SEEKING THE INFLUENCE OF COONEY, SHEALY, AND ARVOLD'S (1998) BELIEF STRUCTURES

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Cooney, Shealy, and Arvold (1998) wrote a widely-cited paper that described four belief structures of prospective teachers and argued the structures can aid in describing the ways beliefs change and the influence of authority on the individual. In this paper, we investigate the impact of this manuscript on the field. We first conducted a literature review (n = 48) of journal articles and proceedings published since 1998 covering the same population and goals of Cooney et al. (changing prospective teachers' beliefs). We then conducted an analysis of 106 journal articles citing Cooney et al. to see why the author(s) cited the piece. We conclude the impact of Cooney, et al.'s article differs from that of their results and suggest belief structures should be more carefully investigated by the field.

Keywords: Teacher Beliefs, Affect, Emotion, Beliefs, and Attitudes

There is a long history of studies focusing on the beliefs about mathematics and mathematics teaching and learning of students, prospective teachers, and inservice teachers (Philipp, 2007). These studies have argued that being informed about the beliefs of these populations is helpful in designing appropriate interventions for shifting beliefs (Philipp et al., 2007) and evaluating the success of a teacher preparation program (Charalambous, Panaoura, & Philippou, 2009). Cooney, Shealy, and Arvold (1998) sought to understand the development of and opportunities to change prospective teachers' beliefs and the structure of their beliefs. Cooney et al. (1998) concluded with four belief structures: isolationist, naïve idealist, naïve connectionist, and reflective connectionist. Each of these described the ways the beliefs of the individual were held and could help in explaining the changes in beliefs of the individuals. "We posit the notions of naïve idealist, isolationist, and connectionist with the intent that a description of preservice teachers can enhance our understanding of the ways preservice teachers construct meanings as they progress through their teacher education programs" (Cooney et al., 1998, p. 331).

Although Cooney et al. (1998) is cited frequently in the field (382 times according to Google Scholar as of Jan. 2, 2017), we could not find many studies that used their belief structures as an explanatory tool to shifts in beliefs. Studies have shown the strength of using Cooney el al.'s belief structures: "One of the strengths of the Cooney et al. construct of belief structures is its explanatory power with respect to propensity to change and success in changing" (Conner, Edenfield, Gleason, & Ersoz, 2011, p. 501) We investigated the influence of Cooney et al.'s belief structures by reviewing literature with the same focus, changing beliefs of preservice teachers, and the ways Cooney et al. has been referenced since its publication. We provide a summary of Cooney et al.'s report followed by the methods used to investigate the influence of the article. We then present our results of both investigations and conclude by discussing future research trajectories and issues to be addressed by mathematics education researchers.

Background: Summary of Cooney, Shealy, and Arvold (1998)

Cooney et al. (1998) conceptualized their study through a constructivist perspective influenced by the cognitive and social construction of knowledge. They desired to the students in their secondary mathematics methods course to see themselves as participants in a community of mathematics educators. Cooney et al. used multiple theoretical frameworks to make sense of the

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beliefs of the prospective teachers. These frameworks helped them to consider the influence of context and reflection (Bauersfeld, 1988; Dewey, 1933), how beliefs are held (Green, 1971), and one's orientation to authority (Belenky, Clinchy, Goldberger, and Tarule, 1986; Perry, 1970). Bauersfeld (1988) provided a way to consider the sociocultural aspects within cognitive interactions with his description of how communities construct knowledge. This was important to Cooney et al.: "Because much of what an individual learns about teaching is through interactions within various communities, it seems reasonable to assume that those contexts are important influencing factors in what is learned" (1998, p. 307). Dewey (1933) aided in operationalizing reflection and how reflection influences the changes of beliefs because reflection is necessary to resolve problematic experiences. Green (1971) described the metaphor of a beliefs systems to emphasize how beliefs are held. He described three characteristics of a belief system: (a) There is a quasi-logical relationship between beliefs; (b) Beliefs are both peripheral or central and derivative or primary; and (c) Beliefs exist within clusters that are isolated from one another (thereby allowing the possibility of an individual having contradictory beliefs). Finally, Belenky et al. (1986) and Perry (1970) were "two schemes that address one's reliance on authority for knowing… These two schemes are similar in that they describe individuals who range from those for whom an authority dictates truth to those for whom truth is seen as contextual" (Cooney et al., 1998, p. 311). To Cooney and colleagues these frameworks collectively provided a way for them to investigate the beliefs about mathematics and mathematics teaching and learning of prospective teachers and gave new insight into the ways prospective teacher hold their beliefs.

Cooney et al. (1998) purposefully selected four participants from a cohort of 15 prospective secondary mathematics teachers. The cohort was in the final year of the teacher preparation program and all students were enrolled in a mathematics methods course. The participants were selected based on survey results as well as observations and assignments completed in the methods course. Each participant was interviewed 5 times during the course and student teaching, and Cooney et al. used a constant comparison procedure (Strauss, 1987) to identify themes that emerged from the data. They reported on four cases.

Based on the four cases, Cooney and colleagues described four possible belief structures: naïve idealist (characterized by uncritical acceptance of ideas presented by authority figures resulting in clusters of contradictory beliefs), isolationist (belief are held strongly and nonevidentially so contradictory ideas are rejected without reflection), and naïve or reflective connectionist (characterized by attempts to incorporate new ideas meaningfully into already present belief structure more or less critically and coherently). Cooney and colleagues end the paper with comments on the importance of considering belief structures in teacher education. "An analysis of belief structures… can provide a forum by which our teacher education programs will be better able to address issues of reform" (Cooney et al., 1998, p. 331). Cooney et al. claimed the goal of teacher education is to develop reflective connectionists, though they admit to having difficulty imagining how to do so with isolationists and naïve idealists. They call for future research to investigate these possible shifts. Based on Cooney et al.'s call to action, we sought to see how researchers had responded after 18 years.

Methodology

We set out to explore the ways Cooney et al. (1998) may have influenced the field. The first exploration entailed conducting a literature review of studies published from 1999 to 2016 with a similar focus as Cooney et al.'s investigation, changing beliefs of prospective teachers. We began by conducting searches in both ERIC and EBSCO using the words beliefs, preservice teacher, change, and mathematics, focusing on peer-reviewed hits. The initial search had over 700 hits. As we began to look through the 700 publications, we realized many of the pieces found did not match our criteria

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but instead had within the article the searched for words. To aid in focusing specifically on studies about beliefs, we choose to change the search criteria. The second time, we searched both ERIC and EBSCO databases for manuscripts with belief in the title, and including the words preservice, mathematics, and change anywhere in the text from 1999 to 2016. We repeated the searches replacing belief with conceptions and then orientation as we found these words could potentially be synonymous with beliefs. Finally, we repeated the previously mentioned searches in both databases, replacing preservice with prospective. After duplicates were removed, we had 86 peer-reviewed journal articles and proceedings. For this first part the publication was the unit of analysis. In a spreadsheet, we collected information from each publication such as: (a) author; (b) title; (c) abstract; (d) intervention described to change beliefs; (e) beliefs attempting to influence; (f) grade band of prospective teachers; and (g) did they cite Cooney et al. and if yes, then did they use belief structures as an explanatory tool. As we read through the 86 publications we found only 48 pieces fit the search criteria (empirical studies about prospective mathematics teachers' shift in beliefs). Those excluded either focused on the wrong population (e.g. students in mathematics content courses, prospective science teachers, etc.), wrong phenomenon (e.g. content knowledge) or were not empirical.

The second investigation required us to do a citation analysis similar to Leatham and Winiecke's (2014). Using a Google Scholar citation report for Cooney et al. (1998), of the 382 citations listed, we located 106 peer-reviewed English language articles. We then sought out in each article the line of text or statement that was a direct citation to Cooney et al. (1998). Four articles did not have proper citations and were excluded. For this part of the investigation, the unit of analysis was the citation instance in each article (n = 142). We used a constant comparative method (Strauss, 1987) to identify categories of the purposes of citing Cooney et al.

Results

The results of our investigation are reported in two parts. The first part focuses on the 48 manuscripts in which the authors investigated aspects of beliefs similar to Cooney et al.'s (1998) study. We then report on the citation analysis conducted. Overall, Cooney et al.'s construct of belief structures has minimally been used in the field. Two of the 102 manuscripts examined used belief structures as an explanatory mechanism for the change in beliefs of the participants. The citation analysis revealed the purpose of citing Cooney et al. (1998) was to justify claims of the impact of beliefs on teacher perspectives or practices, statements about the influences on beliefs and the difficulty in changing them or to describe how beliefs are held.

Nature of the 48 Publications on Changing Beliefs of Prospective Mathematics Teachers

Cooney et al. (1998) was focused on changing prospective mathematics teachers' beliefs about mathematics and mathematics teaching and learning. The majority of the studies (n = 29) were focused on changing the same beliefs. A number of studies, however, focused on other kinds of influential beliefs, for example, teacher efficacy, epistemological beliefs, the incorporation of a concept, skill, or philosophy (e.g. social justice), and others on specific mathematical constructs (e.g. proof). Table 1 enumerates foci of the beliefs publications. Some publications considered multiple beliefs categories, such as Charalambous et al. (2009) who investigated the change of epistemological and efficacy beliefs of prospective elementary teachers, thus the total number of pieces in the table is greater than 48.

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Table 1: Foci of Beliefs Publications

Focus	# of Pieces
Mathematics, Mathematics Teaching and Learning	29
Teacher Efficacy	8
Epistemological Beliefs about Mathematics	4
Technology Use in Mathematics Education	4
Equity/Social Justice Issues in the Mathematics Classroom	3
Proof	2
Confidence in Teaching Mathematics	2
Mathematics Teaching Incorporating Arts	1
STEM Incorporation	1
The Role of Teachers and the Learners	1
Mathematical Knowledge	1

A number of studies used beliefs to evaluate their teacher education programs (e.g. Charalambous et al., 2009). The shift of prospective teachers' beliefs toward more reform-oriented (NCTM, 2014) beliefs provided evidence of success of the content, methods, or general program. This was true for both studies focused on beliefs about mathematics and mathematics teaching and learning, and those focused on teacher efficacy and epistemology. Cooney et al. did not explicitly seek out to evaluate the teacher education program or course in which the prospective teachers were enrolled. Their focus was on the beliefs about mathematics and mathematics teaching and learning. This matched the majority of studies found.

Cooney et al. (1998) did not examine the influence of a particular intervention. Instead, the intervention was more implicit as the catalyst to change beliefs was the teacher education program itself. This can be seen as a macro level intervention because the planned intervention was at the group level. This matched the majority of the studies on prospective teachers. Table 2 lists the categories of interventions used in the 48 publications. Some studies (Philipp et al., 2007) used multiple interventions in different sections of a mathematics methods course for prospective elementary teachers. Each intervention in these cases was counted separately.

Most interventions were more at a macro level or did not intervene at an individual level. The intervention was the teacher education program or course (n = 13), a course or program with a specific philosophy informing the make-up of the course or program (n = 14), or the inclusion of a field component (n = 5). These interventions are not guided towards individuals but instead at the group of individuals. This is different from more micro or individualistic interventions like specific activities conducted in the course (n = 11), or the addition of a technology component (n = 5). These interventions were targeted to individuals to participate in the intervention. A few studies combined both micro and macro level interventions (Philipp et al., 2007).

Finally, Table 3 shows some other characteristics of the 48 publications. Out of the 48 pieces about changing beliefs of prospective mathematics teachers, the majority of the studies focused on elementary teachers (n = 38). Only three studies focused on secondary mathematics teachers, while the remaining seven had a combination of secondary and elementary teachers. The lack of secondary investigations could potentially be due to the methods used to investigate beliefs. Quantitative studies (n = 25) along with heavily quantitative mixed studies (n = 6) represented about 65% of the

publications. The use of quantitative methods requires a large number of participants. Secondary mathematics programs typically have fewer students than elementary teacher preparation programs. Additionally, research has shown prospective elementary teacher programs have a high percentage of students with negative dispositions towards mathematics (Szydlik, Szydlik, & Benson, 2003). Therefore, changing beliefs of prospective elementary teachers may seem more relevant to producing reform-oriented mathematics teachers.

Table 2: Interventions Used to Change Prospective Teachers' Beliefs

Type of Intervention (Micro/Macro)	Description of Intervention	# of Pieces
Philosophy Informing Course/Program (Macro)	Describes a theory, construct, or philosophy guiding the structure, activity, and/or goals of the course	14
Teacher Education Program (Macro)	Goal is to evaluate or see the changes incurred by the current teacher education program or course.	13
Specific Activity (Micro)	Describes a specific activity or intervention (observations during field placement, or pedagogical activity) as catalyst for change.	11
Field Component (Macro)	The addition of a field component to course	5
Technology Component (Micro)	The addition of a technological tool to the course (e.g. use of wikis, online discussion boards; online workshops)	5
Program Addition (Micro)	The addition of activities outside of courses (mentoring by experts, monthly seminar, small discussion groups, etc.)	2
Student Teaching (Macro)	Goal is to evaluate or describe the changes incurred by the student teaching experience.	2

Table 3: Characteristics of Manuscripts by Grade Level Focus of Participants

	Elementary	Secondary	Elementary & Middle	Elementary & Secondary	Not Specified
Qualitative	13	2	0	2	0
Quantitative	20	1	1	1	2
Mixed	5	0	0	1	0
Cited Cooney et al. (1998)	7	2	0	0	0
Used Belief Structures for Analysis	1	1	0	0	0

Of the 48 publications, only nine cited Cooney et al. (1998), although all publications were reporting on similar populations and phenomena. Of those nine, two studies (Conner et al., 2011; Mewborn, 2000) used belief structures as described by Cooney et al. This demonstrates the construct of beliefs structures has not been taken up by the field, at least when investigating similar phenomena. Cooney et al.'s study required multiple sources of data and deep qualitative investigation. Most of the studies found were quantitative in nature and therefore would not have the data necessary to use belief structures. If only 9 of the 48 publications cited Cooney et al., then what

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explains the 382 publications found in the Google Scholar citation report? This finding led us to conduct the citation analysis described below.

Nature of the 102 Publications Citing Cooney et al. (1998)

Following Leatham and Winiecke (2014), we conducted an analysis of the 142 citation instances collected from 102 journal articles. Using a constant comparative method (Strauss, 1987), we found eight categories reflecting the reasons Cooney et al. (1998) has been cited. In this section we briefly describe each category and provide examples. These categories represent the impact Cooney et al. has had on the field. Table 4 summarizes the primary purposes for citing Cooney et al.

Table 4: Summary of the Primary Reasons for Citing Cooney Et Al. (1998)

Reason Cited	Percent (n)
Impact of beliefs on perspective or practice of teachers	25% (n=35)
Influences on beliefs and difficulty in changing them	18% (n=25)
How beliefs are held	13% (n=18)
No mention of beliefs (content knowledge, role of teacher education, etc.)	12% (n=17)
Casual citation (no specific content of article referenced)	11% (n=15)
Potential of reflection	8% (n=12)
Methodology	8% (n=11)
Different types of beliefs exist	6% (n=9)

The most common reason for citing Cooney et al. (1998) (35 or 25%) was to support claims about the ways beliefs influence teachers' perspectives or classroom practice. These included descriptions of the general relationship between beliefs and practice and the way beliefs act like a filter when making sense of a situation. Furthermore, some publications used Cooney et al. to highlight how beliefs influence certain actions in the classroom. For example, Philipp et al. (2007) stated: "Beliefs might be thought of as dispositions toward action, having a motivational force (Cooney et al., 1998…)" (p. 450). Although, Cooney et al. discussed the impact of beliefs on teachers, the focus of their study was not on these relationships. They conjectured how beliefs structures may influence the actions of the prospective teachers, but the relationship between practice and beliefs was part of the rationale for the study.

Researchers also cited Cooney et al. (1998) to describe experiences influencing the development of beliefs of teachers (25 or 18%). Claims included the impact of context on beliefs and how the background of the individual impacts beliefs about mathematics and mathematics teaching and learning. "Beliefs tend to be context specific, arising in situations with specific features (Cooney et al., 1998)" (Philipp et al., 2007, p. 450). As before, Cooney et al. justified their work based on these conceptualizations of beliefs; these statements were not part of their results.

The next largest group of statements described how beliefs are held (18 or 13%). This is the group that is closest to the main focus of Cooney et al.'s (1998) study. Cooney and colleagues were interested in how beliefs are structured and how those structures influence prospective teachers' beliefs about mathematics and mathematics teaching and learning. These statements focused on the use of Green's (1971) metaphor of belief systems, the use of Perry's (1970) discussion about authority and knowing, and in-depth descriptions of belief structures. Discussions of Green and Perry were included in Cooney et al.'s theoretical framework, while in-depth descriptions of belief structures comprised their findings.

The next two groups cited Cooney et al. (1998), but they made no specific link to the conducted research. The category of no mention of beliefs was made up of a collection of statements that cited

suggestions or other aspects of teacher education Cooney refers too. For example, Conner et al. (2011) stated: "Cooney et al. (1998) suggest that one goal of teacher education is to help teachers become reflective connectionists" (p. 500). Many of these statements were used to back up claims about the role of teacher education, characteristics of teachers, or prospective teachers' mathematical content knowledge. The collection of casual citations (15 or 11%) cited Cooney et al. in a generic way: "Many studies have been designed to bring about changes in the conceptions of preservice and inservice teachers (e.g. Cooney, Shealy & Arvold, 1998…)" (Steele, 2001, p. 140).

Cooney et al. (1998) emphasized the importance of reflection as a way to change beliefs of prospective teachers, and this was highlighted by a number of publications (12 or 8%). Cooney et al.'s argument about reflection followed their conceptualization of beliefs and how beliefs are held. The claims made focused on the power of reflection to change beliefs or the importance of reflection in teacher education. Philipp et al. (2007) highlighted Cooney et al.'s study to stress the importance of reflection, "Researchers studying teacher education have added to our understanding of the role that reflection plays in teacher education. Cooney et al. (1998) found that…" (p. 471). Many of the researchers built on Cooney et al.'s conceptualization of reflection's role in changing beliefs.

The final two categories cited Cooney et al. (1998), usually in a list of other researchers, either to justify or describe the chosen methods (11 or 8%) or to emphasize the existence of different kinds of beliefs (9 or 6%). Though these are valuable contributions, neither of these reasons for citing Cooney et al. are explicitly about the results of the study.

Discussion and Conclusion

Our results show Cooney et al. (1998), although widely cited, has not significantly impacted research on changing beliefs. The most common reasons to cite Cooney et al. demonstrate the usefulness of Cooney et al.' conceptualization of beliefs and beliefs change. Cooney et al.'s belief structures, however, are minimally considered by those in the field. Only two publications (Conner et al., 2011; Mewborn, 2000) that cited Cooney et al. explicitly used belief structures as an analytical tool. A slightly bigger impact was shown by the 18 citation statements (from 14 publications) that discussed how beliefs are held. We considered statements about how beliefs change to be potentially referencing ideas close to Cooney et al.'s belief structures. The remaining 124 citations cited Cooney et al. without reference to their major results. These researchers cited Cooney et al.'s theories and interpretations of other researchers, often without clarifying their intention, rather than citing the theory resulting from the empirical results of the study. We found this to be problematic. Depending on the citation statement, Cooney et al. could be seen as either a study about the relationship between beliefs and practice, a study about prospective teachers' content knowledge, or a study about the role of teacher education.

Cooney et al.'s conceptualization of belief structures and the studies that explicitly use beliefs structures suggest more focus on beliefs structures could be a powerful direction for future research. Our review of 48 peer-reviewed publications addressing beliefs change in prospective teachers demonstrated that trends in research on changing prospective teachers' beliefs aligns with Cooney et al.'s (1998) chosen intervention and focus on beliefs about mathematics and mathematics teaching and learning. Studies examining beliefs and beliefs change have established that while change is slow, it can happen. However, little is known about why and how beliefs change. That is, researchers have established that reflection and particular interventions within coursework and field experiences can promote change, but little is known about the mechanisms for that change. Cooney et al.'s beliefs structures potentially provide insight into those mechanisms for change. The use of beliefs structures as an analytical tool could move forward beliefs research by providing a deeper understanding of how beliefs shift over time. This will require the development of instruments and possible ways of collecting more pointed data for identifying the belief structures of teachers. Furthermore, specific

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interventions for different belief structures need to be developed if the goal of teacher education, as stated by Cooney et al., is to develop reflective connectionists.

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