

## **Developing a responsive professional development (RPD) survey for high school physics teachers**

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By taking a responsive approach to the design and enactment of teacher professional development (PD), PD instruction can be tailored to teachers' needs, interests, and concerns. This is of considerable importance in the high school physics teacher PD space, wherein teacher needs turn out to be particularly complex and diverse due to differences in teacher preparation within the discipline. More generally, understanding the degree to which PD programs are responsive to their teachers' needs can support increased responsiveness. To this end, having a validated survey can assist in measuring the criteria for this responsiveness. This study presents the initial development of a responsive professional development (RPD) survey based on interviews with 13 high school physics teachers. Nine responsive codes were identified through thematic analysis of teacher interviews, and the resulting survey has been administered to 33 teachers for piloting purposes. In this work, the initial survey development process is presented.

## I. INTRODUCTION

Many researchers and practitioners believe that teacher professional development (PD) is an effective means for improving classroom instruction and student achievement [1, 2]. However, PD programs may follow a prescriptive approach, suggesting or mandating specific curricula and pedagogies, which may remain disconnected from teachers' knowledge, beliefs, or local realities of their classroom context. By taking a responsive approach to teacher PD, facilitators can attend to teachers' diverse perspectives and adapt the program based on those needs. We define responsiveness as being *attentive* to emergent teacher needs and interests, and *adaptive* to these needs. Attentiveness means creating multiple opportunities for teachers to communicate their needs, interests, and concerns. Adaptiveness then allows for tailoring PD activities to reflect these needs. These adaptations can occur at any level from redesigning the structure of week-long intensive PD workshops to changing assigned conversation partners based on informal survey feedback. From the responsive PD perspective, high-quality PD is not defined by a single characteristic (e.g., prolonged, discipline-specific) [3, 4], but rather a combination of features [5, 6] aligned with teachers' needs and interests, all of which could contribute to the eventual success of the program.

Responsive Professional Development (RPD) is inspired by "responsive teaching," a pedagogical approach in which instructors attend to students' thinking and adapt instruction based on students' existing disciplinary ideas [7–9]. This approach has been adopted by teacher education programs to build connections to teachers' existing disciplinary ideas as an asset-based facilitatory strategy [10–12]. Going beyond the disciplinary ideas in teachers' thinking, other PD approaches have been attentive and adaptive to teachers' professional and pedagogical needs [13, 14]. These individual needs can vary according to teachers' classroom and school teaching contexts, their disciplinary training, and their pedagogical values. Such a responsive PD approach allows teachers to co-design and co-facilitate the PD activities with program facilitators, which can benefit teachers in their self-efficacy and sense of community belonging [15, 16].

We argue that it remains difficult to measure whether a PD program has effectively responded to a group of teachers' needs, interests, and concerns. One reason for this difficulty is that relevant dimensions of responsive PD approaches are not currently articulated. Better articulation and measurement of teachers' responsive PD experiences can advance research into the impacts of responsive PD. There are currently no surveys that specifically target teachers' perceptions of PD responsiveness. This paper presents initial survey items for assessing different aspects of teachers' perceptions of the responsiveness of a PD program. These survey items were created from interviews with teachers in a responsively-designed physics teacher PD program. Future work includes completing survey validation and using it to characterize and compare the responsiveness of different PD programs.

## II. RESPONSIVE PROFESSIONAL DEVELOPMENT

The existing literature shows that some structural elements in teacher PD, such as the duration, content, and focus of the PD matter greatly in the design of high-quality experiences for teachers. For instance, many works endorse sustained teacher PD experiences as opposed to single-shot PD experiences [3, 4, 16–18]. Some empirical review studies also show that content-specific PD instruction is significantly more effective when the focus is on developing teachers' content knowledge [4, 19]. As for findings on responsive PD design in the literature, the integration of design-based research (DBR) approaches into teacher PD appears to support the adaptive aspect of responsive PD [20]. Findings from these studies also support the argument that improved PD instruction that aligns with teachers' specific goals may positively influence student outcomes [21] in teacher communities of practice [22]. Additionally, efficacious teacher PD facilitation strategies that align with an RPD approach have been documented, such as Richards' [23] *focused responsiveness*, an approach that centers on an asset-based view to teacher involvement in PD, explicitly valuing teacher voices in the PD process. Yet, works such as these do not show much empirical clarity around potentially replicable responsive elements in teacher PD.

## III. METHODS

### A. Context

The survey design process took place in the context of a partnership program called Illinois Physics and Secondary Schools (IPaSS) between the University of Illinois and a group of Illinois high school physics teachers. The core goal of the program is to create a community of high school physics teachers working to implement and adapt new pedagogical approaches in their teaching practice. Over time, IPaSS has expanded to include both physics instructional materials used at the University of Illinois (e.g., SmartIllinois an online platform for pre-lectures and homework for flipped instruction, iOLab wireless lab system and associated materials for facilitating investigative lab activities) and resources developed and shared by participating teachers. The explicit messaging of the IPaSS program is for teachers to select, adapt, and implement pedagogical approaches that best fit their teaching contexts and instructional goals. To be responsive to teachers' needs, IPaSS builds in opportunities for teachers to become co-facilitators, supports the sharing of ideas and resources among the teachers, and provides time for teachers to collaborate and support each other in the flexible adaptation and implementation of new curricular resources. The PD is delivered both in-person and online throughout the year. "Teaching fellows" participate roughly in 100 hours of PD each year for four consecutive years. This multi-year PD design allows teachers to receive community sup-

port throughout the implementation-and-revision cycle and eventually grow to become more central leaders in the teacher community as new teachers enter the program each year.

## B. Participants

The survey items were designed by interviewing 13 physics teachers (six men and seven women) in the second year of the program. Eleven teachers were white and two teachers Latinx. Teachers had between two and 32 years of teaching experience, and they taught various levels of physics (e.g., AP Physics C, AP Physics 1, honors physics, regular physics, conceptual physics, etc.). The survey was then piloted with 33 physics teachers (21 men and 12 women) including the thirteen teachers who had been interviewed initially.

## C. Interviews

We conducted 30-minute semi-structured online interviews with all thirteen teachers. The interview protocol was sent to teachers a few days before the interview for preparation purposes. The protocol consisted of two sections relevant to this work. In the first section of the interview, we asked about teachers' overall opinion of the program and encouraged the participants to compare the program with their previous PD experiences (if they had any). In the second section of the interview, we specifically asked about the most effective aspects of the program for their learning and professional growth, and asked for clarification and expansion via follow-up questions.

## D. Data analysis

All interview data were transcribed and analyzed using MAXQDA [24]. A combination of deductive, and inductive coding approaches were used for thematically coding the interviews. The deductive codes were derived from the interview protocol and inductive codes emerged from teachers' expressed perceptions of the effective aspects of the program. Our goal here was to establish a set of broadly understood thematic codes for creating survey items. To serve this goal, three coders coded and discussed disagreements on one randomly selected teacher interview. Based on a refined coding scheme, a second interview was coded and three coders reached Cohen's Kappa of 0.74 (94% agreement) which was an average of two Kappa scores between coder 1 and 2 and coder 1 and 3 on all codes. Then the rest of the interviews were split between coders for coding. Finally, a fourth coder coded all interviews for the existence or non-existence of the defined categories, and the matched results with the previous categorization showed a Cohen's Kappa of 0.86. This indicates high agreement when the codes apply. The two cycles of coding helped improve clarity and agreement around the

coding scheme, which helped us translate interview insights into survey items. Table I reflects the codes derived from the interview analysis, except the co-facilitation code.

## IV. SURVEY DEVELOPMENT PROCESS

The four-phase iterative process of developing and validating a survey is adopted from Sondergeld and Johnson's [25] study: (1) Planning, (2) Developing, (3) Qualitative field testing, and (4) Quantitative field testing. In this work, we have completed the phases of planning and developing and have initiated the early steps in qualitative and quantitative field testing.

### A. Planning: identifying key components of responsive professional development

In the planning phase, a comprehensive literature review, interview, and synthesis of literature review and interview took place. Following the literature review that was discussed earlier, we conducted semi-structured interviews with teachers. Next, in the synthesis step, we analyzed the recorded interviews and created an initial coding scheme comprising 16 codes in four categories. Elements of teacher PD from the literature informed the development of the coding scheme. The full results of these interviews have been expanded in another work [26]. In this work, we focus on the developmental process of creating the survey items.

### B. Item development

Based on the frequency of coded items, we narrowed the coding scheme to nine codes and created survey items based on representative themes in teachers' responses. For each code, a positive item and a reverse-coded item (R) were created, and response options followed a five-option Likert-scale format (1= strongly disagree, 5= strongly agree). These survey items were based on common interview responses that fit each code.

### C. Qualitative and quantitative field testing

For qualitative field testing and ensuring content validity, the first author sought feedback on the survey from four subject matter experts. All subject matter experts have physics backgrounds with various years of experience both in K-12 and higher education. Two of them have expertise in designing and facilitating PD for K-12 teachers. Both face and content validity were ensured before piloting the survey [27]. For quantitative field testing, we administered the survey to 33 physics teachers as a pilot test.

TABLE I. Codes and Survey Items. *Note:* \*For reverse-coded items, means are computed after the scoring is reversed (i.e. 5 represents a the most positive endorsement of PD responsiveness).

Code	Survey Items	Field Test Mean (SD)
Sharing pedagogical ideas	The IPaSS professional development creates opportunities for exchanging ideas with other teachers.	4.94 (.24)
	(R) It is difficult to find opportunities to exchange ideas with other physics teachers during the IPaSS professional development sessions.	4.55 (.61)
Collaborative group work	The IPaSS program creates opportunities for collaborative work with other teachers in the program.	4.53 (.69)
Flexibility in uptake and implementation	The IPaSS program offers flexibility in how we adopt and incorporate university resources into our teaching practices.	4.78 (.41)
Practicality of materials	The IPaSS materials provided by the program are practical (they can easily be incorporated into my curriculum without significant modification).	3.97 (.95)
	(R) The University of Illinois materials provided by IPaSS cannot be easily adapted into my curriculum.	3.85 (.97)
Sharing both university and non-university resources	The IPaSS program facilitates the sharing of resources beyond those used at the university.	4.73 (.51)
	(R) The IPaSS team heavily promotes university materials and is not welcoming of other materials or pedagogical practices.	4.45 (.75)
Serving teachers with diverse backgrounds/ experiences/needs	The IPaSS serves teachers with diverse backgrounds and a range of experiences.	3.61 (1.02)
	(R) The IPaSS program exclusively caters to AP physics teachers, failing to address the specific requirements of other teachers who may not necessarily teach AP courses.	4.12 (.65)
Learning from teachers (bi-directionality of mentor and mentee)	The IPaSS program allows me to learn from teachers at different stages in their career path than me.	4.87 (.33)
Adaptability of PD instruction	The professional development offered by IPaSS is tailored to meet my specific needs and evolving interests.	4.24 (.66)
	(R) The IPaSS professional development curriculum is prescribed; it often does not fully accommodate our individual needs and interests.	4.36 (.60)
Co-facilitation	The IPaSS program recognizes my strengths as an educator and allows me opportunities to plan, lead, and facilitate professional development sessions.	4.42 (.66)
	(R) The IPaSS team takes full control of planning and facilitating PD instruction with minimal input from teachers.	4.58 (.56)

## V. RESULTS

We calculated Cronbach's Alpha, a measure of the inter-item correlation, for the entire survey. Although Cronbach's Alpha is typically used to test whether a set of survey items reflect one central construct, we do not interpret it this way here. Since we believe that the nine code constructs in our survey are not theoretically required to be correlated with one another in general, we interpret the correlations between constructs as indicating whether teachers agree that the nine different constructs are simultaneously supported as features of a responsive PD program. The overall Cronbach's Alpha for the initial 18 items was 0.79. Three reverse-coded items were removed, because their removal increased Cronbach's Alpha to 0.88. In part, we were concerned that the reverse nature of these items created confusion for survey respondents. The current version of the survey consists of 15 items (Table I).

The means and standard deviations for the 33 teachers' survey responses from the pilot test are given in Table I. These results suggest that teachers found the program highly responsive across all nine constructs, with Likert averages of 4.3 or greater out of 5 across all code categories except "Practicality of materials" and "Serving teachers with diverse backgrounds/experiences/needs." The high agreement with the survey items indicates some success in translating the interview themes into survey items that broadly captured the collective responsive PD experiences of these teachers.

While some teachers have found the university materials highly practical, others found the level too difficult for high-school students. To understand why, we analyzed the only free-response follow-up question for this survey item, inserted as part of our pilot survey administration. The question asked, *Why do you think university materials are practical/impractical?* In response to this question, the teachers who were teaching more advanced physics courses found the materials more practical and rated the practicality as high, i.e., 4, or Agree (e.g., "They are very usable in AP C level." - the calculus-based Advanced Placement physics course). Although most teachers of lower-level courses gave practicality of materials a rating on the lower end of the Likert scale, some of these teachers still found the materials useful, rating the practicality as high as 4 in the scale. In general, teachers of conceptual, regular, and honors physics courses judged that the university materials could not be used directly in these courses without some adaptations. For teachers who had a basis for comparison of the utility of the materials across levels, this point came through clearly. As one teacher noted: "The university materials are practical because I could take them unchanged and give them to my physics classes and they would be useful labs and activities for most of my classes. At lower levels, they need to be modified to provide more scaffolding but the activity they are having the students complete is very useful." Overall, teachers' opinions about the practicality of the university materials varied greatly depending on the extent to which they make adaptations. Taking a more neutral stance, a teacher with 30 years of experience shared

her belief that it is never possible to use any instructional material without adaptation: "In order to use something in my classes, I will always adapt to my group of students, sometimes even making changes between different sections of the course within one year. Each teacher needs to know their students." This teacher rated the practicality as neutral, i.e., 3, or neither agree nor disagree.

## VI. DISCUSSION AND CONCLUSIONS

The guiding principles of responsive PD (attentiveness and adaptiveness) have been shown as effective PD structures as evidenced by prior qualitative research on similar programs [13, 14, 28]. To advance quantitative research in this area, we developed initial survey items for assessing teachers' perceptions of responsive PD features. We envision that a future quantitative survey could be used to compare the responsiveness of different PD programs or characterize the range of experiences teachers have in the same PD program. One hypothesis for future study is that teacher perceptions of responsiveness are correlated to the degree of uptake of PD instructional materials and pedagogies in their own teaching.

One limitation of the current survey is that some aspects are specific to a particular PD context (e.g., a focus on adapting university materials for high school) while others have the potential to be more generally applied (e.g., a focus on teacher collaboration and exchange of ideas, teacher leadership and co-facilitation in PD activities). While the current survey is useful for broadly assessing the state of the PD program that informed survey design, future work will aim to generalize the responsive PD categories so that the survey can be given and compared across different PD programs and contexts.

Within the current PD context, the interview-survey construction cycle can be completed by having teachers answer the survey questions in an interview context. Teachers' qualitative explanations can validate researchers' design intentions and assumptions in interpreting the quantitative survey results. However, validation of quantitative survey interpretation is not a one-and-done proposition, because these survey interpretations should be context-dependent, especially since responsive teacher PD programs and this survey are not currently well-defined or understood. As this survey continues to be developed and applied in new settings, survey response interviews will need to be done in each PD context. We hope these future survey interviews will not only validate the interpretation of the survey results but also expand our understanding of teachers' perceptions of responsive PD.

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