1.1 THEORIZING THE EMOTIONAL QUALITY OF TEACHING AND LEARNING RELATIONSHIPS IN STEM FACULTY DEVELOPMENT

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1.1.1 ABSTRACT

The emotional quality of learning relationships can affect student attainment and engagement and should, therefore, be a focus for STEM faculty development activities. This chapter introduces the range of ways in which educational relationships in STEM classes have been conceptualised and measured. It explores how analyzing these relationships using a three-dimensional framework based on affection (warmth), attachment (safety), and assertion (status) would support faculty development work. It illustrates this by applying this three-dimensional model to faculty development work on interactive teaching and on classroom management in STEM settings.

1.1.2 THE EMOTIONAL DIMENSION OF STEM TEACHING RELATIONSHIPS

Student-teacher emotional relationship has not been a common topic of research in science, technology, mathematics, and engineering (STEM) education. As Goldin (2014, p. 391) has noted "the wider mathematics education research community has but begun to address the affective domain theoretically". A similar claim could equally be applied to science education (Sinatra et al., 2014; Bellocci, 2016) or engineering education (Lönngren et al., 2020). This is not to say emotion has not been addressed in these domains. In STEM education there has been a growing interest in the emotional experience of conceptual change (e.g. Linnenbrink & Pintrich, 2002; Broughton et al., 2012), of engaging in science learning activities (e.g., Ainley and Ainley, 2011), and disciplinary anxiety in its various forms (mathematics anxiety, chemophobia, see Eddy, 2000; Tobias, 1993; Devine et al., 2012). Sinatra and collagues (2014, p. 416) argue that

> In order to broaden participation in science, we must capitalize on student emotions that are adaptive for science learning and those that promote sustained interest and pursuit of science careers. We must also understand what emotions serve as barriers to learning about science and may discourage engagement in the scientific enterprise and science careers.

If much of the focus of research on emotions and learning has been on specific instructional or testing activities, the social relationships of the classroom constitute an important part of the ecological system within which these emotions are experienced (Meyer, 2014). There is evidence, for example, that instructional practices can impact students' attitudes toward science (e.g., Lee & Erdogan, 2007), while the structure and clarity of instruction and assessments, workload demanded by teachers, and a feeling of public humiliation after poor performance are linked to students' anxiety (Zeidner, 1998; 2014). Stipek et al. (1998) found that teacher displays of positive affect and equal treatment of learners were linked to help-seeking behavior by students, student achievement and motivation in mathematics (see also Frenzel et al., 2009; Bjorklund et al., 2004; Niemi et al., 2017).

Indeed, even beyond their emotional component there is substantial evidence that relationships are important for student learning – including in STEM disciplines. Cornelius-White's 2007 meta-analysis on student-teacher relationships and learning, for example, found that relationships with empathy and warmth showed a moderate to strong correlation with achievement in mathematics (r=.36). While other studies have found more moderate impacts on cognitive learning (r=.17; Wit et al. 2004), there is also evidence that the quality of these relationships affect student attendance and absenteeism (Rocca, 2004) and classroom incivilities (Boice, 1996). Learning to manage this relationship is, therefore, important for learning to teach in STEM.

There is now a substantial body of research on student-teacher relationships in education. Historically, these relationships were generally understood in terms of observable features of interaction (including measures of appropriate eye contact, vocal expressiveness, forward leaning, and straight posture). This changed somewhat following the *emotional revolution* (Sutton & Wheatley, 2003) in psychology, neuroscience, and sociology of the 1990s that shifted the focus towards understanding how the emotional quality of these relationships affects learning. These relationships, however, remain an under-researched area in higher education (Walker & Gleaves, 2016). As Quinlan (2016, p. 105) noted, "discussions of such matters often

revolve around personal preferences and opinions, rather than being grounded in theory or evidence". The challenge is to identify an appropriate theoretical framework for thinking about these relationships in ways that can support faculty development work.

In this chapter, we present a three-dimensional model for thinking about student-teacher relationships in terms of *affiliation*, *attachment*, and *assertion*. The structure provided by the model can be employed by STEM teachers, and STEM faculty developers, to consider how instructional choices and teacher-student interactions influences the emotional relationship. The value of the model for faculty development work is illustrated with reference to examples of our work with teachers on classroom management and interactive teaching.

1.1.3 DEVELOPING THEORIES OF STUDENT-TEACHER RELATIONSHIP FOR HIGHER EDUCATION

Three questions have dominated theory development for student-teacher relationship in higher education: (i) what are the relative roles of behavior and emotion in the relationship, (ii) should it be characterized as unidimensional or multidimensional, and (ii) how can it be measured?

Early attempts to articulate a model of student-teacher relationships in higher education research tended to represent the relationship as a single dimension in which students and teachers were perceived to be either *close* or *distant*. These studies, like that of Boice (1996), typically focused on teacher behaviors that communicate *immediacy* or *distance* (Goodboy & Myers, 2009). The "perceived non-verbal immediacy scale" (Thomas et al., 1994), for example, asks students to rate how often the teacher smiles, moves around the class, and makes eye contact, and has been used in STEM higher education (Furlich & Dwyer, 2007). This work was influenced by communication studies theories that emphasized the role of non-verbal communication in human interaction and was often driven by questions of *civility* and *incivility* in classrooms (e.g. Boice, 1996; Alt & Itzkovic, 2015). Such a behavioral focus raises questions about the international validity of such measures and their underlying theorization; evidently, there are cultural differences in relational display rules such as smiling and making eye contact, and this has led to some attempts to develop culturally appropriate versions of non-verbal immediacy scales in other contexts, such as the *Chinese Teacher Immediacy Scale* (Zhang & Oetzel, 2005).

Alongside this work in the field of communication studies, researchers in education, higher education and STEM education have also worked on making sense of the relationship between students and teachers. Early work in this area included Marsh's (1982) *Student Evaluation of*

Educational Quality which included a scale for measuring what was referred to as *teacher rapport*. Like the work on teacher immediacy, this was conceptualized as a single dimension of *closeness versus distance* and was measured through a student questionnaire in which the teacher was rated based on their perceived friendliness and accessibility. Later work on classroom relationships, however, highlighted that a single dimension was insufficient to capture the complexity of these relationships. For example, the *Questionnaire on Teacher Interaction* (QTI; Wubbels & Brekelmans, 2005) is another behavior-based questionnaire based upon the argument that classroom relationships needed to be conceptualized in at least two dimensions: one that mapped *influence* (defined as *dominance* versus *submission*) and the second that mapped *proximity* (defined as *opposition* versus *cooperation*). This allowed for more complex differentiations to be made; relationships characterized as teacher dominant and cooperative were called *leadership teaching*. *Strict teaching* was also characterized by teacher dominance but combined with an oppositional quality, while relationships marked by teacher submission and cooperation were labelled as *student freedom teaching*. Although developed for school teaching, the QTI has been adapted for university settings (e.g. Kendall & Schussler, 2013) including STEM education (den Brok et al., 2003). A separate multi-dimensional model of classroom relationships is the *Student-Teacher Relationship Scale* (STRS; O'Connor, 2010; Pianta, 2001). Based on attachment theories in psychology, teaching relationships were modelled as akin to parental relationships. Three dimensions were identified as necessary to describe the complexity of the relationship: *closeness, independence*, and *conflict*. Although this model does provide an approach to measuring and describing relationships that is strongly based in research and theory, it was developed for use with younger children and its application with older children or emerging adults in higher education is, at best, questionable (Koomen et al., 2012).

The emotional revolution of the 1990s and early 2000s saw a theoretical shift in emphasis from quantitative measurement of behaviors to affording a greater role to emotion in human interaction. As with earlier work, much of this continued to focus on school-aged learners, and, initially at least, it often returned to thinking about relationships as characterized as unidimensional. Hargreaves (2001), for example, introduced the concept of emotional geographies as representing "the spatial and experiential patterns of closeness and/or distance in human interactions and relationships, that help to create, configure and color the feeling and emotions we experience about ourselves, our world and each other" (2001, p. 1061). For Hargreaves, less distance is pedagogically valuable, and the goal is to generate relationships in

which learning is supported by closeness. In contrast to the more behavioral work discussed above, Hargreaves' work was qualitative in nature. Other qualitative and sociological work followed, often focusing on specific relational emotions such as gratitude and liking (Uitto et al., 2015). In higher education for example, Moore and Kuol (2007) reported that students described excellent teaching in terms of the emotions that it elicited in them including terms like love, passion, enjoyment, compassion, empathy, and exhilaration. This more sociological work also included wider concerns such as the cost to the teacher of their emotional labor, the gendering of care relationships, and the way in which emotional relationships interact with the power dynamics and organizational structure of the school.

Another way in which the teaching-learning relationship is often described - especially in qualitative research work - is in terms of *care*. Following on from the work of educators like Noddings (2012), the concept of care covers both caring for the learner as a person and caring for them as a learner. Care is not simply a feeling the teacher has, but is also described in terms of caring actions, such as listening to students. Noddings notes that power plays a role in this, in that the teacher may assume the power to define what they believe the student needs, which may not be the same need expressed by the student (2012). While this focus on caring relationships has been influential in thinking about higher education and STEM education (Pantazidou & Nair 1999; Riley et al., 2009), one issue which has been raised is that the concept of *care* is often readily gendered, a context in which the allocation of roles and duties means that women academics typically end up devoting more time to *service* and *care* work than do men (see Ducharme & Ducharme, 1996; Acker & Feuerverger, 1996; Lipson et al., 2021). In addition to thinking about the teacher-student relationship itself, it is also necessary to consider the social and organizational context of this relationship and within which the teacher's work of relationship-building takes place.

While there is evident richness to such qualitative work, there are times when reliable and valid quantitative measurement can be useful. In this context, it is worth noting Titsworth et al.'s (2010) *Classrooms Emotion Scale* (CES) that aims to measure, among other things, the valence (that is, the positive or negative feeling) of the emotions experienced by students during teaching. However, while this instrument does have other emotional dimensions, the emotional quality of the student-teacher relationship itself is once more reduced to a single dimension. Trigwell (2012) has also developed an instrument, the *Emotions in Teaching Inventory* (ETI), which aims to assess the emotions experienced by teachers in a range of teaching settings. The ETI has been criticized as lacking a strong theoretical basis (Hagenauer & Volet, 2014) and for

mixing behavioral and emotional elements in a way that compromises the dimensional structure (Tormey, 2021). In a separate approach, White (2013) listed sixteen different emotions and asked students how often they had experienced these emotions in courses that they had taken. This has been analyzed to identify an underlying multidimensional structure, with the emergent structure based on two dimensions which describe the positivity of the emotion (valence) and if the emotion is associated with action (activation).

In summarizing the various quantitative and qualitative attempts to theorize and measure student-teacher relationship in higher education, Tormey (2021) noted a number of issues. First, behavior-based accounts of student-teacher relationships are culturally limited, and, in a context in which student mobility and wider access to higher education means a greater cultural diversity in classrooms, their limitations become ever more apparent. As the wider educational debates since the 1990s make clear, focusing on emotion rather than behavior is likely to be of value. This does, however, need to be based on a solid theoretical framework for understanding the role of emotions in social relationships, as well as including a focus on the way in which emotions intersect with questions of power, inequality, and identity in higher education. Second, the use of a unidimensional model of student-teacher relationship (whether framed as valence or immediacy or closeness) has value but it also may hide important aspects of teaching relationships: "a teacher who surprises students with an unexpected mid-term exam may generate negative emotions in students just as much as a teacher who is perceived as incompetent in their subject area, but these two situations have important differences between them" (Tormey, 2021, p. 2). Finally, for faculty developers, the model should enable teachers to think about and improve their teaching.

How then to frame student-teacher relationships in STEM education in a multidimensional way that captures pedagogically important elements of the relationship and at the same time helps to understand the social contexts of power and identity within which these relationships are framed? One multidimensional framework for thinking about the emotional quality of student teacher relationships is that proposed by Tormey (2021) based on the work of the psychologists of emotion Jennifer Jenkins and Keith Oatley (see Oatley, 2004; Oatley et al., 2006). In this model, emotions and feelings are seen as providing us with information about the quality of our relationships with other people. The model proposes that it is useful to think of our social relationships in terms of three dimensions: these are named as *affiliation* (or warmth), *attachment* (or security), and *assertion* (or status).

Affiliation is a dimension characterized by emotions like affection, warmth, liking, belonging, or love. This dimension provides a foundation for social living – we want to spend time in the company of others when we share a sense of mutual affection or warmth. In a context in which there is ever increasing evidence about the importance of cooperation for active and interactive learning in STEM higher education (Johnson et al., 2014; Menekse, 2013; Freeman et al., 2014; Prince 2004), feelings of warmth or attachment to a class or a group is arguably crucial for engaging to learn.

Attachment reflects feelings of security and safety. A large body of evidence shows that feelings of fear or anxiety hinder student learning in STEM, and has been widely researched in math education, for example. Pekrun et al. found 1,200 studies on academic anxiety between the 1950s and 1990s that show "test anxiety can reduce working memory resources, leading to an impairment of performance at complex or difficult tasks that draw on these resources. Consequently, test anxiety tends to correlate negatively with academic achievement at school and university" (2002, p. 96-97). In research about parenting, the *attachment* and *affiliation* dimensions have often been collapsed into one; that is, parents who are seen as warm and loving were often also assumed to provide a sense of safety within which the child could explore and learn. More recently, and in light of a greater consideration of non-Western cultural settings, Oatley et al. (2006) highlight the need to distinguish the two dimensions. A similar dynamic also plays out in learning research: while it is easy to imagine situations in which teachers who communicate that they like students also make students feel secure, it is possible to imagine teachers who may appear warm (high *affiliation*) but who nonetheless are perceived by students as unreliable (low *attachment*).

The *assertion* dimension is perhaps different to the two proceeding dimensions in that it arises, not from a psychological literature on caring relationships but from a sociological literature on power in relationships (e.g., Kemper and Collins, 1990). While *lay theories* of power in social relationships tend to see power as being most evident in situations of conflict, sociologists have long been interested in situations where power differentials are taken for granted or seen as natural in the ability to set agendas or to shape the thinking of others (e.g. Lukes, 2005). Perhaps the prototypical emotion of status is anger, which is typically felt when one experiences a slight or an insult towards one's status. Clearly, there are occasions in teaching and learning when teachers and students feel anger or contempt; however, non-conflictual emotions of status are nonetheless important. A sense of *awe*, or more modestly being *impressed*, attributes status to

the person who is making the impression and can be seen as representing the teacher's desirable cultural capital.

It is worth noting that *assertion* is itself a multidimensional phenomenon. In a social organization, power can derive from the rules and laws of the organization (which give the teacher the *right* to decide certain things about their class and to then impose them on the students) and can also come from the teacher's status or cultural capital (which gives them a sense of authority that allows them to influence the thinking of students and, indeed, colleagues). In pedagogical relationships, it seems likely that it is this latter aspect of *assertion* that is most relevant. Hence, it makes sense to focus on emotions such as awe and a sense of being impressed.

This *assertion* dimension may be particularly important for novice teachers, as their claim to *status* may well be of central importance to them. Accounts of the development of teacher expertise have long identified that teachers often begin their career trajectory with a concern for their own status and identity as a teacher (Conway and Clark, 2003). For novice teachers, in particular, being respected as a teacher by students may be a primary concern that overshadows their work on other dimensions of relationships.

Tormey (2021) tested this three dimensional model of emotional qualities of student teacher relationships using a quantitative measure called the *Classroom Affective Relationships Inventory* (CARI) with STEM university students and found that the three dimensional model provides a good fit for how students describe their emotions with respect to their teachers. It is interesting to note that, despite the stereotypes that science and engineering are unemotional disciplines, the model provided a good fit for these relationships in STEM classes, including those with over 200 students. Overall, the three dimensional model explained almost 60% of the variance in students' ratings of course quality.

It was noted above that it is important not simply to focus on the teacher-student relationship itself, but also on the social and organizational context of STEM. Work by social psychologists on implicit bias and rapid social appraisals show that evaluations of warmth and status are not simply a function of the behavior of the person being appraised (e.g. the teacher) but are affected by socially constructed implicit beliefs about gender, ethnicity, social groups (Fiske et al., 2002; 2007) and STEM disciplines (Cheryan et al., 2017). Hence teachers who belong to particular social groups (white middle-aged men, for example) may implicitly be evaluated as having

more authority and status than female teachers, younger teachers, and those who belong to groups which are underrepresented as STEM university teachers. It should be remembered, therefore, that student evaluations of the emotional quality of the relationship are not *neutral* evaluations but are already infused with assumptions about discipline, gender, and ethnicity – assumptions that may contribute to discrimination against some higher education teachers.

Seen in this way, the three-dimensional model of the emotional components of student-teacher relationships does not simply provide a tool for "maximizing" the relationship but also a framework that helps teachers – especially novice teachers – to identify the factors that are impacting on these relationships. This model is, therefore, useful for STEM faculty developers when assisting teachers to, for example, improve students' in-class participation, interpret students' course evaluation feedback, or address incivilities. In recognizing that *assertion* and *affiliation* may be gendered differently in students' implicit perceptions, to take one example, teachers may find the model useful to consider what combinations of instructional strategies will best support the relationship they wish to create with their students. In the following two sections, we explore some specific applications of this model in faculty development work.

1.1.4 CLASSROOM MANAGEMENT AND THE EMOTIONAL QUALITY OF RELATIONSHIPS

Work on K-12 and university teacher development has long identified (Fuller, 1969; Conway & Clarke, 2003; Kugel, 1993) that teachers' concerns often follow a trajectory of stages, starting with a concern for themselves and their own identity as a teacher, moving through a stage of concern for the transmission of their subject, before becoming a concern for their students' learning. In the early stages of their career, their concern for feeling secure in their identity as a teacher means classroom management is a source of considerable concern for novice teachers. This insecurity may negatively affect their ability to see things from a student's perspective (i.e., showing empathy). It may also mean that novice teachers are overly attentive to the authority or *assertion* dimension of their relationship with students, which may negatively influence on the other two dimensions. We may intuitively think that creating and sustaining a class climate that is good for learning relies on teachers' ability to prevent disruptions. Contrary to this idea, the three-dimensional model allows us to consider how actions that evoke warmth, trust, or power affect student-teacher relationships, and therefore, the learning environment.

Assertion in student-teacher relationships is characterized by emotions such as awe, admiration, anger, and shame (Tormey, 2021). How teachers deal with disruptions could raise students' admiration or reduce the teacher's status by evoking anger and shame in students. This section examines first how *assertion,* then the other two dimensions, can be used to consider issues of classroom management.

Student disruptions are often a minor but cumulative annoyance that can make teachers feel disrespected. Student disruptions include students texting or watching videos (Baker, 2008; Alberts et al., 2010), chatting (Woodcock, 2012, Bjorklund, 2009, Baker, 2008) and switching off their webcams (Stanford News, 2021). In Alberts et al.'s study, college geography instructors cited strategies that relied on shaming or embarrassing students when asked to name effective ways to manage student disruptions, such as "I do my best to embarrass someone who sleeps or plays in class…" (2010, p.452). Such displays of power are effective for getting students' attention but the damage to the *attachment* or trust dimension of the relationship is illustrated in the teachers' concern that "… the professors are being evaluated for tenure. If you try to adopt a strong class discipline like in Europe, you will end up with very poor evaluations..." (Alberts et al., 2010, p.452). Here, the weak sense of *attachment* (embarrassing the student erodes trust) combines with disdain (*assertion*). Alternatively, a teacher might use a kind but humorous reminder (*affiliation*) if they are concerned about getting negative student feedback (*attachment*). Whilst these examples are similarly low in trust (concern for the teacher, shame for students), they are both high on *assertion.*

Attachment is strengthened when teachers foster a climate of mutual trust by demonstrating that they are reliable. *Attachment* is undermined when teachers go against their own rules; teachers arriving late or cancelling classes at the last minute is perceived as disrespectful by students (Boice, 1996). When preventative strategies fail, teachers' *in the moment* reactions can also benefit from analysis with the three dimensions. Discrete actions, such as continuing to teach while moving to stand beside students who are chatting, are unlikely to have a significant negative effect on the teacher-students relationship as they do not weaken the *attachment* dimension nor rely excessively on *assertion* (Tormey & Isaac, *2*022). Setting clear boundaries with a class is a common preventive strategy for class management (Alberts et al., 2010; Woodcock et al., 2012) and adhering firmly to such rules should foster *attachment.*

However, a lack of flexibility is contrary to expressing the *care* fundamental to a strong *affiliation* dimension. The Covid-19 pandemic was a stark reminder that renegotiating rules can

be an important expression of compassion. Previously seen as a disruption, pandemic guidelines recommended that students should be allowed to switch off their webcams (TopHat, 2021; Stanford Newsletter, 2021). Teachers changing their previously announced assessment methods and deadlines (Guangul et al., 2020) garnered students' appreciation, a flexibility that strengthened feelings of *affiliation* (Sarrade & Tormey, 2020).

This approach to class management illustrates how the three dimensions of the model can structure teachers' thinking about how their pedagogical actions influence their relationship with a class and how they can attend to particular aspects to establish a climate that meets both their own and students' needs. Table X.1 presents an analysis of how common class management techniques affect the emotional quality of the student-teacher relationship. Below, we describe how faculty developers can facilitate this reflection using the example of one of our training workshops for teaching assistants.

[INSERT TABLE X.1 HERE]

Attending to the emotional relationship with a class starts with developing empathy for students' experiences of class disruptions and class management. In our workshop, we have the teaching assistants brainstorm the misbehaviors most frequently identified as problematic by teachers and then those most frequently identified by students. The subsequent plenary discussion compares their ideas to the research evidence on students' and teachers' perceptions (e.g., Boice, 1996; Bjorklund & Rehling, 2009), highlighting (i) the challenges for teachers to identify students' perceptions of misbehavior, (ii) the gap between the teachers' perceptions of misbehavior and the research findings, and (iii) that much of the *misbehavior* identified by students is *teacher misbehavior*.

We use Boice's (1996) finding that classroom misbehaviors are reduced when there is greater immediacy in classroom relationships to introduce the three-dimensional model of student-teacher relationships. For these novice teachers, the distinction between *organizational power* and *status authority* in the *assertion* dimension is particularly salient. We present data on the positive association between student course ratings and both the *assertion* dimension (which measures status authority and not organizational power) and the *attachment* dimension (which measures students' sense that the teacher is reliable and non-arbitrary). Our workshop participants then return to the data on teachers' and students' perspectives on misbehavior and assign each type of *misbehavior* to one of the three dimensions. STEM faculty developers can

use such activities in individual consultations or workshop settings as a platform to discuss what productive strategies teachers can adopt to manage disruptions and build relationships that are based on warmth, trust, and status authority.

1.1.5 INTERACTIVE TEACHING AND THE EMOTIONAL QUALITY OF RELATIONSHIPS

Despite the robust evidence for the value of interactive and participative classes (Prince, 2004; Watkins & Mazur, 2013; Freeman et al., 2014; Chi et al., 2018), STEM students "are often reluctant to interact during lectures, even when explicitly encouraged to do so" (Yoon et al., 2011, p.1107). Students interviewed by Yoon and colleagues (2011) reported that they rarely participated actively during class and that this was useful to allow the "lecturer to get through the content in the allotted lecture time, while enabling students to avoid being publicly embarrassed in the lecture" (2011, p. 1107). Interactive teaching requires that students accept a new set of classroom norms, and a strong relationship between the teacher and students can be helpful for both encouraging students to accept the change and to engage actively with the activities. Faculty developers can support teachers who are moving to more interactive teaching strategies by exploring these three dimensions of the teachers' relationship with students.

In our faculty development work, we have accompanied both experienced and novice STEM higher education teachers who are concerned about how students will react to interactive teaching strategies. Teachers' concerns include losing control of the class period, students refusing to participate, and receiving poor course evaluations from students. In this section, we use the three-dimensional model to examine student-teacher emotional relationships in classes with interactive teaching. Interactive teaching can strengthen the *affiliation* dimension and requires that *attachment* is carefully cultivated, while shifting norms may pose significant challenges to the *assertion* dimension. Table X.2 presents a summary of how interactive teaching strategies can reinforce or threaten the emotional quality of the student-teacher relationships. While interactive teaching strategies can build particular types of assertion, they may also challenge more traditional *assertion* strategies, as illustrated in the top row of the table. This helps to draw attention to why some STEM teachers have concerns about interactive teaching. As noted above, there is substantial research in STEM that highlights the value of interactive teaching; nonetheless, teachers' willingness to use such strategies may be tempered by anticipating that students will see them as less competent or expert. STEM faculty developers may, therefore, find the tabular format useful to structure conversations with teachers about making choices to balance the overall impact of interactive teaching.

[INSERT TABLE X.2 HERE]

Core requirement courses in STEM tend to be large, making it difficult to get to know enough individual students (Breen & O'Shea, 2019) and developing a positive relationship with a class usually takes intention. The warmth of a strong sense of *affiliation* can be supported by instructional strategies that seek students' engagement and provide more frequent opportunities for verbal and non-verbal behaviors that convey teacher immediacy (see review in Gilstrap, 2004). This dimension is strengthened by interactive teaching strategies, particularly when the teacher makes use of the format to engage with smaller groups of students, to move around the classroom, and other behaviors that convey immediacy. A strong sense of *affiliation* can also encourage students to *help out* the teacher by assuming a more active role in class. When faculty anticipate that the other two relationship dimensions may be challenged by their instructional choices, it is important to ensure that this one is well maintained.

Attachment is essential for interactive teaching because students will both have more control and more responsibility for their learning and will also be expected to reveal more about their thinking and understanding. This means that adequate trust of the other party is important for both teachers and students; a weak *attachment* dimension in the relationship can be a major impediment to interactive teaching. A weak sense of *attachment* explains, for example, that mathematics students' biggest reason not to answer questions was how they would be judged by the teacher and their peers (Yoon et al., 2011). STEM and other higher education teachers share the concern about causing students embarrassment (Breen & O'Shea, 2019; Scager et al., 2017) and are also worried about being challenged in front of their students (Martin & Lueckenhausen, 2005). Clearly, avoiding public embarrassment is a major part of the implicit classroom agreement between students and teachers (Yoon et al., 2011). For students to be willing to engage with interactive teaching, they must trust that their discomfort will not be excessive and that their effort will be reflected in their learning. This connection may be poorly appreciated by STEM students who are often unfamiliar with collaborative learning strategies (Novak et al., 2017).

Interactive strategies that enable students to answer anonymously, such as clickers and other online tools, can resolve some of these concerns. While these strategies can generate useful feedback about learning for students and teachers, some of the greatest learning benefits have been identified when STEM students discuss with each other (Crouch & Mazur, 2001). This means that students must be willing to share the thinking behind their answers. Debriefing

prompts such as “Who can explain why they chose answer B?” asks students to un-anonymize themselves and weakens attachment by betraying the trust established. Instead, using the prompt “There is clearly something attractive about answer B since 25% chose it - who can share something that makes it a good option?” is more effective since it maintains trust.

The impression of teacher competence or *assertion* in STEM is typically founded both on a traditional teacher-centered approach (Gardner & Jones, 2011; Luft et al., 2004) and, at the undergraduate level, an epistemological approach that seeks single correct answers from experts (Isaac, 2021). This means that some teachers may experience sharing control with their students of both time management and the information shared in class as a weakening of their authority. This model may help teachers to explicitly identify these concerns and consider how the other dimensions and pedagogical outcomes counterbalance a potential weakening of *assertion*. The impact on *assertion* may be stronger when working with students for whom interactivity is novel, particularly if students are already prone to associating some aspect of the teacher’s identity with lower competence.

Interactive teaching requires managing many things simultaneously, which makes it difficult for teachers to consider how their interactions with students affect their relationship with the class. We offer this three-dimensional model of the emotional relationship between teachers and students as a tool for instructors to clarify *why* their course design, instructional strategies, or facilitation methods are supporting or discouraging the active participation of their students.

1.1.6 Considering faculty developer-teacher emotional relationships

The three-dimensional model of social relationships has, up to now, been used to think about how students and teachers relate to each other. We have shown how faculty developers can use the model to help teachers to think about the kinds of emotional relationships they have in their classes and the kinds of relationships they would like to foster.

If the emotional relationship between student and teacher is important for student learning, we should also expect that the relationship between faculty developer and teacher is important for teacher learning and development. Indeed, over sixty years ago Carl Rogers (1958) argued that central to the success of any helping relationship was the helper’s ability to communicate trustworthiness, warmth, and respect for the agency of the other person. While the emotional dimension has been a minority interest in recent faculty development scholarship, as in other areas of educational research, there is now growing body of research looking at the role of

emotion in the professional relationships of faculty developers and teachers (Kelly, 2015; Timmermans et al., 2018; Wilder, 2019; Bessette & McGowan, 2020).

In this context, it seems likely that the application of the three-dimensional model of social relationships to the faculty developer-teacher relationship could well be enlightening. Just as with students, teachers need to feel secure to step outside their comfort zone and try new teaching strategies. The *attachment* dimension for example draws attention to the need to create relationships of trust within which teachers can manage their sense of uncertainty or threat in their teaching life (i.e. Bessette & McGowan, 2020). The *assertion* dimension draws our attention to the way in which authority is shared, that is, if the teacher feels a sense of agency and an internal locus of control over their work (Wallen & Tormey, 2019), while at the same time respecting the faculty developer's pedagogical expertise . The *affiliation* dimension captures the dimension of faculty developers communicating care (Timmermans et al., 2018) to teachers.

Bessette and McGowan have argued that emotional "labor is very much still under-theorized within higher education more generally …and faculty development more specifically" (2020, p.137). We would suggest that as this theory develops, the three-dimensional model of faculty developer-teacher relationship might be a productive avenue to explore.

1.1.7 Value of a framework for emotional teacher-students relationships in STEM faculty development

Given the importance of student-teacher relationships for learning, the three-dimensional model of the emotional quality of teaching and learning relationships can be a useful reflection tool for STEM faculty developers. The multiple dimensions allow for a more nuanced understanding of these relationships compared to previous work that considered only a single dimension. We illustrated how faculty developers can use the three dimensions of *affiliation, attachment,* and *assertion* to analyze how teachers approach their classes around interactive teaching and classroom management. We chose these examples as relevant to faculty developers who are often asked to accompany teachers in implementing either innovative teaching strategies or addressing problematic situations in their courses. While this model was developed for teacher-student relationships, it may also serve as a useful lens for faculty developers to consider how

to manage their relationships with teachers. Faculty developers can analyze their own actions when facilitating workshops or collaborating with teachers in terms of these three dimensions and the ensuing impact on their emotional relationship with teachers. The structure of this model can be applied to many STEM learning situations to help both faculty developers and teachers to better perceive patterns between teaching actions, the resulting emotional relationship and student learning.

Table X.1 How do common classroom management strategies influence the 3-dimensions of the student-teacher emotional relationship? [1]

Dimension	+ **Assertion** -		+ **Affiliation** -		+ **Attachment** -	
Teacher behaviors	awe, admiration, respect	disrespect, disdain	warmth, care, sense of belonging	detachment, coldness	safety, trust	fear, distrust
Causing a student embarrassment		-				-
Last-minute cancellations or changes		-				-
Punishing students with a surprise test		-				-
Requiring students to keep on their webcams						-
Joking about a disruption in front of the entire class						-
Telling students to leave the classroom				-		
Speaking rapidly without pauses and not answering students' questions				-		
Allowing students to determine when to have their webcams on or off			+			
Adapting assessment to unexpected events			+			
Learning students' names			+			
Using subtle non-verbal cues, such as a direct gaze or physical proximity, to remind students of teacher expectations			+		+	
Speaking with disruptive student(s) after class, in a less public way	+				+	
Providing students with a document that clearly	+				+	

[1] Dark shading indicates a challenge to the dimension and light shading a reinforcement of the dimension.

communicates behavioral expectations						

Table X.2 How do interactive teaching strategies influence the three-dimensions of the student-teacher emotional relationship?

Dimension	Reinforcing aspects	Detrimental aspects
Assertion *awe, admiration* *vs.* *disrespect, disdain*	Teacher demonstrates disciplinary expertise by guiding students' thinking (through assigned tasks and questions), rather than by expository presentation Teacher demonstrates skill in facilitation, rather than presenting	Class is noisier, more improvisational than traditional class Teacher has fewer opportunities to awe students with their erudite expertise Teacher doesn't conform to typical "professorial" behavior Lesson content may come from a reading or peer discussion rather than directly from the teacher Teacher shares control of information flow and class time with students
Affiliation *warmth, liking, care, sense of belonging* *vs.* *detachment*	Teacher have increased opportunities to use verbal and non-verbal cues to solicit, welcome, and value students' contributions Teacher is attentive and facilitates the participation of all students Teacher is willing to adapt and revise their teaching plan	Teacher asks students to do things outside of STEM classroom norms
Attachment *safety, trust* *vs.* *fear*	Teacher is reliable, consistent, and adheres to the announced expectations Teacher trusts students to come prepared and participate Teacher demonstrates for students that interactivity results in robust and effective learning Teacher minimizes potential risk and embarrassment for students	Students are asked to expose themselves to potential embarrassment Teacher breaks implicit STEM classroom code

1.1.8 References

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