Understanding Why Math and Science Teachers Quit: Evidence of Cognitive Errors

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Article Info	Abstract
	Every year school districts must fill tens of thousands of teacher vacancies in mathematics and science. Reasons for the high rate of attrition are described in general terms, such as lack of administrative support and dissatisfaction. Analysis of direct quotes from qualitative research, however, suggests the presence of cognitive errors within the decision-making process of those teachers who quit. Cognitive errors include all or nothing thinking and fortune telling, among others. Results of this study are interpreted in comparison to the attrition literature. Suggestions for future research, such as Cognitive Behavioral Therapy training for preservice teachers, are presented.

Introduction

Problem of Teacher Attrition in Math and Science

Every year school districts in the United States must fill tens of thousands of teacher vacancies in mathematics and science. Reasons for the large number of openings include growing student enrollment, teacher retirement, and the departure of new teachers who move between districts or quit teaching altogether. Researchers refer to the latter two phenomena as migration (moving) and attrition (quitting). Migration and attrition are problematic because of the impact on school stability and student learning. For example, Milanowski and Odden (2007) indicated school districts spend between $9,061 and $23,038 for each new teacher who leaves within the first year of employment. Guin (2004) reported statistically significant negative correlations between student performance and teacher turnover. Likewise, Ronfeldt, Loeb, and Wyckoff (2013) have shown teacher attrition negatively impacted student achievement in math and English Language Arts, with effects that were more harmful in schools with large numbers of underperforming Black students.

Another issue associated with new teacher attrition is that the exact rate of quitting is unknown. Ingersoll (2003) suggested that 40% to 50% of new teachers leave the classroom within five years, while Hanna and Pennington (2015) reported 30%, and Gray and Taie (2015) indicated 17%. Regardless, the number of new teachers quitting

each year has a destabilizing effect on the organization of schools, as suggested by various studies that deal with the workplace environment. For example, Little (1982) found that teacher cooperation and collegiality is predicated on teacher retention. Similarly, Johnson, Berg, and Donaldson (2005) summarized several research articles that affirmed the positive relationship between teacher collaboration, academic test achievement, and retention. Also, Simon and Johnson (2015) provided evidence that teacher turnover in schools serving low-income students of color was attributable to the quality of school leadership, collegiality, and school culture.

Survey of Teacher Attrition Research

There is ample evidence indicating new teacher attrition exerts a negative effect on school workplace environment and student learning. One result of this is that much of the literature that deals with new teacher attrition describes the reasons teachers quit in general terms that are useful for generating top-down policy solutions. For example, Sutcher, Darling-Hammond, and Carver-Thomas (2016) found that teachers quit for various reasons such as dissatisfaction, family or personal reasons, pursuit of an alternative career, and financial considerations. Specific to math and science attrition, Ingersoll (2006) cited dissatisfaction, family needs, personal reasons, and pursuit of an alternative career. In addition, research by Ingersoll and May (2010) reported math and science teachers quit because of salary, frequency of student discipline problems, effectiveness of school leadership, lack of administrative support, availability of classroom resources, degree of classroom autonomy, usefulness of professional development in classroom management, and usefulness of professional development in subject areas.

Literature dealing with burnout provides a slightly more specific set of explanations for why teachers quit. Maslach, Schaufeli and Leiter (2001) defined burnout as an ongoing response to chronic stress, the source of which is emotional and physical depletion, cynicism, and a sense of ineffectiveness. According to Iancu, Rusu, Maroiu, Pacurar, and Maricutoiu, (2018), teacher burnout is related to workload, lack of collaboration with colleagues, lack of support from supervisors, and difficulties with classroom management. Unterbrink et al. (2012) added that teacher burnout is associated with effort-reward imbalance and the frequency of interpersonal conflicts with students, parents, and colleagues.

One of the similarities among literature dealing with policy solutions and burnout is that little distinction is made between math and science teachers and teachers of other subjects or levels (i.e. primary, middle, high school). For example, the analysis conducted by Unterbrink et al. (2012) and Iancu et al. (2018) aggregated responses from teachers who taught different subjects. In addition, Iancu et al. (2012) also compared responses from teachers between levels but found inconclusive results. It may be that studies involving teacher attrition, such as those conducted by Unterbrink et al. (2012) and Iancu et al. (2018) aggregate results to increase sample size and thereby improve the power of their statistical analyses. Nevertheless, including teachers of other subjects and levels conceals potentially unique characteristics surrounding math and science teacher attrition.

Indeed, math and science teachers quit at rates that are much higher compared to teachers of other subjects (Ingersoll, 2006), suggesting that math and science teacher attrition is unique. The characteristics that make

math and science teacher attrition unique are suggested by some research. For example, Ingersoll and May (2010) corroborated evidence of the effort-reward imbalance as a source of burnout. For math and science teachers in particular, Ingersoll and May (2010) noted i) frequency of student discipline problems, ii) extent of professional development in classroom management, and iii) effectiveness of subject-area professional development as predictors of attrition. Likewise, Emmerich, Rock, and Trapani (2004) found that attribution of classroom events differed between math and science teachers and teachers of other subjects, noting that "compared to other secondary school teachers (especially high school teachers of English), teachers of science experience relatively low sense of control in response to a negative classroom event" (p. 30).

At the same time, other research suggesting that math and science teacher attrition is unique is far from conclusive. For example, Rockoff, Jacob, Kane, and Staiger (2008) reported attrition of elementary and middle school math teachers in New York was not predicted by two personality traits derived from the Five Factor Model, conscientiousness and extraversion. At the same time, Bastian, McCord, Marks, and Carpenter (2017) showed that conscientiousness was significantly associated with effective teaching, such as higher value-added estimates, higher evaluation ratings, and improved rates of retention. Although, as with teacher attrition literature in general, participants in the study by Bastian, McCord, Marks, and Carpenter (2017) were not exclusively math and science teachers.

Studies that involve efforts to mitigate teacher attrition are similarly inconclusive and tend to include samples of teachers from various subjects and levels. For example, according to Iancu et al. (2018), the overall effect size of interventions intended to reduce teacher burnout was small, $r = 0.09$. One result of the limited success of attrition interventions is that policy has focused on producing more math and science teachers to fill vacancies (Ingersoll & May, 2010), rather than establishing systems to retain those math and science teachers who are already on the job.

While Iancu et al. (2018) reported an overall effect size of interventions for reducing teacher burnout that was near zero, the meta-analysis included potentially meaningful interventions, specifically those involving cognitive behavioral therapy (CBT). Studies involving CBT as an intervention for teacher burnout have shown effect sizes between $r = 0.11$ to $r = 0.28$. As with other literature in teacher attrition, studies examining the effects of cognitive behavioral therapy included teachers across subjects and levels, including 18 elementary school teachers (Flook, Goldberg, Pinger, Bonus, & Davidson, 2013), 92 special education teachers (Cooley & Yovanoff, 1996), 150 teachers from a variety of grades and subject areas (Ebert et al., 2014), and 167 teachers across grades 6, 7, and 8 (Anderson, 2000).

Cognitive Behavioral Therapy

The potential of CBT as an intervention for dealing with teacher attrition is perhaps unsurprising, given that there are more than 325 published studies on the effects of CBT (Butler, Chapman, Forman, & Beck, 2006). A meta-analysis on the comparative efficacy of CBT and other therapeutic approaches showed that CBT is widely applied to a variety of psychiatric disorders and is at least as effective, if not more effective, than behavioral or

pharmacotherapy approaches (Butler et al., 2006). In addition, the cognitive model has been utilized to examine work-related stress and anxiety in a variety of professions including those in the military (Cracsner & Mogosan, 2015), educators that teach students with emotional disorders (George & George, 1995), pre-service educators (Yavuzer, 2015), and higher education faculty (Hutchins, 2015).

CBT was derived from early attempts to interpret depression through a psychodynamic model (Alford & Beck, 1977). Psychoanalytic theories of depression were derived from the premise that those suffering from depression manifested anger reflected inward, resulting in a maladaptive need to suffer (Alford & Beck, 1977). Careful observation revealed that when depressed patients experienced success, their mood improved, and they did not appear to resist these improvements as would have been consistent with a psychoanalytic model. Identification and further analysis of these inconsistencies resulted in an alternative explanation of depression as the expression of a profound negative bias toward one's goals, future, and self (Alford & Beck, 1977).

An individual's behaviors, emotions, and physiology are influenced by their perception of events (Beck, 2011). The interplay of these factors in those suffering from anxiety or depression is complex and occurs, at least initially, beyond the awareness of the individual (Beck & Clark, 1997). Individuals process stimuli in three distinct stages of perception: the initial registration, the immediate preparation, and the secondary elaboration (Beck & Clark, 1997).

The initial registration of a stimulus is both rapid and automatic, requiring no additional cognitive processing (Beck & Clark, 1997). This threat detection system is simplistic (allowing people to categorize events as a threat or no threat), required for the physiological allocation of resources, and necessary for survival (Beck & Clark, 1997). Following the initial recognition of a potential threat, processing is characterized as immediate preparation to maximize security and minimize risk to the basic human needs for survival, procreation, safety, and sociability (Beck & Clark, 1997). This stage also occurs rapidly yet utilizes a greater degree of cognitive processing. The individual consciously registers the stimulus as threatening although some processing continues to occur at a subconscious or automatic level (Beck & Clark, 1997). At this stage, the initial markers of pathology may emerge as maladaptive mindsets (e.g. a tendency to discount the positive or catastrophic thinking) that is assigned further meaning through subsequent processing or elaboration (Beck & Clark, 1997). The final stage, secondary elaboration is deliberate and is characterized by metacognition in which the individual may escalate anxiety or worry through subsequent thoughts or choose to engage in further analysis that results in a more realistic appraisal of the situation (Beck & Clark, 1997).

Secondary elaboration and an individual's behavior are closely tied to his or her beliefs about an event rather than the event itself (Beck, 2011). Core beliefs are resistant to change and are highly influential in the process of secondary elaboration (Beck, 2011). Once an event has occurred and subsequent to initial registration and immediate preparation, core beliefs held during secondary elaboration influence the person's behavior and response. If the individual is inclined toward a negative interpretation of events, his or her thoughts, occurring with a great deal of automaticity, may reflect specific cognitive errors (Beck, 2011).

Identification of cognitive errors and learning to counter them through logic and empirical testing is central to CBT (Beck, Kovacs, Hollon, & Rush, 1977). A number of measures to assist in the therapeutic identification of thinking errors have been developed, although debate exists as to their construct validity. These measures may identify thinking errors or related underlying cognitive distortions (Morrison et al., 2015). While the nomenclature used to illustrate these errors is contested, Beck, Rush, Shaw, and Emery (1979), Beck (2011), and Morrison et al. (2015) provide a parsimonious list:

1. All or nothing thinking (i.e. dichotomous thinking): situations are either black or white rather than existing on a continuum.
2. Fortune telling (i.e. catastrophizing): the future is always negative regardless of other, less catastrophic possibilities.
3. Discounting the positive: attending to the negative aspects of a situation and discounting any positive elements.
4. Emotional reasoning: placing too much emphasis on emotions as related to a situation despite contrary evidence.
5. Labeling: placing a fixed label on an individual or situation while failing to consider contrary evidence.
6. Magnification or minimization: magnifying the negative aspects of a person or situation while minimizing the positive.
7. Selective abstraction (i.e. mental filter): attending to one detail of a stimulus at the expense of the whole.
8. Mind reading: believing that you know the thoughts of others.
9. Overgeneralization: reaching a false conclusion about a person or situation based upon previous experience.
10. Personalization: misattributing the words or actions of others to oneself.
11. Should statements: assigning rules to how oneself or others should behave.
12. Jumping to conclusions: reaching an erroneous conclusion without considering all aspects of a situation.
13. Blaming: blaming oneself or others for difficulties or pain despite evidence to the contrary.
14. What if: negative hypothesizing about a situation or the future.
15. Unfair comparisons: comparing oneself to others in a disadvantageous way.

As several studies indicate CBT is an effective intervention to teacher burnout (Anderson, 2000; Cooley & Yovanoff, 1996; Ebert et al., 2014; Flook, Goldberg, Pinger, Bonus, & Davidson, 2013). This suggests the presence of cognitive errors within the decision-making process of those math and science teachers who decide to quit. The purpose of this study is to provide evidence of cognitive errors among math and science teachers who decided to quit, thereby justifying further investigations into the use of CBT as a potentially effective intervention for preventing math and science teacher attrition.

Method

The method of this study is characteristic of a literature review. Boote and Beile (2005) indicate literature reviews are useful for meeting several research objectives, such as distinguishing what has been learned, identifying what still needs to be accomplished, and generating new perspectives. Randolph (2009) also notes

that literature reviews are for achieving several goals, including identification of a research problem, seeking new lines of inquiry, and identifying recommendations for further study.

While the methodological basis for this study is a review of literature, it is specifically a systematic review, which Vogt and Johnson (2015) define as a type of literature review that emphasizes procedures for selecting studies for analysis to generate conclusions. Research by Lawson, Çakmakb, Gündüzc, and Busher (2015) provides an example. The purpose of the systematic review by these researchers was to identify the main issues and components of student teaching as represented in research literature. The general steps taken by Lawson, Çakmakb, Gündüzc, and Busher (2015) included establishing search criteria, developing keywords, searching databases, and conducting additional searches based on results.

Similar to Lawson, Çakmakb, Gündüzc, and Busher (2015), the researchers in this current study began this systematic review by identifying search terms used in mathematics and science supply and demand research conducted by Ingersoll (2006), Ingersoll and May (2010), and Sutcher, Darling-Hammond, and Carver-Thomas, (2016). Ingersoll (2006) defined teacher attrition as those teachers who leave teaching altogether, whereas teacher migration refers to those who transfer or move to different teaching positions either within or across districts. Furthermore, Ingersoll (2006) defined teachers who leave as leavers, and teachers who migrate as movers. Ingersoll added that total turnover, or departures, was equal to leavers plus movers. Sutcher, Darling-Hammond, and Carver-Thomas, (2016) also defined turnover as the total of movers and leavers, and attrition as teachers who leave the profession. Ingersoll and May (2010) added that teachers who leave are the same as those who quit.

Based on a survey of the literature of mathematics and science teacher supply and demand, the search terms used in this study were *math, mathematics, science, leave, turnover, quit,* and *attrition*. We excluded the terms *migrate* and *movers* since we were interested in reasons teachers leave teaching rather than those teachers who move between schools or districts. Fourteen keyword search combinations were conducted in three databases, Education Resources Information Center, Psychinfo, and PsychArticles. Search terms were entered in different combinations. For example, *teacher*, *science*, and *quit*, or *teacher*, *turnover* and *math*. Additional criteria included research studies published in peer-reviewed journals between 1978 and 2018. Each search produced between 1 and 272 results. The title, abstract, and descriptors of each of the studies were examined for relevance. Twenty-eight studies met all of the selection criteria. From these 28 studies, 10 were identified as qualitative. From the 10 qualitative studies, 7 included direct quotations from participants which we could analyze.

These 7 studies were further compared to categories of trustworthiness identified by Williams and Morrow (2008), including data integrity, balance between reflexivity and subjectivity, and clear communication of findings. Each study addressed data integrity with a description of its method. For example, studies by Lloyd and Sullivan (2012), Ng and Peter (2010), and Southerland, Kittleson, and Hutner (2013) describe multi-year data collection using observations and interviews. Each study also addressed reflexivity and subjectivity, albeit with different approaches and with different levels of detail. For example, Schaefer, Downey, and Clandinin

(2014) describe use of autobiographical narrative and transcripts of researcher-participant conversations, whereas Patterson, Roehrig, and Luft (2003) describe development of case descriptors and categories based on a survey, field notes, and semi-structured interviews. Last, while the category of clear communication includes different components, such as the importance of findings, the researchers were most interested in the presentation of direct quotations from participants. In each study, authors indicated when they were reporting the words of participants through formatting and punctuation. Most studies also provided context about how these quotes were recorded, such as use of transcription from audio and video, or directly from written correspondence.

After completing these initial steps, direct quotes were copied from studies and organized on a spreadsheet. Following this, direct quotes were divided among the researchers and they coded each one independently based on its correspondence to the 15 cognitive errors. After assigning individual codes to each of the quotes, the researchers reconvened to reconcile differences, according to group processes described by Armstrong, Gosling, Weinman, and Martaeu (1997).

As a final step, the researchers evaluated their method according to categories of trustworthiness outlined by Williams and Morrow (2008). Careful documentation of how they established search criteria, identified search terms, and located relevant literature is one source of evidence of data integrity. The researchers sought to maintain accurate interpretation of quotes by applying individual codes, followed by discussions to reach group concordance.

Results and Discussion

Five of the studies took place in the United States, one in Canada, and one in Australia. Information for determining the sex of participants, seven female and nine male, was provided in six of the seven studies. The same six studies also provided information for identifying participants by subject area, thirteen science and three math. The study by Handal, Watson, Petocz, and Maher (2013) involved survey research with 59 math and science teachers, but additional information for identifying participant characteristics were not reported.

Again, the researchers in this study analyzed each of the seven articles for direct quotes from math and science teachers who quit. Forty-two quotes were matched to one or more of the 15 cognitive errors. Table 1 provides a summary of results by source, cognitive error, and the direct quote used as evidence. All but two of the 15 cognitive errors were used for coding. Evidence of labeling and personalization were not observed. The six cognitive errors observed most as shown in Table 2 were all or nothing, fortune telling, blaming, magnification/minimization, mind reading and overgeneralization.

Evidence for all or nothing thinking was cited most frequently and came from six studies (Gilbert, 2011; Saka et al., 2013; Schaefer et al., 2013; Handal et al., 2013; Lloyd & Sullivan, 2012; & Patterson et al., 2003). Fortune telling was cited in five studies (Gilbert, 2011; Schaefer et al., 2014; Handal et al., 2013; Lloyd & Sullivan, 2012; & Patterson et al., 2003). Blaming was cited in four studies (Schaefer et al., 2013; Ny & Peter, 2010;

Handal et al., 2013; & Lloyd & Sullivan, 2012). Magnification or minimizing came from three studies (Saka et al., 2013; Schaefer et al., 2013; & Ny & Peter, 2010). Mind reading was noted in three studies (Gilbert, 2011; Saka et al., 2013; & Lloyd & Sullivan, 2012). Overgeneralization was identified in three studies (Ny & Peter, 2010; Lloyd & Sullivan, 2012; & Patterson et al., 2003).

Table 1. Evidence of Cognitive Errors by Study

Studies with Cognitive Error	Direct Quote
Gilbert (2011)	
Fortune telling	I always loved science in high school and everything and then being the teacher pleaser that I was, I kind of had a little of a breakdown when I did not get an A... and then I got to college and I got a B in Chemistry and I was pretty sure that it was the end of the world (p. 401).
Mind reading	But then more recently, it's always been the colleagues in particular… sometimes even fighting against the way I wanted to teach... I learned just to keep my mouth shut and not to talk about multiculturalism in the... meeting, not talk about the achievement of females... not talk about how many white faces there were in our AP classes (p. 402).
All or nothing thinking	There's no support by colleagues. There's total isolation. So you have nobody to go to. If you go to somebody it's almost admitting failure and you can't be. I'm a professional. I must be able to do my job (p. 403).
Jumping to conclusions	I knew I wasn't gonna stay there... I sometimes think my test scores were an issue... I mean in interviews people ask you what your test scores are. How many of your students passed your Achievement Test... I was trying to get jobs in districts where 90 percent were passing, and I'd get an interview and then I'd have to be like 72 percent passed (p. 403).
Discounting the positive	I don't like what med school has done to my personality (p. 407).
Saka, Southerland, Kittleson, & Hunter (2013)	
Magnification or minimization	I had considerably larger challenges than other first-year teachers (p. 1231).
Magnification or minimization	Little did I know how difficult it is to be an effective science teacher and a successful graduate student at the same time... I don't wanna fail my class, OK! But it is hard finding the time for both... But what happens is that I get home I feel so tired and I am like, you know forget it (p. 1231).

Mind reading	I think my department as a whole knew that I didn't need their help unless I really asked for it. But I was pretty confident, pretty much knew what I wanted to do and how I wanted to handle things. So, they needed to be hands off (p. 1234).
Mind reading	[The school administration] wanted to fire me for the entire month of September. And coming to work every day was miserable because I walked on eggshells for a month, a month and a half (p. 1235).
All or nothing thinking	I know how to be a good science teacher...but I am not in the situation that allows my abilities, my natural abilities to come into play (p. 1237).
Schaefer, Downey, & Clandinin (2014)	
Selective abstraction	She tells of how she and her colleagues were not recognized for their innovative work but that someone else was given the credit (p. 10).
Emotional reasoning	I actually would love for the school system to give teachers more time to do a good job and to be the teachers they want to be… I feel like if I am not teaching I should at least be trying to improve the school system from the outside… Because how long can you really stay in the system (p. 16)?
Magnification or minimization	I was probably firing off 80 to 85 hours a week at the school but I loved the coaching… It was basically every weekend, three times a week practices, so my time commitment had gone up 30 hours a week… I was kind of burnt out by the end of volleyball (p. 18).
All or nothing thinking	I genuinely think it is impossible to be a high school teacher and to be decent at your job, and have a healthy home life.... Either you're kind of a mediocre teacher and really on top of your family life, or you're a good teacher, or a great teacher, but your family is suffering in some way (p. 17).
Fortune telling	… there's 180 days in the school year and when day one starts and they all come barreling down the hallway and bust through your door and they're basically like "We're yours. You've got to deal with us every day." ... like, for the next 180 days it feels like just one big long day... that you're waiting to end (p. 20).
Blaming	She said that I was kind of like a butterfly...that I might need to fly away, that there might be a better setting for me. I think she was like "private school or some different type of education that's happening." I think she kind of saw how the education system was heading and did kind of share that with me (p. 21).

Ng & Peter (2010)

Blaming	for me to stay it would have to be a big change in administration this next year, and I would have to really like the changes (p. 134).
Magnification or Minimization	I honestly thought by getting into teaching I would be moving into an industry that was less paper intensive. I was quite shocked to find out that teaching school has a lot more to do with moving papers than it really does with teaching students (p. 136).
Overgeneralization	...it took six or seven meetings. My schedule was set in the first ten minutes. After that, I sat there for six hours and listened to the other teachers argue and had no way to really input anything and couldn't have impacted the outcome of all these petty arguments anyhow (p. 136).
Emotional reasoning	motivating through fear... To some degree... I almost live two separate realities… Authoritarian power is overrated - it is so lonely at the top. Controlling by fear only works for so long, and, quite frankly, it does not fit my personality (p. 137).
Discounting the positive	I don't have the luxury of time like [other teachers] do. I have three children. I have a mom who has rheumatoid arthritis and because of that lives with me, and I have to take care of them. I don't even know when I go home tonight... Can I do school work? I just have to learn to manage it (p. 137).

Handal, Watson, Petocz, & Maher (2013)

Unfair comparisons	There are smaller schools than mine. There is a lack of colleagues for support within a KLA and that is a problem (p. 20).
Discounting the positive	Small school numbers mean teachers have to be prepared to teach outside their subject area. Some teachers are not prepared to do this (p. 20).
All or nothing thinking	Training is ONLY offered in Sydney which is a 12 hour drive (p. 20).
Should statements	It should be possible for teachers to participate in the marking process without exchanging/long service leave (p. 20).
Blaming	Inexperience teachers were expected to 'step up' to take leadership roles (p. 21).
Fortune telling	The fear of being trapped here forever will discourage relocations to rural and remote schools (p. 22).
What if	Falling numbers could be a problem. There could be possible forced transfers. If a school is too small, parents would be more inclined to

	send more capable students to private school (p. 22).
All or nothing thinking	They are appalling work and living conditions (p. 23).

Lloyd & Sullivan (2012)

Blaming	So part of me just wants to fight everyone and fail him because I am just so ticked off about it. ...The tutor the last time we talked said that if he fails, he is just going to drop out and give up, and he is going to be a failure in life. So that will be on my shoulders (p. 147).
Mind reading	I don't think they went into teaching to teach; they went into teaching because they had a math major and a lot of them wanted to stay home half time. And they wanted to have the summer off (p. 150).
Jumping to conclusions	The people I should be able to count on to help me just completely blew me off (p. 152).
Fortune telling	I've found that the only way to not go completely crazy is to let go of a lot of the little things... Unfortunately, as time goes on and I get older, I think I'll have to let more stuff go in order to survive, and that's definitely not a recipe for good teaching (p. 157).
Overgeneralization	I spend all my free time chasing kids around who don't care, who never change, and who give me attitude (p. 158).
All or nothing thinking	But I can't talk myself into giving only 90% (p. 158).

Patterson, Roehrig, & Luft (2003)

Overgeneralization	I taught in two different classrooms, taught four sections of challenging classes where students were not particularly motivated (p. 18).
Overgeneralization	...had to go to numerous after school parent conferences for students who didn't care (p. 18).
Selective abstraction	...had to fight copy machines which didn't work 50% of the time. (p. 18)
Fortune telling	I don't think I will ever be able to get the education I want working for this or any other public school. (p. 19)
Unfair comparisons	As a starting chemist, I worked 40 hours per week and was paid $44,000. As a teacher, I have to work far more hours for much less pay (p. 19).
All or nothing thinking	I could work a 40-hour week, but my teaching would suffer. It's a no-win situation. (p. 19)
Emotional reasoning	[a participant complained that teaching] sucked everything out of me. (p. 19)

Table 2. Frequency of Cognitive Errors

Cognitive Error	Frequency
All or nothing thinking	7
Fortune telling	5
Blaming	4
Magnification/Minimization	4
Mind reading	4
Overgeneralization	4
Discounting the positive	3
Emotional reasoning	3
Jumping to conclusions	2
Selective abstraction	2
Unfair comparisons	2
What if	1
Should statements	1

The analysis of qualitative research conducted in this study corroborates general reasons found in literature explaining why math and science teachers quit. The analysis, however, provides additional evidence that math and science teachers who quit may be amplifying negative aspects of their experiences through cognitive errors. There are several findings in the attrition literature that relate to the findings of this study to support this claim.

As noted in the review of literature dealing with teacher attrition, Little (1982), and Johnson, Berg, and Donaldson (2005) have suggested there is a relationship between teacher retention and school workplace environment. In particular, teacher-to-teacher collegiality and cooperation promote retention. A direct quote from one teacher both affirms the retention and workplace relationships, while also exaggerating the isolation inherent in teaching through All or Nothing Thinking, "There's no support by colleagues. There's total isolation. So, you have nobody to go to. If you go to somebody it's almost admitting failure…" (Gilbert, 2011, p. 403).

The urgent need to fill math and science teacher vacancies has led to emphasis of top down policy solutions. One result is that reasons for attrition are described in general terms, such as lack of administrative support, financial considerations, and effort-reward imbalance (Ingersoll & May, 2010; Sutcher, Darling-Hammond, & Carver-Thomas, 2016; Unterbrink et al., 2012). Quotes from math and science teachers who quit clearly show these themes, while also indicating evidence of cognitive errors. For example, one teacher stated "[The school administration] wanted to fire me for the entire month of September…" (Saka, Southerland, Kittleson, & Hunter 2013, p. 1235), which could be interpreted as a lack of administrative support but also Mind Reading. Another quote shows an example of financial considerations and effort-reward imbalance, along with Unfair Comparisons: "As a starting chemist, I worked 40 hours per week and was paid $44,000. As a teacher, I have to work far more hours for much less pay" (Patterson, Roehrig, & Luft, 2003, p. 19).

Dissatisfaction is another reason cited in the math and science teacher attrition literature. Similar to lack of

administrative support, financial considerations, and effort-reward imbalance, dissatisfaction is described in general terms. It includes a wide variety of experiences, including dissatisfaction with salary, job security, workplace conditions, lack of autonomy, and lack of professional development, among others (Ingersoll & May, 2010). Nevertheless, one experience not always associated with dissatisfaction is a sense of ineffectiveness. Several quotes from teachers suggest a sense of ineffectiveness, amplified through All or Nothing Thinking, as shown in the following statements:

- "I know how to be a good science teacher...but I am not in the situation that allows my abilities, my natural abilities to come into play" (Saka, Southerland, Kittleson, & Hunter, 2013, p. 1237);
- "I genuinely think it is impossible to be a high school teacher and to be decent at your job, and have a healthy home life…" (Schaefer, Downey, & Clandinin, 2014, p. 17);
- "But I can't talk myself into giving only 90%" (Lloyd, 2012, p. 158);
- "I could work a 40-hour week, but my teaching would suffer. It's a no-win situation." (Patterson, Roehrig, & Luft, 2003, p. 19).

As noted previously, literature dealing with math and science teacher attrition often aggregates results of teachers from different subject areas and from different levels (e.g. Iancu et al., 2018; Unterbrink et al., 2012). This aggregation makes it difficult to determine whether there is anything unique underlying the high rate of math and science teacher attrition. Along these same lines, the analysis of direct quotes conducted in this study does little to suggest math and science teachers possess unique characteristics, except perhaps with regard to conscientiousness, one of the factors of the Five Factor Model of personality (Costa & McCrae, 1995). Conscientious teachers are orderly, dependable, dutiful, self-disciplined, and planful (Bastian, McCord, Marks, & Carpenter, 2017). It is plausible that a highly conscientious teacher would be frustrated working in a school environment that is sometimes characterized as inefficient and unfocused. Results of the analysis provided in this study hints that there may be a relationship between conscientiousness and attrition. The cognitive errors Magnification or Minimization and Overgeneralization provide some empirical basis for this hypothesis:

- "Little did I know how difficult it is to be an effective science teacher and a successful graduate student at the same time... I don't wanna fail my class…" (Saka, Southerland, Kittleson, & Hunter, 2013, p. 1231);
- "I was probably firing off 80 to 85 hours a week at the school…" (Schaefer, Downey, & Clandinin, 2014, p. 18);
- "[I] ...had to go to numerous after school parent conferences for students who didn't care" (Patterson, Roehrig, & Luft, 2003, p. 18);
- "I was quite shocked to find out that teaching school has a lot more to do with moving papers than it really does with teaching students" (Ng & Peter, 2010, p. 136);
- "I sat there for six hours and listened to the other teachers argue and had no way to really input anything and couldn't have impacted the outcome of all these petty arguments…" (Ng & Peter, 2010, p. 136).

The claim by Emmerich, Rock, and Trapani (2004) that attribution of classroom events differed between math and science teachers and teachers of other subjects, may be associated with level of conscientiousness. Again, however, studies by Rockoff, Jacob, Kane, and Staiger (2008) contradict this assertion, leaving questions about

personality differences between math and science teachers and teachers of other subjects for future research.

Last, Ingersoll and May (2010) identified three predictors of math and science teacher attrition, i) frequency of student discipline problems ii) extent of professional development in classroom management, and iii) effectiveness of subject-area professional development. Evidence alluding to discipline problems are somewhat apparent in this analysis, for example,

- "there's 180 days in the school year and when day one starts and they all come barreling down the hallway and bust through your door and they're basically like 'We're yours. You've got to deal with us every day.' ... like, for the next 180 days it feels like just one big long day... that you're waiting to end" (Schaefer, Downey, & Clandinin, 2014, p. 20);
- "motivating through fear... To some degree...I almost live two separate realities… Authoritarian power is overrated - it is so lonely at the top. Controlling by fear only works for so long, and, quite frankly, it does not fit my personality" (Ng & Peter, 2010, p. 137).

Evidence related to effectiveness of subject-area professional development, however, was not apparent in this analysis, except tangentially in quotes such as "Small school numbers mean teachers have to be prepared to teach outside their subject area. Some teachers are not prepared to do this" (Handal, Watson, Petocz, & Maher, 2013, p. 20).

Conclusion

The analysis provided in this study suggests cognitive errors are part of the decision-making process of those math and science teachers who decide to quit teaching. Moreover, there is some research to show that CBT is effective for ameliorating cognitive errors to reduce teacher attrition (Anderson, 2000; Cooley & Yovanoff, 1996; Ebert et al., 2014; Flook, Goldberg, Pinger, Bonus, & Davidson, 2013). Even though studies involving educators and CBT are not specifically focused on reducing the number of math and science teachers who quit, it corroborates the overall efficacy of CBT, which has also been successfully applied as an intervention in professions other than teaching (Cracsner & Mogosan, 2015; George & George, 1995; Hutchins, 2015; Yavuzer, 2015).

Nevertheless, research focused on reducing math and science teacher attrition using CBT is undeveloped. One reason for this is the notion that producing more math and science teachers to fill vacancies is the primary way to resolve math and science teacher shortages. This perspective is understandable for several reasons. Each year there are a large number of math and science teacher vacancies that must be filled. Reasons for math and science teacher attrition are stated in general terms, terms which are useful for policy development, but not necessarily for retention efforts. Studies dealing with math and science teacher attrition is somewhat indistinguishable from attrition of teachers of other subjects and at other levels. Research attempting to show that math and science teachers differ in some way from those who do not teach these subjects is inconclusive. Last, various interventions used to reduce attrition have shown modest success. At any rate, attempts to fill math and science teacher vacancies by increasing supply has proven insufficient. Resolving shortages of math and science

teachers involves efforts to improve retention.

Recommendations

The conclusions provided have limited generalizability and reliability due to the small number of direct quotes available for analysis and complexity of associating quotes with cognitive errors. Nevertheless, the findings provide direction for future studies in the area of retention. For example, researchers might incorporate CBT training with math and science teachers during preservice and in-service teacher induction to determine any effect on attrition rates. Similarly, researchers might examine the effects of CBT as an intervention to reduce attrition among veteran math and science teachers who are dissatisfied and contemplating quitting. Several instruments are available for this research, including the Cognitive Distortion Scales, Cognitive Distortions Questionnaire, Beck Depression Inventory, Automatic Thoughts Questionnaire, and Satisfaction With Life Scale, among others. Moreover, the Cognitive Distortions Questionnaire has shown sound psychometric properties for assessing the frequency and intensity of cognitive errors (Kaplan et al., 2017). In addition, there are various studies that could be adapted to include samples of math and science teachers to test the effects of CBT in training programs or as an intervention (see Cracsner & Mogosan, 2015; George & George, 1995; Yavuzer, 2015).

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