers on the quantitative nature of the end points and his numerical estimation. However, he doesn't discuss the object (the cup of coffee). Thus, the probing question, while still broad, is required to prompt Oliver to make an explicit statement about the object, and not just the scale. In contrast, Emma approached the question with an object-focused, qualitative lens, drawing from personal experiences and cultural context. Despite a similar interviewer probe, Emma still does not elaborate on the scale ends.

Emma: So I pick the hot side because I generally like it when I drink hot coffee. If I drink iced latte or iced coffee, then it doesn't feel like coffee. It might be because of the culture I'm coming from. And I didn't want to go all the way down, because other people are drinking iced coffee as well.

Interviewer: Are there other reasons why you're not pushed down further here *(towards the cold end)*?

Emma: Like if you get ordered hot coffee, then it's going to be really hot. But I was considering the rest of the coffees in general in the world. They're both cold coffee and hot coffee. So I wanted to make it closer to the middle because of that.

From comparing Emma's and Oliver's responses, the methodology allows for variability in interpretation, where Emma's framing of the object (coffee) emphasized user experience rather than physical characteristics. While Oliver's response allowed the interviewer to infer his reasoning and placement on the scale, Emma's interpretation left more ambiguity regarding her scale interpretation and required follow-up to elicit ideas about scale. However, in the last training question, where students placed their typing skills along a spectrum from "slow" to "fast", Emma demonstrated a more balanced approach. Although her response remained personal and object-focused, she began incorporating elements of scale reasoning that clarified her placement.

Emma: My typing skills? I'm not the fastest typer. I think I have practice with it because I have to type a lot of homework papers. But, I've seen so many other people who are typing so fast, like the flash. So I don't know. I put myself not in the slow part because I have practice. Like I can go fast if I want to, but most of the time, I don't like typing fast. I try to catch my thoughts first and then type...Like people in *(liberal art)* majors, like non-STEM majors. They are typing so many papers for their classes, typing so fast. Like my roommate last year, I've seen them finish a paper really quickly and they type without like stopping for a second.

By this point, Emma appears to be "learning the game", responding in a way that retains her personal style while also helping the interviewer understand how she is constructing the scale. Following the training segment, students responded to questions related to their perceptions and experiences in quantum mechanics. For example, Q12 asked students to reflect on the difficulty of the course:

Oliver: I would place *(the course)* around the rightmost quarter *(near the difficult end)*. I never felt like I wasn't grasping the material. If it was a super complex subject, I would just leave it. I feel I have a good concep-

tual understanding of the first half: Quantum entanglement, Stern-Gerlach experiments, the double slit experiments, iridescence. I found it really enjoyable... Last half of the course with factorization technique, perturbation theory, working through the problem sets. I felt sometimes lost, but I was able to complete the stuff given enough time and given enough help and support. So, around here in the right quarter, I'd place myself. Maybe like 90 percent of the way to exactly on pace. I haven't put as much time into this course as I used to. And also perturbation theory, I don't think I completely have that have that down yet.

Emma: ...I didn't want to put *(the course)* all the way up because I don't think I fully get everything we have done so far. Like I can carry out some calculations, but don't get the full meaning behind it. But I did want to shift it up a little bit...Like I learned how to work with the operators at a higher level. We learned BCH and worked with the exponential disentangling and that kind of stuff. They were completely new things to me and I learned and obtained some *(new)* information on those things and got some practice with them, so I wanted to move it *(up from the previous question)*.

As the interview progressed, we observed increasing convergence in the reasoning strategies of Oliver and Emma. Oliver maintained a quantitative approach, referencing specific dial positions and focusing on scale interpretation, but became more adept at articulating his object-reasoning without interviewer prompts. Emma, initially object-focused and grounded in personal experience, began to incorporate justifications that reflected a growing consideration of the scale.

Although we present only a subset of interview questions and student responses, these examples reveal meaningful trends. Initially, some student responses lacked the detail necessary for interviewers to infer scale interpretation or object placement, but as the interview progressed, students developed more robust and interpretable responses. These later responses provide insight not only into the object being placed and the student's experience with it, but also into their underlying reasoning and interpretation of the constructed scale. We see similar evidence across all the students interviewed that indicate that the students continued to "play the game" throughout the target questions, allowing for the elicitation of their perspectives with minimal interviewer probing.

IV. DISCUSSION AND CONCLUSION

This study represents a pilot investigation of an interview methodology developed in response to a lack of existing instruments designed to capture student perpectives. We have briefly described a methodology that involves 1) an adaptation of a quantitative tool inside a semi-structured interview setting, with 2) the inclusion of a "learning to play" training session to enrich responses to subsequent content-specific items.

We argue that the manipulative dial-based interview protocol shows strong potential as a research tool to investigate student perspectives, particularly for qualitative studies. It provides a structured, yet flexible framework that prompts students to reason from object-focused and scale-focused perspectives, integrating both qualitative and quantitative reasoning, enabling cross-participant comparison while preserving the richness of individual student voice. The protocol also supports non-invasive probing, encouraging elaboration without introducing bias. Additionally, including a content-neutral, low-stakes training segment at the outset helps students calibrate their responses and be more consistent across the target questions.

However, with many qualitative studies, the sample size is small and the results produced in this interview will be limited in terms of generalizability. While potential for quantitative analysis exists, especially through comparisons of dial placements, students often interpret both the scale and the object of placement in highly individualized ways, complicating direct quantitative comparisons across participants. Thus, for the purposes of this paper, quantitative analysis of the methodology of the interview instrument was not accessed and left for future work. Also, even within a single interview, the consistency of students in how they "play the game" can vary, especially depending on the question being asked.

Future work on this methodology is being conducted to answer two major open-questions: 1) Can students "learn how to play the game" effectively, giving more meaningful, descriptive responses that are interpretable to researchers? 2) Does this protocol offer a productive means of eliciting both quantitative data (via dial responses) and qualitative data (via students' justifications)? For the first question, a deeper analysis dive through all methodological codes is being conducted to find patterns in the efficacy of the "learning to play the game" training segment and the entire methodology holistically. While the second question is being evaluated through interview data on introductory physics students solving computational physics problems through two interview protocols: one using this methodology and another that does not.

In conclusion, this preliminary study suggests that manipulative, semi-structured interview protocols like the one described here may offer a promising direction for future research that seeks to elicit student perspectives in an interview format.

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