Chapter 11
Theory-Based Intervention Framework to Improve Mathematics Teachers' Motivation to Engage in Online Professional Development

Nathan A. Hawk, Margaret A. Bowman, and Kui Xie

Teacher professional development (TPD) is an often used, well-resourced, and indispensable activity that allows primary and secondary mathematics teachers to continue developing and improving both their content and pedagogical knowledge. Recently, mathematics TPD is moving toward online or blended formats (Wasserman and Migdal 2019) in part because online TPD is generally considered more cost-effective, less intensive, can be completed asynchronously, and can occur over a longer period of time (Dede et al. 2016; Goos et al. 2018; Heck et al. 2019). The COVID-19 pandemic enhanced the need for flexibility, more sustainable and scalable programs, and new professional learning approaches, making the relevance and usage of online TPD even more evident.

Teachers, however, often have difficulties engaging in an online TPD (or the online portion of a blended TPD) experience. As a result, this disengagement has at times negatively impacted the effectiveness of TPD, including possible dropout (Parsons et al. 2019; Russell et al. 2009b; Xie et al. 2017). One factor found to be critical to successful online and blended learning professional development (PD) is sustaining teachers' motivation and engagement (Kowalski et al. 2017). In fact, teachers' motivational perceptions and beliefs about TPD impact their engagement in professional development courses (Russell et al. 2009a, b). To address these concerns, researchers have been looking for different motivational frameworks while examining teachers' TPD experiences. One empirically tested and well-validated motivational framework is the Expectancy-Value Theory (EVT; Eccles 1983). EVT

N. A. Hawk (✉) · M. A. Bowman
Research Laboratory for Digital Learning, The Ohio State University, Columbus, OH, USA
e-mail: hawk.226@buckeyemail.osu.edu; bowman.1359@osu.edu

K. Xie
Department of Educational Studies, The Ohio State University, Columbus, OH, USA
e-mail: xie.359@osu.edu

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posits that one's expectancies for success combined with four distinct task values help determine one's likelihood to engage in a learning task (Wigfield 1994; Wigfield and Eccles 1992). While EVT has been widely used in examining students' motivation in academic settings, empirical research exploring teachers' motivational and personal value beliefs on engagement in TPD is still lacking. In particular, few well-structured analyses and syntheses of these findings exist in the extant literature.

As a result, the goal of this chapter is to collect and synthesize the available, relevant literature concerning mathematics TPD and teachers' values and expectancy for success toward TPD. Synthesizing these research findings will allow instructional designers to discern important design principles to utilize when developing online PD experiences. Contextualizing the EVT in mathematics TPD settings, we develop and promote several key design principles *with a focus on increasing mathematics teachers' positive value toward, and their engagement in, online TPD experiences*.

In the first section, we briefly outline the existing research on the importance of teacher motivation. In particular, we discuss its impact on teachers' engagement in PD and argue that we should view motivational values using a more concise and multidimensional framework. Second, we present the Expectancy-Value Theory, discussing why EVT is significant for online engagement in mathematics education. We note that teacher motivation in online TPD is understudied within mathematics education; however, the topic is well-established within other areas. In our literature review, we briefly discuss the breadth of research on teacher motivation, TPD, and online learning in other areas to help illuminate these topics within mathematics education. Third, we propose five design principles, based on the EVT framework, noting how these design principles are intended to support and improve positive value perceptions for mathematics teachers engaged in online learning. We conclude with some final remarks on the implications for mathematics teacher education and practice.

11.1 Teacher Motivation and Engagement Toward Mathematics Professional Development

Karabenick and Conley (2011) stated, "Motivational concerns…remain a critical yet understudied component of teacher PD interventions" (p. 9). Motivation is broadly described as the process through which goal-directed behaviors are both initiated and sustained (Cook and Artino Jr 2016). Often, academic motivation theorists attempt to describe the reasons why learners initiate, sustain, and engage in specific learning tasks. Empirical research has also supported the strong relationships between learners' motivation and engagement in classrooms (Greene et al. 2004; Liem et al. 2008; Xie et al. 2020) as well as in online learning settings (Xie et al. 2006, 2011; Xie and Ke 2011). Engagement and motivation are intertwined,

with one often influencing the other. When a person is motivated to learn, they often engage more in the learning process (Martin 2007; Skinner and Belmont 1993). Mathematics teachers' motivation for learning engagement, for instance, may help explain whether they engage in online TPD (Parsons et al. 2019; Wentzel and Miele 2009; Wigfield 1994).

According to de Araujo et al. (2018,), "PD should focus not only on teachers' content and pedagogical knowledge but also on their attitudes and dispositions about learning and teaching mathematics" (p. 324). Engagement in TPD faces multiple challenges, as some mathematics teachers may resist difficult or demanding professional development (Pasley 2011). Masuda et al. (2013), for example, found that the professional development opportunities that teachers are provided are often in-school and district-wide, involving quick lectures with little to no opportunity to observe, practice, or implement what was learned in a meaningful way. Teachers are often given little choice in the timing or topic of TPD, feeling that it has been imposed upon them (Francis-Poscente and Jacobsen 2013; Masuda et al. 2013). Dede et al. (2009) stated that many TPD programs in the past have been of poor quality, ineffective, and often do not provide ongoing support, leaving teachers frustrated and unable to implement what they learned. This, coupled with the amount of time it takes for teachers to participate in TPD, leaves many teachers feeling that TPD isn't valuable or worth engaging in. This leads to poor engagement and thus, little classroom use of what was conveyed in the TPD program. In addition, mathematics teachers often have difficulties engaging and persisting in online TPD (Parsons et al. 2019; Xie et al. 2017).

To address these challenges within online mathematics TPD, we believe that an exploration of how a focus on a specific motivational framework could impact TPD is useful. Within this chapter, we target the various reasons why teachers engage in professional development, from a motivational values perspective. Along these lines, four primary motivational values are discussed.

First, interest (domain-specific) is a salient personal variable that impacts teachers' sustained engagement. In one study, mathematics teachers involved in unmoderated (non-facilitated), self-paced workshops showed that their increased interest positively related to engagement and motivation toward the work experience (Renninger et al. 2011). When TPD experiences are meaningful, well-designed, and provide intrinsically motivating outcomes, teachers are more inclined to participate (Lebec and Luft 2007).

Second, other frameworks have examined perceived usefulness. In one study, Smith and Sivo (2012) found that teachers who perceived an e-learning course experience as useful were more likely to engage in future e-leaning experiences. One model, the technology acceptance model (TAM; Davis 1989), historically has been used to describe teacher-technology integration (Teo et al. 2008; Xie et al. 2019). Extending its use, Smith and Sivo (2012) utilized the TAM framework to predict teachers' intentions to continue in online TPD.

Third, perceived importance is another influential determinant of teacher engagement in PD (Battle and Looney 2014). Generally, the perceived importance of PD refers to the extent a teacher thinks a learning experience is important to their work.

In some past research, importance and interest were statistically related and predicted the continuation in teaching and teaching activities (e.g., Battle and Looney 2014). Thus, when teachers perceive an experience as both important to their teaching and intrinsically interesting, they are more likely to remain engaged.

Finally, several studies promote the importance of ability beliefs, ease of use, or self-efficacy beliefs. Self-efficacy or ability beliefs generally refer to how confident one feels about accomplishing a task (Bandura 1977; Wigfield and Eccles 2000). Conceptually, there is often a significant relationship between motivational values and one's self-efficacy or ability beliefs (Wigfield and Eccles 2000). When teachers are personally confident in their capabilities, they are more likely to learn for intrinsic reasons (Kao et al. 2011). For example, according to Appova and Arbaugh (2018), mathematics teachers may feel motivated to become better teachers—they may feel they are a good teacher, but there is always room to learn more. As a result, these positive motivational perceptions often lead mathematics teachers to change their instructional practices (Kao et al. 2011; Palermo and Thomson 2019).

While past research has separately discussed different motivational values, we believe that a more comprehensive and concise exploration of how these values are interconnected and can impact TPD is needed. One under-examined area in adult motivational research describes one's expectancy for success and reasons for engaging in a task. In searching for a widely used and validated theoretical framework with which to examine teachers' values toward TPD, the Expectancy-Value Theory has emerged as one that is well-defined and well-suited to this chapter's objectives. Past research and measurement instruments help demonstrate its strength in empirical research. This empirically tested framework is explored further below.

11.2 Expectancy-Value Theory and Its Implications for Online Mathematics TPD

Expectancy-Value Theory (EVT) focuses on achievement-related choices and performance outcomes (Eccles and Wigfield 2002). Earlier research with this framework focused on students, but more recent research has studied teachers' attitudes and values through the lens of EVT (Bowman et al. 2020; Cheng et al. 2020; Vongkulluksn et al. 2020). For instance, empirical research has shown the importance of the teacher's value beliefs, such as usefulness, along with personal characteristics, and internal and external barriers to technology integration, suggesting the importance of perceived values on whether or how technology is integrated (Vongkulluksn et al. 2018; Cheng and Xie 2018). EVT encompasses four motivational values as well as one's expectancies for success to describe one's reasons for engaging in learning tasks (Wigfield 1994; Wigfield and Eccles 1992). According to Wigfield and Eccles (2000), a distinction is made on what one perceives he or she is good at (expectancy) and what one values (task values). Expectancy for success is conceptually similar to the construct of self-efficacy (Bandura 1977), or perceived

capability to complete a task successfully. Expectations of success involve an individual's belief about how well they expect to do on a task. Subjective task value is further broken down into four factors: interest or enjoyment value, utility value, attainment value, and cost. Interest describes a learner's perception of whether a task is enjoyable or personally of interest. Those who espouse interest might personally enjoy learning about, or practicing with, new mathematics techniques or new classroom technologies. Utility value describes the perceived usefulness of the task. Mathematics teachers exhibiting utility value may find a particular instructional method useful to their overall development. In turn, these methods may ultimately benefit students. Attainment value describes whether the task is personally important to the learner. Mathematics teachers who espouse attainment value might decide to engage in a task because it is important to their overall professional development goals. For instance, the professional development experience might help them to develop instructional practices that better support students. Cost describes what one believes they would need to sacrifice to engage in another task. Mathematics teachers exhibiting time cost value might have to give up other activities or personal family time to attend new learning opportunities.

The expectancy for success and task values play separate roles. "In other words, in choosing whether to learn something the task value matters most; once that choice has been made, expectancy of success is most strongly associated with actual success" (Cook and Artino Jr 2016, p. 1003). Research shows that lower levels of one construct may be compensated for by higher levels of another construct, suggesting that both expectancy and values may be required to drive learning behavior (Putwain et al. 2019).

Prior research has shown the importance of EVT in explaining learning engagement for a wide variety of learners and contexts, including in mathematics (Wentzel and Miele 2009). First, both expectancy and value predict engagement, and high expectancy can compensate for perceived low value (and vice versa), according to Putwain et al. (2019). Next, positive professional development experiences are related to improved motivation (Brinkerhoff 2006; Kim et al. 2017; Kleickmann et al. 2016). Further, teachers who value a TPD experience will engage more in the learning, leading to increased perceived value for both the TPD in general and for the specific learning goals and experience (Rutherford et al. 2017). Finally, when these experiences are perceived as valuable, this can outweigh the perceived time cost for their participation. This suggests the need to significantly add opportunities for teachers to perceive added value in exchange for their time (de Araujo et al. 2018; McCourt et al. 2017). Indeed, teachers may be able to overcome challenges to implement instructional changes if they value these changes in their pedagogy highly enough. Grove et al. (2009) stated, "If the participants believed they had the ability to make changes in their classroom and valued a particular element, some changes were seen in their teaching practices" (p. 258).

EVT is an important framework to examine across online mathematics TPD. Mathematics teachers express that one reason for the lack of online learning engagement is a perceived lack of time, particularly if there is not an extrinsic reason to participate (Lebec and Luft 2007). On the other hand, when considering

specific values, teachers are more likely to seek additional learning opportunities. Further, these differences were observed between online and traditional learners (Renninger et al. 2011). According to other research, adult online learners are more likely to learn when their perceived task values are positive; however, the expectancy-value model was not able to detect differences between learners who are normally face-to-face versus online (Zimmerman 2017). In sum, evidence suggests that in online learning, experiences should be of high quality and target specific values in order to emphasize impact.

11.3 Guidelines for Enhancing Motivation in Online TPD Experiences

In recent years, the ways in which TPD is conferred has changed, and online TPD has become more prevalent. While it may be more convenient and often less costly, there remain concerns about TPD quality and the extent of participant engagement. Online TPD participants often do not feel a strong connection to the instructor or other participants. As a result, this leaves them feeling dissatisfied with the experience (Holmes et al. 2011) and sometimes not completing the program (Reeves and Pedulla 2011). This may also contribute to poor attitudes and low engagement in TPD.

There are, however, teachers that are not unhappy with or disengaged from TPD. It may be beneficial to closely examine these teachers' motivations and incorporate findings into future TPD to address the lack of motivation and engagement by others. Occasionally, teachers are given provisions to seek out their own TPD or to participate in research-based TPD led by institutions of higher education. Often the participants in these types of TPD programs are highly motivated, see the value in the TPD, or acknowledge the need for a change in their own teaching practices. Thus, they choose to register and participate in the TPD program. While research has shown that these teachers do engage more and perceive the TPD as valuable, much of the research is limited to self-selected teachers (Barrett et al. 2013). Perhaps if more teachers are provided high-quality, engaging TPD and the value of the TPD is conveyed to teachers in a meaningful way, teachers' attitudes toward TPD would improve. As a result, they may also engage more in the TPD, and their teaching practices would be more positively improved (Holmes et al. 2011; Reeves and Pedulla 2011).

Masuda et al. (2013) found that "Teachers' attitudes and willingness to engage in PD were closely tied to the perceived value or importance that the PD experience held for them. In turn, the value of the PD was closely tied to its perceived quality based on their experiences" (p. 10). For teachers to gain the most benefit from professional development, they need to appreciate what they are learning. Hargreaves and Preece (2014) emphasized the need to focus teacher development on "philosophically important values rather than just the practical details" (p. 131). According

to the literature, it has been shown that TPD instructors have to emphasize, explain, and model the value affordances associated with the TPD content.

Using the Expectancy-Value Theory as a framework, we propose five principles with which to develop mathematics teachers' motivation to engage in online professional development. These principles are designed to support and improve each of the three positively associated value beliefs, decrease beliefs about the perceived cost of participation, and enhance teachers' expectancies for success.

11.3.1 Principle 1: Promote Intrinsic Value

Teachers are more likely to participate in TPD if they know it will be interesting, enjoyable, and fun (Karabenick and Conley 2011) and that there is a meaningful purpose (Thomas 2009). The purpose of the TPD should be conveyed in a way that helps the teachers see its value and is linked to their current and future work. When teachers have a sense that they will accomplish something meaningful by engaging, they may perceive greater intrinsic value toward the TPD. Furthermore, they may be increasingly motivated when they know at the outset that they will have enjoyable and fun interactions throughout the TPD. Therefore, TPD may benefit from the addition of games, awards, and badges to increase interest, accountability, and record of accomplishment (Diamond and Gonzalez 2016).

Another way to increase teacher-perceived intrinsic values in the TPD is to provide active participation opportunities (Bayar 2014; Kanaya et al. 2005). These opportunities may include engaging with the instructor, engaging with other teachers in the TPD, and engaging with the content. The instructor should model his or her own intrinsic value for engaging in the TPD. Research shows that "intrinsic motivation can be facilitated through the mere perception that the teacher is intrinsically motivated" (Patrick et al. 2000, p. 219). Furthermore, when the instructor presents the content energetically and enthusiastically, the participants' intrinsic value is more likely to increase.

Creating opportunities for teachers to engage with each other is another way of promoting intrinsic value. Open discussions with other teachers involved in the TPD can create a sense of belonging and trust (Thomas 2009). These discussions could be during live, synchronous sessions, or through written discussion boards, which are designed to provide social interaction (Hoskins 2012). The more complex these interactions are, the more likely the participants are to be engaged. For example, if TPD participants are assigned to groups to debate for or against a particular mathematical method, the surrounding discussions can be meaningful, valuable, and motivating.

Engagement with the content is also important and can increase intrinsic value (Brophy 2008; Hoskins 2012). Online professional development opens up opportunities for more interactive learning. Providing teachers with engaging, interactive experience may increase teachers' value for the content and ultimately increase their integration of the learned content into their classrooms.

Implications for Online Mathematics TPD

To make TPD meaningful for mathematics teachers, it should be linked to the teachers' sense of purpose. For example, some teachers may choose to teach mathematics because it may be viewed as difficult and less valued by many students (Eccles et al. 1989). They may also be motivated to engage in their own learning opportunities if it is closely tied to their students' learning. Appova and Arbaugh (2018) found that "teachers are motivated to learn from observing their students' struggles with understanding mathematics and, as a result, from developing a feeling of dissatisfaction with their own teaching. This sense of responsibility for students' learning encourages teachers to want to engage in PD to become 'better' teachers" (p. 15). Developers and instructors of TPD for mathematics teachers may benefit by emphasizing the meaningful nature of the TPD, tapping into teachers' intrinsic value for both teaching and learning.

Mathematics teachers may also enjoy engaging in and be intrinsically motivated by mathematical puzzles and games or researching historical backgrounds of specific mathematical concepts. For example, teachers may enjoy learning about the discovery of π by various mathematicians, or how the Pythagorean theorem was discovered. This may both engage them in the TPD and provide activities and learning opportunities that can be incorporated into their classrooms.

Finally, implementing active participation into the TPD is important. Research on TPD has shown repeatedly that collaboration is a strong motivating factor. Participants should engage in meaningful discussions with other participants and with the instructor, whether through video conferencing or online discussion forums. Additionally, including games in which the TPD participants work together in small groups may increase intrinsic motivation further.

11.3.2 Principle 2: Highlight Utility Value

Utility value is the belief that something (e.g., a workshop or conference) is useful or relevant. For a teacher to value the PD, they need to see and believe that the content is useful to them and relevant to their work. For example, Kanaya et al. (2005) found that teachers who perceived the content of the TPD as both useful and relevant were more likely to engage and have successful outcomes from the TPD. Two recent specific examples focused on TPD for technology integration. Bowman et al. (2020) determined that teachers who believe that technology is useful and valuable are more likely to perceive technology-related TPD as useful, and thus, integrate technology into their classrooms in more meaningful ways. Similarly, when examining profiles of teacher value beliefs toward technology using EVT, Vongkulluksn et al. (2020) found that more adaptive value profiles were more likely to integrate classroom technology in different ways. While this was specific to teachers participating in technology-focused TPD, it may be generalized to other types of TPD. Perhaps, if teachers perceive the TPD as relevant to them, to their students, or

to their school, they may exhibit more positive utility value (Bayar 2014) for the TPD.

One way to encourage utility value in the beginning or to encourage participation is to create dissonance. Teachers need to believe that change needs to occur, and therefore the TPD is necessary and useful (Timperley et al. 2007). Additionally, within the TPD program, instructors should not only present content relevant to the teachers but connect the content to classroom practices. Masuda et al. (2013) found that teachers in any stage of their careers wanted an application component and that the content had to be relevant to their own contexts. This improves the likelihood that teachers will engage and use what they learn in the TPD (Saderholm et al. 2017).

Once teachers see the need for change or growth, certain TPD experiences can be successful in changing or developing teachers' utility value. In other words, if teachers see the content of the TPD as being useful, they are more likely to have positive views of the TPD. For example, a study of the professional development program for one school district's iPad initiative revealed that teachers who had a positive view of technology and felt capable of using iPads had more positive views of the iPad TPD (Liu et al. 2018). In another instance, a 1-year-long PD for digital content evaluation, for 171 teachers from 5 Central Ohio school districts, incorporated a focus on utility value because the content of the PD was new and the facilitators felt that teachers would need to see the relevance and utility of the new skills being learned in order to motivate them to engage and go on to use what they learned in their classrooms (Kim et al. 2017; Xie et al. 2017).

Implications for Online Mathematics TPD

Research has shown that it is important for mathematical experiences to be meaningful (Di Martino and Zan 2001). For this to occur, teachers need to see and believe its relevance to their own life and work. The utility value should be linked to the teachers' specific needs. For example, for teachers who struggle to understand and explain a specific mathematical concept to their own students, the TPD program could provide resources and activities to increase teachers' deep conceptual understanding, which is promoted as part of the value of the program. The utility value of the TPD should be explicitly stated and demonstrated early on in the TPD program. To help teachers see the connection between the TPD and their own teaching practices, it may be useful to have teachers present examples of student work or their own teaching practices that they would like to see improved. In this way, the program can create dissonance for teachers who may be less prone to see the need for the TPD. Then, once teachers understand the need for improvement, the program can introduce interventions regarding the relevance of the TPD.

Two relevance-related interventions have been shown to increase utility value for mathematics content. In the first, students reflected on quotations that explicitly stated the usefulness of course materials (Durik and Harackiewicz 2007). In the second, students generated written arguments for why the course material was useful (Hulleman et al. 2010; Hulleman and Harackiewicz 2009). Perhaps these same

interventions could have the same effect on teachers' utility value for mathematics TPD. The TPD program could open with a statement explicitly conveying the usefulness of the program in relation to teachers' classroom practices as well as student learning. The TPD could close with a time of discussion and reflection on the usefulness of the program, allowing teachers to express what they found most relevant and how they plan to incorporate what they learned into their classrooms.

11.3.3 Principle 3: Foster Attainment Value

Attainment value is the importance one places on an activity as it relates to their identity or self-concept. If a teacher's identity is tied to being a mathematics teacher, they are more likely to set goals or engage in tasks and activities that will improve their teaching knowledge and performance. To support attainment value, the TPD should be closely tied to teachers' identities. Teachers have reported they are most willing to participate in TPD when they are discipline-specific (Garet et al. 2001) and the objectives are tied to mathematics course-specific needs, such as improved subject-matter knowledge (Karabenick and Conley 2011; Krille 2020; Qian et al. 2018; Xie et al. 2017). Additionally, teachers are more likely to engage and participate when they play a role in the selection and development of the TPD itself, that way the TPD topics are directly tied to their needs and are relevant (Bayar 2014).

Teachers' identities may also be tied to their educational community. Teachers should feel supported by other teachers, support staff, and administration. Additionally, collective participation, collaboration, social presence, and social opportunity to exhibit support are shown to impact learning engagement (Kowalski et al. 2017; Palermo and Thomson 2019). Grove et al. (2009) stated,

> Teachers may attend a professional development program, and gain insights and knowledge, to return to their classroom and implement new ideas along with their renewed excitement for their content area. However, if the teacher feels that the changes are not appreciated and/or not supported by peers or administration, there may be little motivation to put the changes to thinking and planning into practice. (p. 258)

It may be beneficial for the TPD instructors to provide information to the school, explaining the purpose and value of the TPD. In doing so, teachers can feel more supported by their community and their identity as a teacher among a community of educators can be further encouraged.

Implications for Online Mathematics TPD

While some teachers may be interested in or need more general development in mathematical content knowledge or pedagogical development, for example, it may be most beneficial to provide professional development that targets specific mathematical domains. At the high school level, a teacher seeking improvement in

teaching Geometry may have different needs from a teacher of Algebra I. At the middle school level, a teacher may be confident in teaching the number sense domain but desires to improve his or her pedagogical knowledge in the expressions and equations domain. More general TPD can be planned for a larger group of mathematical teachers, but it may be useful to group the participants by their needs. In this way, the teachers can have some control and choice over the topics with which they engage.

By forming small groups, teachers can also form communities of practice. According to one review of multiple online TPD intervention programs, among the design principles were collective participation, collaboration, and communities of practice (Kowalski et al. 2017). Increasing the support mathematics teachers feel in their work, and tying that feeling of support to improved communities of practice, might help enhance their identity and attainment value. Furthermore, teachers may be more engaged in online TPD if they take ownership of some of the TPD components. For example, having a teacher or group be responsible for teaching a certain topic may help them to see the value of the topic as it relates to their own identity as both a teacher and as a member of the online TPD community.

11.3.4 Principle 4: Reduce Perceived Cost

Cost is negatively associated with the other three task values. If teachers feel the cost is too high and that they are giving up too much in order to participate in TPD, they are less likely to engage or value the TPD. For example, if teachers feel they must take additional time to find ways to integrate what they learned into their own classrooms, they may become overwhelmed and perceive the additional costs outweigh the value of the experience (Masuda et al. 2013). On the other hand, more positively adaptive intrinsic, utility, and attainment value may help to compensate for the lower perceived cost. Teachers report that a determining factor that reduces the perceived cost of attending and engaging in PD is its specific application. Masuda et al. (2013) stated, “Teachers must have something tangible to show for their investment of time” (p. 12).

Teachers are more willing to engage if TPD is short, concise, efficient, well-designed, and organized, reducing the time and effort it takes to complete the TPD (Karabenick and Conley 2011). In contrast, long-term TPD is shown to be more effective in terms of improved teaching practices and student success (Bayar 2014; Clary et al. 2017). The amount of time the TPD takes may not be as important as how effectively the time is used. Making every minute of the TPD count will reduce what might be seen as time lost (Loucks-Horsley et al. 2009).

Implications for Online Mathematics TPD

Online mathematics TPD should be well-designed, easy to use and navigate, and easily accessible to reduce the time a teacher might spend on simply learning how to use and engage in the online learning platform. In addition, there is a strong relationship between the ease of use or technology self-efficacy and other motivational values such as perceived usefulness (Teo et al. 2008; Davis 1989; Zimmerman 2017). As mathematics teachers become more comfortable and confident in the learning platforms, other values increase. In turn, this may reduce perceived cost.

Another way to reduce perceived cost specifically for online TPD is to spend time focusing on the technology as it relates to the participants' students. Most recently, many TPD efforts are spent on instructing teachers how to teach online (Lay et al. 2020). It may be valuable for the TPD online learning platform to be the same as that of the students. This allows teachers to learn and use the platform in meaningful ways while also engaging in the content of the TPD. This may reduce the cost that teachers feel in participating in an online TPD.

11.3.5 Principle 5: Increase Expectancy for Success

Improving teachers' value for TPD has been shown to increase their expectations for success (Rutherford et al. 2017). Implementing mastery experiences into the TPD may allow for the greatest increase in teachers' expectations for success (Tschannen-Moran and McMaster 2009). Mastery experiences, which are past experiences of success, are generally considered one of the four sources of self-efficacy (Bandura 1977; Usher and Pajares 2008). Self-efficacy is a closely related concept to expectancies for success. For example, the previously described PD program designed to train teachers to evaluate digital content also focused on expectancy for success (Kim et al. 2017; Xie et al. 2017). Teachers were given opportunities to evaluate digital content in small groups with the help of the PD instructors. Later, they were asked to find and evaluate digital content on their own and were provided feedback. In this way, teachers were afforded the opportunity to learn and be supported, increasing their expectations for their own success.

Implications for Online Mathematics TPD

First, regarding expectations of success for engaging in the online TPD itself, considering that it is online and requires the use of technology,

> online PD may fail to motivate or engage teachers who do not feel comfortable or skillful using technology. Another challenge to online PD, therefore, is to find technical support for those in need, and to differentiate resources and tasks for teachers with different levels of comfort and expertise with technology. (CADRE 2017, p. 6)

In terms of expectations for success for learning and eventually implementing the content of the TPD, teachers should be offered mastery experiences. Again, collaboration with other participants and with the instructors is key. Another source of self-efficacy includes the social context in which teachers are involved, and vicarious experiences and verbal and social persuasions are key sources to one's adaptable self-efficacy or positive perceptions of expectancy for success (Usher and Pajares 2008). Teachers should be given opportunities to practice new concepts and skills with other teachers while being supported, eventually practicing, and perhaps presenting their learning on their own. Mathematics teachers especially may need opportunities to practice mathematical concepts to build confidence before designing and implementing teaching practices (see a summary of these principles in Table 11.1).

11.4 Implications and Significance to the Field of Mathematics Education

Overall, our synthesis of the available research provides some overarching implications for researchers, instructional designers, and practitioners. First, research shows that when mathematics teachers' expectancies and values increase and their perceived costs decrease, they are likely to engage more, persist longer, and increasingly find ways to integrate their gained knowledge and skills into their teaching practices. Thus, instructional designers and online learning developers should consistently find ways to build value-based instructional practices into online mathematics TPD. For example, building opportunities to increase interest or perceived values of usefulness may help to mitigate other concerns, such as the diminished social presence or lack of traditional forms of teacher engagement or collaboration. Second, research has shown that increased engagement also leads to greater expectations of success. Consequently, more positive expectancies of success in mathematics teachers' own abilities to transfer their TPD knowledge and skills often lead to increased student achievement (Rutherford et al. 2017). Finally, empirical interventions and mathematics TPD experiences should focus on multiple values simultaneously. Our research (e.g., Vongkulluksn et al. 2020) has shown a strong interrelation between task values. Similarly, other research has found that a high task value can compensate for another low task value or expectancy for success. For instance, when the perceived attainment value is low, overall engagement was managed with more adaptive expectancies of success (Putwain et al. 2019).

Using a theory-based approach to recommend several design principles, our research synthesis also promotes opportunities for future empirical research. First, our research synthesis should encourage future quality intervention-based research to empirically examine our design principles. Using our guidelines, future researchers may consider how to both incorporate and evaluate teacher-related outcomes across new online TPD experiences. Evaluating both qualitative teacher data and

Table 11.1 Summary of design principles

Value-focused design principle	Description	Examples
Promote intrinsic value	Provide enjoyable and meaningful activities with opportunities for active engagement with the instructor, other teachers, and the content	• The instructor should model intrinsic motivation • Mathematical puzzles and games • Provide or have teachers research the historical background of how certain mathematical concepts were discovered or developed (e.g., the discovery of π or the Pythagorean theorem) • Discussions with other teachers about the content • Teachers share students' work
Highlight utility value	Provide content that is useful and relevant to the teachers' needs	• Teachers write about and/or verbally explain areas where personal improvement is needed, such as specific mathematical content knowledge or pedagogical knowledge • Explain and support deep conceptual understanding about specific mathematical ideas (e.g., why the Pythagorean theorem works)
Foster attainment value	Tie course content and objectives to teachers' identities	• Teachers select specific mathematical content to be closely examined and have them present their learning to others • Group teachers by specific mathematical domains, forming communities of practice
Reduce perceived cost	Emphasize the benefits of time spent in PD to reduce any drawbacks to participation	• Ensure the learning platform is easy to use. Use the same platform that teachers and students use if possible • Use technology and tools that teachers will use in their own classes, such as virtual manipulatives, *Geometer's Sketchpad*, *Geogebra*, etc.
Increase expectancy for success	Support teachers' expectations that they can successfully implement what they learn into their own classrooms	• Provide opportunities for teachers to practice new mathematical concepts and skills with other teachers while being supported • Have teachers select specific mathematical concepts or skills that they then teach other PD participants

self-report quantitative data could lend further support to our proposed guidelines while adding to the research base of adult-focused EVT research. Second, across much of the empirical literature, EVT-based research has typically focused on children in K-12 settings, according to Wigfield and Eccles (2000). Although we have conducted recent research utilizing EVT among K-12 teachers (e.g., Bowman et al. 2020; Vongkulluksn et al. 2020; Xie et al. 2017), additional research in online

learning contexts could inform more effective TPD practices. Specifically, building TPD programs that include our recommendations and then examining whether they lead to increased engagement, motivation, and application or transfer of learned material is suggested. Finally, research has shown that collective participation, or the ability to participate with those in similar grades or content areas, is an important component in TPD (de Araujo et al. 2018; Kowalski et al. 2017; Tirosh et al. 2015). Future research should consider a specific focus on either similar grades or content areas. That is, if teachers are engaged in TPD within their subject area, they may be more likely to view the experience as useful and important to their professional development.

11.5 Conclusion

In summary, we briefly overviewed and described a multifaceted motivational values' framework, the Expectancy-Value Theory. Subsequently, we described this framework within the general educational literature as well as how it is situated within the mathematics education literature. From the available research, we developed five design principles that we recommended to implement in online mathematics TPD to promote increased engagement and transfer of new knowledge and skills. Our hope is that future designers of online mathematics TPD will consider including value-based principles in their instructional decisions to better maintain engagement and more positive teacher affect.

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