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An Explanatory Sequential Mixed Methods Study of the School Leaders’ Role in Students’ Mathematics Achievement Through the Lens of Complexity Theory

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AN EXPLANATORY SEQUENTIAL MIXED METHODS STUDY OF THE SCHOOL LEADERS' ROLE IN STUDENTS' MATHEMATICS ACHIEVEMENT THROUGH THE LENS OF COMPLEXITY THEORY

by

Emma P. Bullock

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ABSTRACT

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by

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School leaders are expected to make decisions that will improve student mathematics achievement. School leaders make decisions in complex adaptive systems (CAS). The purpose of this study was to explore the role the school leader plays in students' mathematics achievement through the lens of complexity theory. This study employed an explanatory sequential mixed methods design to answer the research questions. The over-arching research question was: What is the school leaders' role in students' mathematics achievement? Subquestions included: (1) What characteristics of the school leader are most important in predicting students' mathematics achievement? (2) What is the relationship between students' mathematics achievement and characteristics of the school leader? (3) What relationships with stakeholders within each school influences school leaders' decisions? (4) What decisions and actions are being made by school leaders? and (5) How are school leaders' decisions and actions associated with students' mathematics achievement?

The researcher collected quantitative survey data from 158 K-12 school leaders to assess the relationship between students' mathematics achievement and characteristics of the school leader. The researcher further explored the school leaders' role qualitatively through three focus groups. The focus groups included five school leaders from schools performing higher than their demographics suggest, six school leaders from schools performing about where their demographics suggest, and six school leaders from schools performing lower than their demographics suggest. In the mixed analysis phase, the researcher utilized a complex array of quantitative and qualitative data analysis procedures to draw meta-inferences.

The researcher found a significant regression equation predicting the school-wide average SAGE mathematics proficiency scores based on several characteristics of the school leader and student demographics. Distinctive patterns emerged in the decisions and actions made by school leaders based on school-wide SAGE mathematics proficiency. Results suggest that the school leaders' first role in promoting higher student mathematics achievement is to directly and indirectly facilitate a shared vision of mathematics education between stakeholders in the CAS. The school leader's second role is to actively work to recruit and retain the highest quality teachers possible.

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PUBLIC ABSTRACT

An Explanatory Sequential Mixed Methods Study of the School Leaders' Role in Students' Mathematics Achievement Through the Lens of Complexity Theory

Emma P. Bullock

School leaders are expected to make decisions that improve student mathematics achievement. However, one difficulty for school leaders has been the limited amount of research concerning content-specific (e.g., mathematics) school leadership and its effects on student achievement. School leaders do not make decisions in isolation; rather, they make decisions as part of a complex adaptive system (CAS), as proposed by complexity theory. The purpose of this study was to explore the role the school leader plays in students' mathematics achievement through the lens of complexity theory.

The researcher collected survey data from K-12 school leaders and conducted focus group interviews to answer the research questions. The researcher found a significant regression equation predicting the school-wide average SAGE mathematics proficiency scores based on several characteristics of the school leader and student demographics. Distinctive patterns emerged in the decisions and actions made by school leaders based on school-wide SAGE mathematics proficiency. Results suggest that the school leaders' first role in promoting higher student mathematics achievement is to directly and indirectly facilitate a shared vision of mathematics education between stakeholders in the CAS. The school leader's second role is to actively work to recruit and retain the highest quality teachers possible.

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Emma P. Bullock

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CHAPTER I

INTRODUCTION

> *In* ***human relations****, this is obvious: I* never *react to you but to* ***you-plus-me****; or to be more accurate, it is* ***I-plus-you*** *reacting to* ***you-plus-me****. 'I' can never* influence *'you' because you have* already influenced me*; that is, in the very process of meeting, by the very process of meeting,* we *BOTH* become something ***different****. It is I plus* ***the-interweaving-between-you-and-me*** *meeting you plus* ***the-interweaving-between-you-and-me****, etc., etc. If we were doing it mathematically we would work it out to the* nth *power.* (Follett, 1924, pp. 62-63; Graham, 1995, p. 42; Jörg, 2016, p. 72)

School leaders/principal's (hereafter just school leader) are expected to make decisions that will measurably and, in some cases dramatically, improve student achievement in mathematics. However, one of the difficulties for school leaders has been the limited amount of research concerning content-specific (e.g., mathematics) school leadership and its effects on student achievement. School leaders do not make decisions in isolation; rather, they make decisions as part of a complex adaptive system (CAS). Educational institutions, such as schools, represent CASs made up of individual stakeholders whose everyday decisions influence all other stakeholders in meaningful ways. As such, a school leader will be influenced by the agency, or interactions, among different stakeholders and, in turn, the school leader will directly and indirectly influence others. This study focuses on three aspects of the school leader: (1) the relationships between students' mathematics achievement and the characteristics of school leaders and their students' demographics, (2) the influences affecting the decisions and actions being made by school leaders, and (3) how school leaders' decisions and actions are associated with students' mathematics achievement. By viewing the school as a CAS, the purpose of this study is to pragmatically examine the school leaders' role in students' mathematics achievement in the context of complexity theory.

Background of the Problem

The study of leadership dates back to ancient times (Bass, 1981) and theories of leadership continue to multiply (Northouse, 2016). When considering school leadership, Marzano (2003) found that whether or not a school operated effectively impacted students' chances of academic success such that students in effective schools had a 44% difference in their expected passing rates on standardized exams. Thus, school leaders have an interest in understanding how to help a school operate effectively towards specific goals. However, most research examining the influence of the school leader has sought to isolate the school leader as a variable using traditional linear and/or multiple regression techniques that do not take into consideration the dynamic influences felt by a school leader (Bartholomew-Mabry, 2005; Batchelder & Christian, 2000; Shin & Slater, 2010; Uswatte, 2013). School leaders do not work in isolation, so by considering them in isolation to other stakeholders, prior research presents an incomplete picture. A situated, pragmatic research approach is called for in which a school is considered as a complete organism; and, of which the school leader is but one part, such as that proposed by complexity theory.

In complexity theory, a CAS is "an assemblage or combination of things or parts forming a complex or unitary whole" ("System [Def. 1]," 2015) that demonstrates an additional distinctive property called emergence. Emergence is a form of collaboration in which the collective actions of the complex system in its entirety are more than the sum of the actions of its parts (Holland, 2014). An example of an emergent property would be the "school culture" associated with an aggregate of stakeholders (i.e., students, parents, teachers, school leaders, etc.) in an educational institution (hereafter referred to as a school). It is difficult and unreasonable to assign "school culture" to an individual stakeholder. It is only when the stakeholders work in aggregate that school culture emerges as a property of a school. This nonlinearity of emergent properties leads to the necessity of hierarchical levels of organization to define the properties themselves. Thus, complexity theory addresses the challenges associated with understanding complex systems, their emergent properties, and hierarchical levels of organization with the purpose to guide the complex system towards some desired end, or goal (Davis & Sumara, 2008; Uhl-Bien & McKelvey, 2007). By considering a school as a CAS, and higher student mathematics achievement as a result of an emergent property, a more complete picture of the problem can be generated that provides a pragmatic analysis of what it takes to improve students' mathematics achievement. As school leaders seek to promote students' mathematics achievement, understanding how to move a complex organization, such as a school, towards a goal through a shared vision of mathematics education, becomes imperative to success. In this way, complexity theory allows researchers to answer questions that would otherwise remain unapproachable. Therefore, in this study, due to the emergent properties of the hierarchical system that is a school, the researcher was able to pragmatically explore how school leaders' actions towards various stakeholders may be associated with students' mathematics achievement.

Problem Statement

The purpose of this study was to explore the role the school leader plays in students' mathematics achievement through the lens of complexity theory. By so doing, the researcher developed a conceptual framework that can be used to guide future content-specific leadership research in schools and provided pragmatic suggestions to school leaders as to how they may most effectively lead their respective schools towards higher student mathematics achievement. A large corpus of research exists on the general influence of leadership in schools (Kliebard, 2004; Marzano, Waters, & McNulty, 2005). Generally, this large corpus of research shows that school leadership has a substantial effect on student achievement. There is also a growing body of quantitative research into the role school leaders play into specifically promoting and influencing student mathematics achievement (Heck & Hallinger, 2009; Shin & Slater, 2010). Generally, this growing body of research shows that school leaders directly influence aspects such as teacher efficacy and satisfaction, school culture, teacher professional development, and teacher collaboration practices and that these indirectly influence student mathematics achievement. However, very little research has focused on examining the problem of understanding the reasoning behind the relationships found in recent quantitative studies; particularly through the lens of complexity theory, in which a school is viewed as a CAS (Bower, 2006). Additionally, the relatively new research based on the role of school leaders on students' mathematics achievement is primarily quantitative, with few qualitative and mixed methods studies (Lemons, 2012; Schoen, 2010). This shows that more research, particularly research using qualitative and mixed methods, is needed to understand the role school leaders play in students' mathematics achievement; such as, understanding the reasons decisions are made by school leaders that influence the allocation of resources within a CAS.

Significance of the Study

This study serves to inform future research on aspects of school leadership and mathematics education, including the use of the *School Leadership in a Complex Adaptive System (SL-CAS) Framework,* to understand the role school leaders play in students' mathematics achievement. This study is significant because school systems are being held increasingly accountable for students' mathematics achievement. School leaders and researchers need to understand how to make decisions that promote the most effective use of resources within the complex realities that exist in schools to achieve higher mathematics achievement for all students. The knowledge gained from this study will give direction to researchers and school leaders on the nature of complex adaptive school systems and address pragmatically the understanding of the school leaders' actions to effectively move a CAS toward a shared vision of mathematics education which promotes higher student mathematics achievement.

Research Questions

This mixed methods study included the collection of quantitative and qualitative data to answer the research questions.

Over-Arching Research Question

What is the school leaders' role in students' mathematics achievement in the context of Complexity Theory?

Sub Questions

1. What characteristics of the school leader are most important in predicting students' mathematics achievement?
2. What is the relationship between students' mathematics achievement and characteristics of the school leader?
3. What relationships with stakeholders in the schools influence school leaders' decisions?
4. What decisions and actions are being made by school leaders?
5. How are school leaders' decisions and actions associated with students' mathematics achievement?

Summary of Research Design

This research study employed an explanatory sequential mixed methods design (Creswell & Plano Clark, 2011) and it involved collecting quantitative data first. In the quantitative data collection phase of the study, the researcher collected survey data over the course of two months from 158 K-12 traditional public and charter school leaders in Utah to assess the relationship between students' mathematics achievement and characteristics of the school leader.

The qualitative data collection phase also took two months. In this phase, the researcher explored the school leaders' role through three focus groups consisting of 5-6 school leaders each. The focus groups included 15 school leaders from schools performing higher than their demographics would suggest, school leaders from schools performing about where their demographics would suggest, and school leaders from schools performing lower than their demographics would suggest.

In the mixed methods analysis phase, the researcher iteratively analyzed the quantitative and qualitative data to help explain the results. In this phase, the researcher utilized a complex array of data analysis procedures including Random Forests and variable importance plots (Breiman, 2001; Ho, 1995, 2002; Liaw & Wiener, 2002), model assumption and preliminary correlation analysis (Cramer, 1998; Cramer & Howitt, 2004; Doane & Seward, 2011; Razali & Wah, 2011; Shapiro & Wilk, 1965), network analysis (Wasserman & Faust, 1994), initial regression model development and post-hoc regression analysis, as proposed by Gilstrap (2013), constant comparative analysis (Creswell, 2013) and connected data analysis (Creswell & Plano Clark, 2011). The researcher used these methods to draw meta-inferences through the comparison of traditional quantitative and qualitative analytic methods combined with the more complexity-theory-aligned network and post-hoc regression methods (Tashakkori & Teddlie, 2008).

Assumptions and Scope of Study

The researcher made several assumptions at the onset of this study. First, this study was limited to the K-12 public schools in Utah and the school leaders who responded to the invitation to complete the *Principals Mathematics Questionnaire* during the timeframe allowed. The scope of the study was limited by the characteristics of school leaders employed in the state of Utah. Traditional public school districts and public charter schools, for a variety of reasons, hire school leaders with differing characteristics. It was also assumed that the focus-group participants would talk candidly with each other about promoting students' mathematics achievement.

Definition of Terms

Agents: Individual stakeholders that can learn and adapt in response to interactions with other stakeholders of a complex adaptive school system.

Agency: The interactions between individual stakeholders.

Chaotic behavior: A specific kind of process from which a level of organization and order emerges that is difficult to discern and impossible to measure precisely for long-term prediction (E. S. Johnson, 2008)

Chaos theory: A mathematical theory that deals with seemingly minor details that sometimes have major impacts on larger complex systems.

Complexity theory: A scientific theory that deals with complex systems that all have the following properties: (1) they self-organize into patterns, (2) they engage in chaotic behavior, (3) they demonstrate 'fat-tailed' behavior, where occasional events occur much more often than would be predicted by a normal bell-curve distribution, and (4) they display adaptive interactions.

Complex system: "An assemblage or combination of things or parts forming a complex or unitary whole" ("System [Def. 1]," 2015) that demonstrates an additional distinctive property called emergence.

Complex adaptive system: A complex system in which individual agents of the system are not fixed. In other words, these individual agents can learn and adapt in response to interactions with other agents of the complex system.

Emergence: A form of collaboration in which the collective actions of the complex system in its entirety is more than the sum of the actions of its parts (Holland, 2014).

Internal units of operating chaotic systems: Groups of stakeholder specialists from which a level of organization and order emerges.

Lever points: Small causes, or actions, made by stakeholders that have disproportionate, yet predictable effects on aggregate behavior.

Shared vision: A process of facilitating, through effective communication, a compelling perspective that inspires and guides stakeholder's behavior by helping other stakeholders visualize positive outcomes (J. Johnson, 2013; Vale et al., 2010).

CHAPTER II

LITERATURE REVIEW

Three areas of literature influenced the design and implementation of this study: complexity theory, the general influence of leadership, and the role school leaders' play in promoting and influencing student mathematics achievement. Presented in this literature review is salient research in each area.

Complexity Theory

What is Complexity and How Does It Relate to This Study?

The word complexity originally was a noun meaning objects with many interconnected parts (Holland, 2014). Today complexity designates a diverse scientific field that studies complex systems (Holland, 2014). There are many ways to think about systems. One definition of a system is "an assemblage or combination of things or parts forming a complex or unitary whole" ("System [Def. 1]," 2015). A complex system demonstrates an additional distinctive property called emergence. Emergence is a form of collaboration in which the collective actions of the complex system in its entirety is more than the sum of the actions of its parts. Because of this, an emergent property is nonlinear and can be difficult to define operationally. An example of an emergent property would be the 'school culture' associated with an aggregate of stakeholders (i.e., students, parents, teachers, school leaders, etc.) in an educational institution, (hereafter referred to as a school). It is difficult and unreasonable to assign school culture to an individual stakeholder. It is only when the stakeholders work in aggregate that school culture is emerges and is perceived as a property of a school.

This non-linearity of emergent properties leads to the necessity of hierarchical levels of organization in order to define the properties themselves. For example, without the lower level of the stakeholders in aggregate, it becomes futile to define ‘school culture’. It is only at the higher hierarchical level of organization, found when stakeholders combine to become a school, that the property of school culture emerges. Thus, complexity theory attempts to describe the challenges associated with understanding complex systems, their emergent properties, and hierarchical levels of organization with the purpose to attain some ability to guide the complex system toward some desired end. In this way, complexity theory allows researchers to answer questions that would otherwise remain unapproachable. The idea of complexity was important to this study because school leaders work within a complex school system. In trying to lead schools towards any desired goal, such as greater student mathematics achievement, school leaders must understand the role they play as one part of the whole so they can most effectively focus their time and efforts.

Behaviors of Complex Systems

Due to the emergent properties of complex systems, all complex systems exhibit common behaviors (Davis, Phelps, & Wells, 2004; Davis & Sumara, 2008; Holland, 2014). First, complex systems self-organize into patterns, as occurs with groups of students, same grade level teachers, or parent organizations in school environments. Second, complex systems engage in chaotic behavior in which small decisions by individuals (e.g. implementation of an instructional strategy to meet the needs of an individual student) produce measurable later changes (e.g., implementation of the same strategy school-wide after positive results). Third, complex systems demonstrate ‘fat-tailed’ behavior, where occasional events (e.g., adoption of new mathematics standards) occur much more often than would be predicted by a normal bell-curve distribution. Fourth, complex systems display adaptive interactions, where interacting stakeholders adjust their strategies in different ways as they gain experience. Behaviors of complex systems play an integral role in this study because schools demonstrate all the common elements of a complex system. Thus, to understand pragmatically how school leaders can best guide a school towards a goal, such as higher student mathematics achievement, researchers must consider a school as a complex system.

Two Types of Complex Systems

There are two types of complex systems found in the literature: complex physical systems (CPS) and complex adaptive systems (CAS). The main difference is that CPS have individual elements of the system which are unchangeable, or fixed (such as Von Neumann’s (1956) self-reproducing machines), while CAS have individual elements of the system that are not fixed. In other words, these individual elements can learn and adapt in response to interactions with other elements of the complex system. The literature usually refers to these elements as agents (Holland, 2014; Jäppinen, 2014; Mason, 2008; Stanley, 2006). Schools would fit under the CAS classification due to the regular change in the individual agents of the complex system. This idea of elements of the complex system as agents contributes to the concept of agency (Davis et al., 2004). It is through the interactions of the individual agents, or agency, that complex emergence occurs. For the purposes of this study, I will use the term stakeholders as a replacement for elements, or agents, since the CAS in question is a school. The advantage of considering a school as a CAS is that this allows researchers to explore pragmatically a deep understanding of the agency, or interactions, between individual stakeholders.

Because individual stakeholders of a CAS, such as a school, are in a constant state of change (i.e., student mobility, faculty and staff movement, parental involvement, etc.), it is impossible to expect every stakeholder to converge upon a single ‘optimal’ strategy for almost any decision-making process. As stakeholders interact with each other, adapt, and correspondingly change (e.g. utilize agency), new ideas about decision-making processes will usually emerge. This type of complex feedback loop, in which the agency among stakeholders influences each other’s decisions make CAS difficult to analyze, or even describe (Gilstrap, 2005; Holland, 2014; Stanley, 2006). CAS are important to this study because to treat a school as anything other than a CAS fails to recognize the contextual realities in which school leaders are placed (Koopmans & Stamovlasis, 2016). Researchers have a better, pragmatic understanding of the school leaders’ role in students’ mathematics achievement when considering schools as CAS.

Analysis of Complex Adaptive Systems

Despite the diversity that results from stakeholders continually adapting within the CAS that is a school, all well-studied CAS display what is referred to as lever points in the literature (Holland, 1995a, 1995b, 2002, 2006; Page, 2009; Resnicow & Page, 2008; Rosenau, 1997). Lever points are small causes, or actions, made by stakeholders that have disproportionate, yet predictable effects on aggregate behavior. This generated behavior on the hierarchal levels of the CAS involve a tangled network of agency between stakeholders with many loops providing feedback and the recirculation of resources both physical (e.g., curriculum materials or time appropriation for different activities) and mental (e.g., ideas presented in professional development; Alhadeff-Jones, 2013; Davis & Sumara, 2008; Holland, 2006, 2014; Jäppinen, 2014). It then becomes a matter for network analysis to identify the possible IF-THEN conditions that characterize the influence among the stakeholders on each other (Holland, 2014; Koopmans, 2014).

In addition, because society-based organization extends both downward (i.e., grade-specific or subject-specific teaching teams) and upward (i.e., the district office and/or local school board) from the level of school organization, analysis can examine the diversity, or specialization, found at different levels of hierarchy and their influences on each other. In other words, groups of stakeholder specialists at different levels of hierarchy can be can be thought of as lever points. As such, another way to think of these groups of stakeholder specialists is as internal or external units of operating chaotic systems (Gilstrap, 2005; Holland, 2006, 2014).

Chaos theory and operating chaotic systems. Chaos represents a specific kind of process from which a level of organization and order emerges that is difficult to discern and impossible to measure precisely for long-term prediction (E. S. Johnson, 2008). In other words, chaos deals with seemingly minor details that sometimes have major impacts on larger complex systems. Three properties are found in chaotic systems: nonlinearity (as discussed before, this means the sum of the whole may be more than the sum of the parts), they are deterministic (i.e., given the exact same initial conditions, they are predictable), and they display sensitivity to initial conditions (e.g., student demographics at a particular school; Gilstrap, 2005; Smith, 2007). In CAS, chaotic systems can exist simultaneously and pluralistically (Gilstrap, 2005). Thus, in considering a school as a CAS, it is possible to model groups of stakeholder specialists as internal and external units of operating chaotic systems.

Identifying the initial conditions that are most important. In modeling a CAS, there are hundreds, if not thousands, or millions, of independent variables to consider. Within this understanding, it becomes necessary to identify which initial conditions are salient to understanding the problem at hand. Quantitative data mining techniques utilizing decision trees can allow researchers to filter through the complex landscape of influences and focus on what is most important (Breiman, 2001; Ho, 1995, 2002; Liaw & Wiener, 2002).

Network analysis, multiple regression analysis, and post-hoc regression analysis. Using network analysis (Marion & Schreiber, 2016; Wasserman & Faust, 1994), multiple regression analysis, and post-hoc regression analysis (Gilstrap, 2013), it becomes possible to make predictions about a CAS. This then allows stakeholders to consider the effect of the movement (i.e., changes made by various stakeholders) towards a collective goal, such as student mathematics achievement (Jordan, 2010; Mowat & Davis, 2010), or trajectory, described by Dewey as events with meaning (Osberg, Biesta, & Cilliers, 2008). Dewey (1998) discussed the importance of educators looking far into the future with respect to viewing every present experience of the child with an eye towards future experiences. Applying this concept to a CAS, it becomes the object for stakeholders (such as a school leader) to influence the movement of the CAS (i.e., school) through the agency, or complex emergence (i.e., interactions), of the stakeholders the trajectory (i.e., higher student mathematics achievement).

Empirical Research using Complexity Theory as a Theoretical Framework

There is very little empirical research applying complexity theory to school leadership at the level of the school as an organization. Empirical studies utilizing complexity theory in educational settings have only been found in recent publications. In the past few years, complexity theory has been used to investigate daily high school attendance data (Koopmans, 2016), identify nonlinear dynamical interaction patterns in collaborative groups (Stamovlasis, 2016), investigate teacher-student interactions (Pennings & Mainhard, 2016), and study the effectiveness of a science and technology educational intervention (van Vondel, Steenbeck, van Dijk, & van Geert, 2016). Bower (2006) conducted a qualitative phenomenological study that examined the experiences of the faculty of one middle school through the lens of complexity theory. The purpose of the study was to better understand the phenomena of self-organization and its role in sustaining school improvement. Bower used complexity theory to frame the study by classifying sustained school improvement as an emergent property from within a school. He made this distinction due to the recognition that the core processes of principles, philosophy, and values (i.e., a shared vision) influenced processes like feedback, communication, dialogue, sense making, and relationships leading to the emergent ownerships, renewal, creativity, safe and trusting atmosphere, engagement, and self-organization needed to make sustained improvement possible. Researcher found indirect influences of the school leader on individuals and collective groups of teachers to be important to sustaining reform efforts and improvement. Researchers reported a continual feedback loop between the school leader's actions with staff, the concept of shared leadership, the collective actions of the faculty, and sustained results. Further results suggested the dynamics of self-organization needed collective leadership that focused on collective ownership to sustain improvements over time.

While not addressing complexity theory explicitly, Higgins and Bonne (2011), in their two-year case study, examined how and why four leadership functions were enacted in an elementary school with a particular focus on hierarchical and heterarchical configurations of leadership. They found the influences felt between hierarchical and heterarchical levels strengthened the school's work towards sustaining reform efforts in promoting the teaching and achievement of mathematics. This investigation into the influences between different stakeholders acknowledged the complexities of school leadership and thus has application to this literature.

In two recent books, while Davis and Sumara (2008) and Uhl-Bien and Marion (2008) discuss the theoretical applications to, and suggest methodological approaches for, the use of complexity to school leadership and education research, the actual research implementation of the ideas discussed is negligible to nonexistent. Thus, additional research is warranted on complexity theory in educational settings using mixed methods, and with regards to school leadership specifically.

Influence of Leadership

"After decades of dissonance, leadership scholars agree on one thing: They can't come up with a common definition for leadership" Peter G. Northouse (2016, p. 5).

Despite the quote just stated, several components are found in the literature as essential to the phenomena of leadership: (a) leadership is a process, (b) leadership involves influence, (c) leadership occurs in groups, and (d) leadership involves common goals (Northouse, 2016). It is beyond the scope of this study to review all the literature on leadership. Rather, this section of the literature review will focus on leadership theories and empirical research that conforms with the ideas and principles found in Complexity Theory. As such, this section presents salient research on the following areas: the historical influence of the school leader, adaptive leadership, and shared vision.

The Historical Influence of the School Leader

Leadership is vital to the effectiveness of a school and recent research has shown that school leadership affects student achievement. Leithwood, Louis, Anderson and Wahlstom (2004) concluded that the school leader was second only to the classroom teacher among school-related factors affecting school achievement with a quarter of the school effects on student achievement attributed to the direct and indirect effects of the school leader. Likewise, Marzano et al. (2005) in their meta-analysis of 35 years of research indicated that school leadership has a substantial effect on student achievement.

Leadership Theories and Ideologies

Many leadership theories such as transformational and transactional leadership

(Burns, 1978), service leadership (Greenleaf, 1970, 1977), situational leadership (Blanchard & Hersey, 1996), and instructional leadership (W. F. Smith & Andrews, 1989) emerged with respect to schools starting in the 1970s. Historically, we see that school leaders have only recently been valued as foundational for school improvement. During the nearly century long dominance of the social efficiency school paradigm, school leaders were seen more as managers of the factory model than as facilitators of educational achievement (Kliebard, 2004). However, Marzano et al. (2005) concluded that school leader knowledge of curriculum, instruction, and assessment was the most important factor in enacting reform measures in schools. The historical influence of the school leader informs this research study by allowing the researcher to focus through the lens of the school leader as a way to improve student mathematics achievement. While many stakeholders play significant roles in student mathematics achievement, by focusing the lens on the school leader, other stakeholders may be more effectively supported in their efforts, thus allowing the CAS to move more efficiently towards the desired goal.

Adaptive Leadership

One of the most recent leadership theories to emerge in the literature is adaptive leadership. Adaptive leadership focuses on how leaders encourage people to adapt in the face of real-world problems, challenges, and changes. In his influential book, *Leadership Without Easy Answers*, Heifetz (1994) explained how leaders inspire effective change across multiple hierarchical levels, including self, organizational, community, and societal. The development of the adaptive leadership framework conceptualizes the leader as one who facilitates and mobilizes people to face difficult real-world challenges by providing them with the time and resources necessary to adapt and learn new ways of dealing with change (Heifetz, 1994; Heifetz, Grashow, & Linsky, 2009; Heifetz & Laurie, 1997; Heifetz & Linsky, 2002; Heifetz & Sinder, 1988). This theory of leadership is more follower centered and focuses primarily on the behaviors of leaders (i.e., agency) rather than the characteristics of leaders. Furthermore, adaptive leadership theory concerns itself with how leaders help others explore and change their values to address and resolve changes that are central to their lives. Conceptually, adaptive leadership theory incorporates ideas from four different viewpoints: the systems, biological, service orientation, and psychotherapy perspectives (Heifetz, 1994). The systems perspective assumes many problems are embedded in complicated interactive systems that can evolve and change over time. The biological perspective recognizes that people develop and evolve as they adapt to changes in internal and external environments. The service orientation has the leader using his or her expertise, or authority, to serve others in diagnosing and prescribing possible solutions to emerging problems. The psychotherapy perspective asserts that leaders understand people need supportive environments in which to adapt more successfully when faced with difficult problems.

Furthermore, adaptive leadership is conceptualized as a subset of complexity leadership theory (Uhl-Bien & McKelvey, 2007). Within this framework, Uhl-Bien and McKelvey describe adaptive leadership as a dynamic process that originates in the tensions inherent when people struggle over conflicting needs, ideas and preferences. Therefore, leadership is not conceptualized as a specific person or a specific act but as a process of influences (i.e., agency) between many people (i.e., stakeholders in a school). Thus, the theory of adaptive leadership informs this study by allowing the researcher to consider the dynamic influences of stakeholders on each other as they work towards increases in student mathematics achievement in a more pragmatic, contextual manner than would otherwise be possible with other theories of leadership.

Northouse (2016) summarizes several strengths of adaptive leadership identified in the literature. First, this type of leadership takes a process approach to the study of leadership, in that it recognizes leadership as a series of complex interactional events between stakeholders. Second, it is follower centered, meaning leadership is directed at stakeholder involvement and growth. Third, adaptive leadership is unique in directing attention to the use of leadership in helping stakeholders deal with conflicting values that emerge in social contexts. Fourth, it provides a practical and useful prescriptive approach to leadership by suggesting stakeholders should learn to adapt and leaders should provide an environment in which that is most likely to occur. Finally, it identifies the importance of a leader in creating an atmosphere (physically, virtually, or relationally) were stakeholders feel safe to tackle difficult issues.

The main weakness of adaptive leadership is the absence of almost any empirical research conducted to test its claims. While Heifetz (1994) originally conceptualized adaptive leadership over 20 years ago, without evidence-based support for the theory, the ideas and principles must be viewed as tentative, at best. Thus, empirical research is greatly needed to test the claims made by adaptive leadership theory. Hence, this study tested the claims made by adaptive leadership theory, through the broader lens of

Complexity Theory, while considering a school as a CAS and offer original research to address the lack of empirical evidence.

Shared Vision

The concept of a shared vision has its roots in transformational leadership theory and research. Kouzes and Posner (1987, 2002) identified the concept of a shared vision as one of the five fundamental practices that empower leaders to achieve their goals. A shared vision occurs when leaders create a compelling perspective that inspires and guides stakeholder’s behavior. This is done through a process of visualizing positive outcomes and communicating them effectively to other stakeholders (J. Johnson, 2013; Vale et al., 2010).

In a similar vein, the concepts of shared, or distributed leadership, emerge from the complexities of adaptive leadership and the creation of a shared vision. In the context of Complexity Theory, shared leadership occurs when stakeholders in a CAS take on leadership behaviors (agency) to influence and maximize the effectiveness of the whole (i.e., school; Northouse, 2016). Thus, stakeholders share influence in the creation of the shared vision.

Eriksen and Cunliffe (2010) argued that leading is a relational activity, embedded within leaders’ everyday interactions (agency) and conversations. This idea of relational leadership, while not connected explicitly in the literature to the concept of shared vision, creates a way in which to envision how a leader may use their agency to effectively communicate a shared vision in such a way that it becomes an emergent property of the CAS. Through a process of positive feedback loops (Svyantek & Brown, 2000), a leader can capitalize on the relationships in a CAS (such as school) to guide stakeholders towards that shared vision. This in turn allows a revolutionary reconstruction (McClellan, 2010) of the school towards a common goal (e.g. improved student mathematics achievement). As such, shared vision was an integral part of this study in modelling a school as a CAS.

Role School Leaders Play in Promoting and Influencing Student Mathematics Achievement

Researchers have long looked at the effects of teacher beliefs, implementation, content knowledge, curricular knowledge, etc. on student achievement in mathematics (Hiebert & Grouws, 2007; Hill, Sleep, Lewis, & Ball, 2007; Philipp, 2007; Presmeg, 2007; Stein, Remillard, & Smith, 2007). Only recently have researchers begun to look at school leaders and the direct or indirect influence they may have on student mathematics achievement (Kythreotis, Pashiardis, & Kyriakides, 2010; Williams, 2010). In particular, most of the research conducted has been primarily quantitative in nature.

Quantitative Research

Copious quantitative empirical research has been conducted on the effect of school leaders on teachers directly (i.e., teacher efficacy, teacher satisfaction, school culture, principal support, teacher collaboration, etc.; Bartholomew-Mabry, 2005; Batchelder & Christian, 2000; Shin & Slater, 2010; Uswatte, 2013) and thus student achievement indirectly (D’Agostino, 2000; Dumay, Boonen, & Van Damme, 2013; Forster, 1983). Additionally, recent quantitative studies evaluated the relationship between teacher and school leader professional development and student mathematics achievement (Amsterdam, 2001; Batchelder & Christian, 2000; Corcoran, Schwartz, & Weinstein, 2012), school leader traits and approaches and how they affect student mathematics achievement (Anderson, 2008; Nelson, 2010; Postell, 2009; Walker-Glenn, 2010). Several other studies found that when teachers were asked to whom they turned for advice on or information about mathematics instruction they were more likely to indicate a teacher leader than a school leader (Spillane, Healey, & Mesler Parise, 2009; Spillane & Kim, 2012). In their quantitative study investigating parent and community involvement with student achievement as compared to principal and teacher perceptions of stakeholder influence, Gordon and Louis (2009) found school leaders' perceptions of, and openness to, community involvement were positively associated with student mathematics achievement. In a quantitative study involving 195 elementary schools in on estate over a four-year period, Heck and Hallinger (2009) found that there were significant direct effects of distributed leadership on changes in schools' academic capacity and indirect effects on student growth rates in math. This was important to this study because this showed that school leaders do play a role in student mathematics achievement and that researchers can identify and study these indirect and direct effects.

Qualitative Research

A much smaller quantity of qualitative case studies also looked at the role of school leaders in influencing student mathematics achievement among other outcomes (Dinham, 2005; Huggins, Scheurich, & Morgan, 2011; Lemons, 2012). Carver (2010) conducted a qualitative study group research project, involving eight sessions over 5 months for secondary principals in six south-central Michigan districts, in which they identified potential leadership moves to support teacher lesson planning, lesson delivery, and attending to student thinking in middle school algebra classes. Furthermore, in his qualitative case study of four elementary school principals, Gies (2004) identified specific strategies, behaviors, and actions a school leader might implement to keep staff motivated and focused on increased student performance in mathematics computation. These included the importance of the school leader in communicating a shared vision through the review of student data with teachers. This informed this study by showing it is possible to identify characteristics and relationships between stakeholders that influence the decisions and actions made by school leaders.

Mixed Methods Research

Two mixed methods studies looked at the concept of vision with respect to school leadership and mathematics instruction (McLeod, 2008; Schoen, 2010). In particular, Mcleod explored the relationship between school leadership and middle school mathematics achievement. Results found through both descriptive and inferential analysis reported that there were important differences between principals and mathematics teachers in at-risk schools and advocated a shared leadership model in efforts to support state accountability efforts. In one other study, Gaffney and Faragher (2010) found that sustainable improvement in student achievement in numeracy requires a deliberate focus on two complementary strands of educational endeavors: the practice of effective teaching of mathematics and the exercise of high-level school leadership capabilities. These studies showed that school leaders' decisions and actions are associated with improvement in student mathematics achievement. This illuminates the need to better understand how school leaders' decisions and actions allow a shared vision to be cultivated in order to better promote student mathematics achievement.

Taken as a whole, there is a need for further empirical research on the role a school leader plays in promoting and influencing student mathematics achievement. In particular, there was a dearth of qualitative and mixed methods studies that seek to explain the reasoning behind the relationships found in recent quantitative research. This research study provides empirical results which fill this gap in the literature.

Conceptual Framework

The convergence of complexity theory, the influence of leadership, and the role of the school leader in promoting and influencing student mathematical achievement gives rise to the *School Leadership in a Complex Adaptive System (SL-CAS) Framework* (see Figure 1).

The framework is unique in that it recognizes an educational institution, or school, as a CAS (represented as a funnel; Gilstrap, 2005) containing internal units (i.e., groups of stakeholders such as teacher teams, parent organizations, and student demographics) of operating chaotic systems (represented as circles inside the funnel) in which both individual stakeholders and groups of stakeholders have agency (i.e., interactions with each other represented by two way arrows between the circles; Bruner, 1996; Jörg, 2011). This agency leads to complex emergence in which new practices and customs emerge at higher hierarchical levels of organization (Davis et al., 2004). Using the school leader as

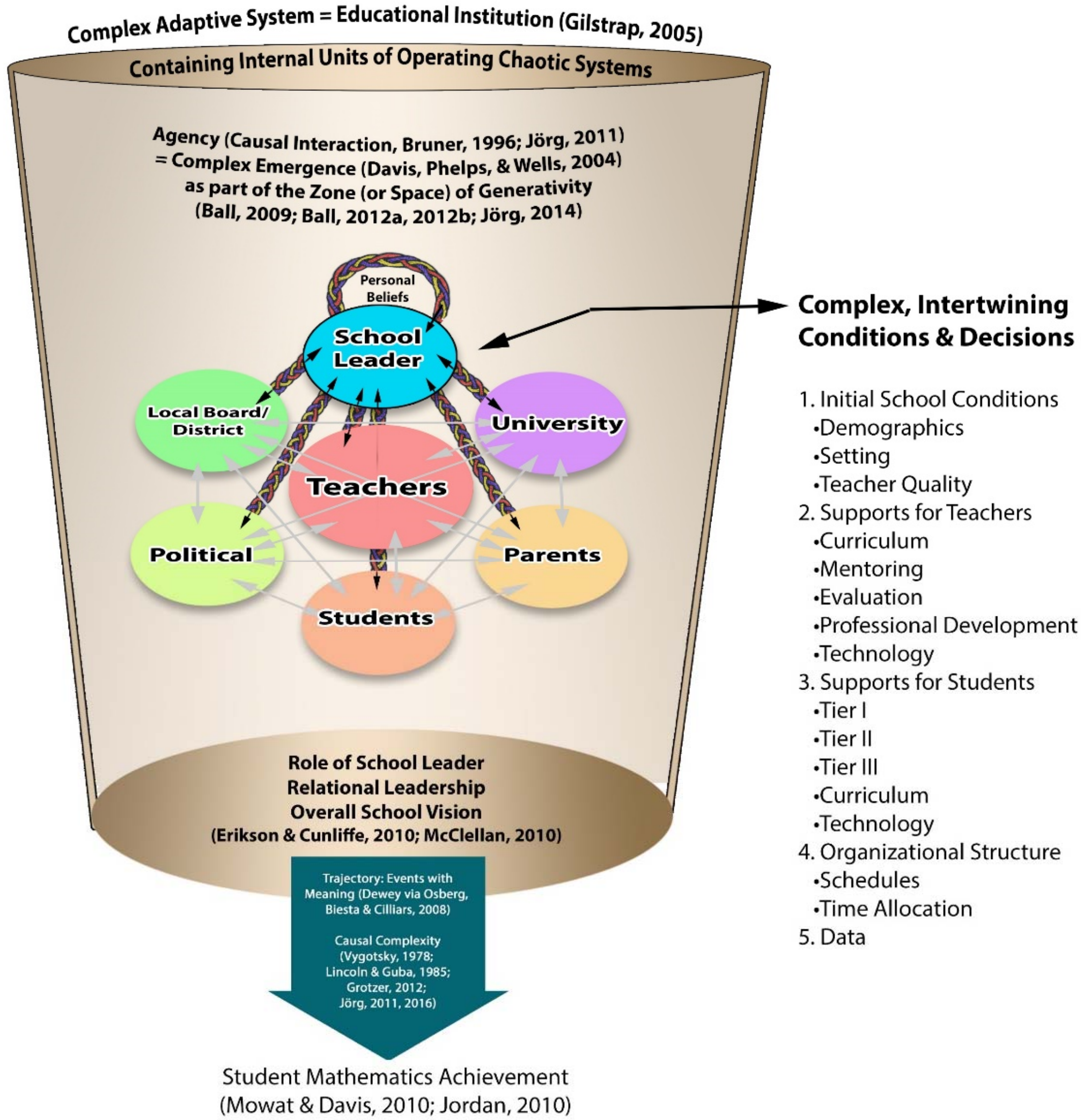

Figure 1. Conceptual framework of school leadership in a complex adaptive system (SL-CAS). This figure illustrates the dynamic organizational system known as a school with internal units of operating chaotic systems, complex feedback loops, and a school's trajectory with respect to student mathematics achievement emphasizing the role of the school leader.

a lens (represented by the darker black two way arrows and darker outlined circle), it then becomes a question of what role does school leaders' agency play in guiding the CAS towards the trajectory (i.e., the goal represented as the arrow in which the complex system is moving towards) to increase student mathematics achievement (Dewey, 1998; Eriksen & Cunliffe, 2010; Grotzer, 2012; Jörg, 2011, 2016; Lincoln & Guba, 1985; McClellan, 2010; Osberg, Biesta, & Cilliers, 2008; Vygotsky, 1978). At play is also the agency of various stakeholders with respect to initial school conditions (e.g., demographics, setting, and teacher quality), supports for teachers (e.g., curriculum, mentoring, evaluation, professional development, and technology), supports for students (e.g., Tier I, II, and II instruction, curriculum, and technology), the organizational structure of the school (e.g., schedules and time allocation), and the availability and use of data, which is represented by the complex braid twisting around the influences between various stakeholders. The influences represented combine and interact to affect the desired outcomes (Ball, 2009, 2012a, 2012b; Jörg, 2014), and must be considered to pragmatically help school leaders promote student mathematics achievement. As an emerging construct, the student leadership in a CAS framework provides a means for analyzing and interpreting the complex realities of educational institutions.

Unique Contributions of the Current Study

A large corpus of research exists on the general influence of school leadership. There is a growing body of research into the role school leaders' play into promoting and influencing student mathematics achievement. However, very little research has focused on this phenomenon through the lens of complexity theory in which a school is viewed as a CAS. Additionally, the relatively new research base on the role of school leaders on student mathematics achievement is primarily quantitative in nature, with very few qualitative and mixed methods studies. By using school leadership in a complex adaptive system framework in an explanatory sequential mixed methods design, the current research study contributes to the field by examining quantitatively relationships between school leader characteristics and students' mathematics achievement. Furthermore, the qualitative analysis in this study allows for a better understanding into what decisions are being made by school leaders that are directly or indirectly influencing students' mathematics achievement and the relationships within and without the school that influence these decisions. Finally, this study links the network of influence between stakeholders together to better understand how a school leaders' decisions and actions are associated with students' mathematics achievement.

CHAPTER III

METHODS

The purpose of this research study was to explore the role the school leader plays in students' mathematics achievement through the lens of complexity theory using an explanatory sequential mixed methods design (Creswell & Plano Clark, 2011). In the quantitative data collection phase of the study, the researcher collected survey data from K-12 traditional public and public charter school leaders throughout the state of Utah to assess whether school leader characteristics related to students' mathematics achievement. The researcher collected the quantitative data over the course of two months.

During the qualitative data collection phase, the researcher explored the school leaders' role through three focus groups consisting of 5-6 school leaders each. The focus groups included school leaders from schools performing higher than their demographics would suggest, school leaders from schools performing about where their demographics would suggest, and school leaders from schools performing lower than their demographics would suggest. The researcher collected the qualitative data over the course of 2 months.

In the mixed methods analysis phase, the researcher utilized an iterative array of data analysis procedures including random forests and variable importance plots (Breiman, 2001; Ho, 1995, 2002; Liaw & Wiener, 2002), model assumption and preliminary correlation analysis (Cramer, 1998; Cramer & Howitt, 2004; Doane & Seward, 2011; Razali & Wah, 2011; Shapiro & Wilk, 1965), network analysis

(Wasserman & Faust, 1994), initial regression model development and post-hoc regression analysis, as proposed by Gilstrap (2013), constant comparative analysis (Creswell, 2013) and connected data analysis (Creswell & Plano Clark, 2011). These methods were used to draw meta-inferences through the comparison of traditional quantitative and qualitative analytic methods combined with the more Complexity Theory-aligned network and post-hoc regression methods (Tashakkori & Teddlie, 2008). See Figure 2 for a procedural diagram of the study.

Research Questions

The over-arching research question and subquestions guiding this study were as follows.

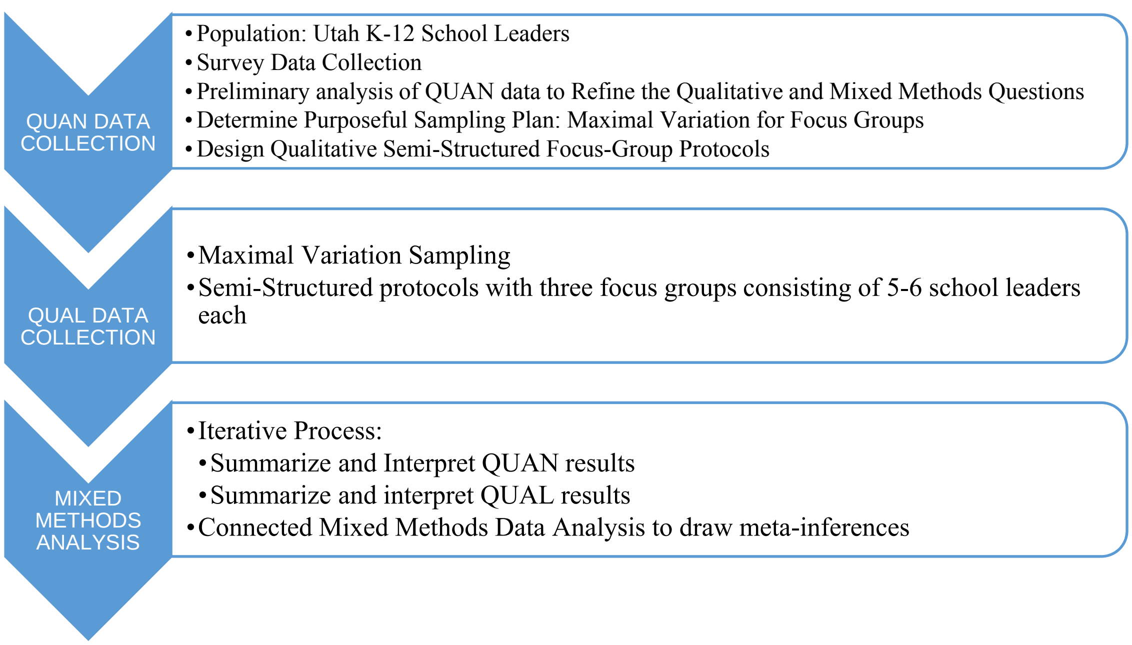

Figure 2. Explanatory sequential mixed methods design (Creswell & Plano-Clark, 2011). This figure illustrates the research design of this study.

Over-Arching Research Question

What is the school leaders' role in students' mathematics achievement in the context of Complexity Theory?

Subquestions

1. What characteristics of the school leader are most important in predicting students' mathematics achievement?
2. What is the relationship between students' mathematics achievement and characteristics of the school leader?
3. What relationships with stakeholders in the schools influence school leaders' decisions?
4. What decisions and actions are being made by school leaders?
5. How are school leaders' decisions and actions associated with students' mathematics achievement?

The following sections outline the setting, participants, procedures, data sources, instruments, and data analysis for each phase of the study.

Participants and Settings

Quantitative Data Participants and Settings

A total of 851 school leaders from 870 traditional public and public charter schools (hereafter called public schools), out of 1067 total K-12 schools in the state of Utah, were recruited to participate in the quantitative data collection phase of the study. Of these, 158 school leaders completed survey responses for an 18.6% response rate. Table 1 summarizes the school demographics information for the school leaders who participated. The state percent of ethnic minority students is 24.5%. This is in comparison

Table 1

School Demographics Represented by Survey Participants

School demographic type	Sub-type	Percent
School settings	Urban	11.4
	Suburban	37.3
	Rural	51.3
Included grades	K-4	63.3
	5-9	86.1
	10-12	26.6
Ethic minority populations (%)	0-20	70.8
	20.1-50	22.1
	> 50	7.1
English language learner (ELL) populations (%)	0-10	78.6
	10.1-25	13.6
	> 25	7.8
Low socioeconomic (low-SES) populations (%)	0-20	22.1
	20.1-50	48.7
	> 50	29.2
Special education (SpEd) populations (%)	0-10	18.8
	10.1-20	72.1
	20.1	9.1

to a 2015 Utah State Office of Education (USOE) news release in which ethnic minorities comprised 24.5% of Utah's student population, low-SES comprised 35%, SpEd comprised 11.3%, and ELL comprised 6.1% (USOE, 2015b).

Qualitative Data Participants and Settings

The researcher used purposeful sampling to identify 16 school leaders, representing traditional public and public charter schools, from the survey participants in the QUAN phase (Creswell, 2013). Purposeful selection ensured maximal variation as determined by student mathematics achievement (as measured by 2015 SAGE standardized student test scores in mathematics) and school demographics. The researcher divided school leaders into three focus groups: five school leaders from schools who are performing relatively higher than their demographics would suggest (referred to as "Higher," six school leaders from schools who are performing about where their demographics would suggest (referred to as "As Expected"), and six school leaders from schools who are performing relatively lower than their demographics would suggest (referred to as "Lower"; Collins, 2010). School leaders were from schools demographically similar to others from their rankings found on the USOE Public Data Gateway website found at https://datagateway.schools.utah.gov/. The description given on the USOE Public Gateway on what constituted "similar" schools was as follows:

> What are "similar schools"? Similar schools are defined by using a statistical approach based on Polytopic Vector Analysis (PVA). In the 2015 edition, schools were analyzed using the size of the school (in terms of October 1 enrollment), percentages of the student population who are ethnic minority, low income, and English language learners, and two measures of rurality based on locale codes assigned by the U.S. Bureau of the Census. Schools which are online or otherwise "virtual" are included but they should be considered carefully in comparisons because they do not fit the geographic assumptions of the model. Schools designed for special purposes—special education, alternative education, and vocational education—and so identified in our data warehouse are not included. The first two types of school have a separate accountability system and the third is not included in accountability.

The researcher looked at the 20 schools listed as demographically similar to each school represented in the quantitative survey data. Each school was then assigned a ranking from 1 to 20, based on SAGE mathematics proficiency scores, within the demographically similar schools. Thus, schools ranked 1-5 were performing relatively higher. Schools ranked 6-15 were performing as expected. Schools ranked 16-20 were performing relatively lower.

The five school leaders from schools performing HIGHER represented three suburban, one rural, and one urban school. They also represented four traditional public and one public charter school and three elementary and two secondary schools. The six school leaders from schools performing AS EXPECTED represented three suburban, two rural, and one urban school. They also represented four traditional public and one public charter school and three elementary and three secondary schools. The six school leaders from schools performing LOWER represented one suburban, three rural, and two urban schools. They also represented three elementary and three secondary schools. Table 2 shows the variation of the school demographics represented by each of the focus groups.

Procedures

Quantitative Participant Identification and Recruitment

The researcher used convenience sampling of Utah K-12 school leaders to collect survey data for the first two research sub-questions. The researcher identified the 1,067 Utah public schools by using Utah's 2015-16 Educational Directory found on the Utah State Office of Education website at www.schools.utah.gov under the Information and

Table 2

School Demographics Represented by Focus Group Participants' School Performance

School performance	Enroll	Eth. Min (%)	Low SES (%)	ELL (%)	SpEd (%)
Higher	75-1373	2.7-64.7	11.4-82.7	0-42.3	0.2-13.7
As expected	122-1616	6.4-47.4	6-80.3	0-23.6	10.7-21.3
Lower	67-692	10.4-79.4	19.9-99.7	0-72.9	9.9-14.3

Education Directory tabs (USOE, 2015a). The researcher contacted 41 public school districts, representing 965 schools, and the state charter school office, representing 102 charter schools, to request permission for school leaders to take the survey as part of the Institutional Review Board (IRB) process (see Appendix A). Every district had its own approval process. The researcher acquired permission from the charter school office at the state office of education and from 38 out of the 41 school districts to invite their school leaders to participate in the survey. The researcher kept detailed records in an excel spreadsheet indicating contact with different district personnel and a folder containing written permission from each district, when required. After also receiving appropriate IRB approval, the researcher invited every K-12 public school leader from the approving districts and charter schools to take the survey. Participants received $5 gift cards for completing the survey (e.g., Subway, Kneaders, McDonalds, and Wendy's). After the research study was concluded, the researcher mailed the gift cards to each participant. The researcher invited school leaders to complete the *Revised Principals Mathematics Questionnaire* via the online platform, SurveyMonkey (see Appendix B for the survey informed consent and Appendix D for the Revised Principal's Mathematics Questionnaire). The researcher kept a detailed participant invitation record in an excel spreadsheet indicating the dates email invitations were sent and who participated. One week after the initial survey invitation, the researcher sent a second invitation to participate (see Appendix E for the recruitment email). A third invitation was sent again 1 week later. One district allowed only two email invitations.

Qualitative Participant Identification and Recruitment

After identifying possible focus group members from the results of the QUAN phase using maximal variation sampling, the researcher personally contacted (via a phone call and/or email) each school leader to invite them to participate in the QUAL phase. The researcher informed prospective participants of the purpose of the study, that their participation would be important and valuable, and why they were selected (see Appendix F for the Dialogue for Recruiting Participants). In addition, prospective participants were informed that the results of the study would be shared with them. The researcher contacted eleven prospective school leaders, representing schools performing HIGHER, before five agreed to participate in the focus group. Similarly, the researcher contacted seventeen prospective school leaders, representing schools performing AS EXPECTED before six agreed to participate in the focus group, and contacted fourteen prospective school leaders, representing schools performing LOWER, before six agreed to participate in the focus group. One school leader participated in both the above and as expected focus groups since they were a school leader of two schools. The researcher coordinated via email individually with each participant to select a focus group option that worked well for participants' schedules. As an incentive to participate in the focus group interviews, each participant received a $25 gift card (Vaughn, Schumm, & Sinagub, 1996), a travel reimbursement of $0.54/mile for round trip travel expenses, and a 1-night hotel stay, if they had to travel more than 50 miles to participate. Some participants chose to participate via Skype or Google Hangouts. The researcher distributed gift cards immediately to those who participated in person and mailed gift cards to those who participated electronically. Travel reimbursements were mailed at the completion of the study.

Conducting the Focus Group Interviews

A total of seven focus group interviews took place with a total of sixteen participants over a 2-month period. The researcher obtained written informed consent for each participant, confidentiality agreements, and travel reimbursement information prior to the beginning of each interview (see Appendix C for the focus group informed consent form and Appendix G for the confidentiality agreement). The researcher kept all documents in a locked cabinet. Each interview took place during one 2-hour session. Five of the focus group interviews took place in a centrally located hotel conference room around a large table. Food and drink were provided for the participants so they felt as comfortable as possible. The food included fruit and vegetable trays, snack bars, and selected pastries. The drinks included water and a selection of soft drinks. One focus group interview was conducted in a library study room, and one was conducted in a university conference room. Two of the focus groups included one or more participants participating via Skype or Google Hangouts. Three school leaders participated electronically. All others participated in person.

The researcher video- and audio-taped the interviews for later transcription using two video-recording cameras on stationary tripods on opposite sides of the focus groups. The cameras were high enough and angled slightly down, to allow a wide enough shot to capture all of the participants in the focus group (Roschelle, 2011). The researcher tested the video equipment in advance to avoid glare and backlighting. The researcher started the recordings before the participants arrived and did not stop the recordings until after the participants left to capture any revealing remarks before or after the interview (Roschelle, 2000). As such, the researcher informed the participants prior to attending that they would be video-taped from the moment they entered the room until they left. The researcher tested the audio-equipment to ensure high-quality audio recordings. The researcher placed the audio recorder on the table in front of the interviewer, very close to the participants, and conducted sound checks prior to the start of the interview. There were extra batteries, in case they were needed. The researcher took all efforts to control ambient noise such as closing windows and doors, adjusting the air conditioning equipment, ensuring the room was carpeted, and closing window curtains to reduce reverberations (Roschelle, 2011).

As suggested by Vaughn et al. (1996), at the beginning of the interview, the researcher welcomed the participants, informed them of the general purpose and topics to be discussed, and the general guidelines the discussion would follow. The researcher allowed for a warm-up period to set the tone and put participants at ease. Then the researcher clarified the meaning of the terms that were used as part of the interview. The bulk of the interview consisted of questions from the semi-structured, focus-group interview protocol (see Appendix H for the Focus Group Protocol Outline). Towards the end of each interview, the researcher closed with an added request for confidentiality of information, answered any remaining questions, and expressed thanks for the school leaders' participation. Following the interview, all video- and audio-recordings were upload to a secure Google Drive to which only the researcher had permanent access. A university employed transcriptionist was secured to transcribe the data and, thus, was granted temporary access. Before access was granted, the transcriptionist was required to sign a confidentiality form that was filed by the researcher.

Data Sources and Instruments

Quantitative Data Sources and Instruments

The Revised Principal's Mathematics Questionnaire (see Appendix D), which aligns with the SL-CAS theoretical framework, was developed as the survey instrument. This 20-minute survey of school leaders began with a portion wherein participants were asked to give IRB consent to participate in the survey (see Appendix B). The survey included questions covering general demographics, teaching experiences, administrative experiences, mathematics demographics, and perceived influence on mathematics curriculum and instruction, mathematics curriculum, and mathematics teaching and achievement. This survey was adapted from Williams' (2010) Principal's Elementary Mathematics Questionnaire and was distributed through an email invitation (see Appendix E) with a link to the SurveyMonkey platform.

The researcher tested items as part of a class project to refine and receive feedback on the previously developed Williams' (2010) Principal's Elementary Mathematics Questionnaire. Changes were made to include school leader's information across all grades K-12 in Utah. In addition, questions were updated to include the most recent documents affecting current mathematics education curriculum and instruction decisions and policies. Questions were also added to inquire as to school leader's perceptions of how to best increase students' mathematics achievement. A small group of school leaders (*N* = 18) from schools identified as high performing on Utah State standardized testing participated in giving feedback on the revised survey items. After the feedback collection process, the researcher reviewed the reported length of time the survey took to complete and other feedback from the school leaders. The researcher then used the Likert scale data to conduct an item analysis using Cronbach's alpha of .70 to determine the internal consistency or average correlation of items to gauge reliability and aspects of validity (Santos, 1999; Tavakol & Dennick, 2011). Based on this analysis, items were deleted to reduce the length of the survey while maintaining the appropriate Cronbach alpha threshold (see Appendix I for Cronbach alphas). The development of the survey instrument established the reliability, and aspects of validity, for the revised survey instrument. The revised survey (see Appendix D) contains the items necessary to validly, and reliably, identify organizational structures, teacher supports, and accompanying school leader perceptions. In addition, the revised survey addresses the feedback that the instrument was too lengthy.

Qualitative Data Sources and Instruments

The researcher used a semistructured, focus-group interview protocol (see Appendix H for Focus Group Protocol Outline) to illicit spontaneous and genuine responses (Vaughn et al., 1996). This protocol was initially developed through the lens of Complexity Theory and based on the SL-CAS theoretical framework and preliminary analysis of the quantitative data.

The researcher tested the focus-group interview protocol outline prior to the focus group interviews. The purpose of this was to test technical aspects of recording the interviews and to practice facilitating the interview in a timely manner while maintaining a warm atmosphere of trust. Test participants were invited to share their frank opinions of the moderation process and the wording of questions in order to ensure a welcoming environment.

Data Analysis

Random Forests and Variable Importance Plots

After the survey data collection, the researcher exported the SurveyMonkey data as an excel file. The researcher then cleaned the data to create a file that could be used in both SPSS and R for the statistical analyses. Then the researcher conducted a preliminary analysis using the statistical strategies of Random Forests and variable importance plots in R using R packages "haven," "dplyr," "tidyr," "ggplot2," "rpart," and "randomForest" (Liaw & Wiener, 2002; R Core Team, 2016; Therneau, Atkinson, & Ripley, 2015; Wickham, 2009; Wickham & Francois, 2016; Wickham & Miller, 2016) to determine which of the independent variables were most important in predicting the dependent variable (Breiman, 2001; Ho, 1995, 2002; Liaw & Wiener, 2002). Random Forests are used in quantitative data mining and utilize decision trees. A single decision tree considers one variable at a time, independently, to find a good initial splitting point. A fixed value of the variable is chosen and data are classified as more or less than that fixed value. The analysis then attempts to find a good splitting point. A good split is the split that tries to put as many samples of one class (such as those in the "more than" group, as determined by the chosen cut point) as possible on one side and as many samples of the other class (such as those in the "less than" group) as possible on the other side. In the end, the best split is the one that is most "pure".

A perfect "pure" split is reached when each section of the final tree contains only members of the same class. The tree continues to split until purity is reached. However, a single tree may reach purity without still demonstrating an overfitting problem. Random Forests (which utilize hundreds, if not thousands, of trees) effectively overcome this problem through "ensemble thinking". Ensemble thinking is similar to a Board of Directors making decisions for an organization. In a board, various people bring different perspectives and areas of expertise thus generally ensuring a better decision than a single person. This is done statistically through the techniques of bagging (where randomized samples from your data set are employed to create different distributions), randomizing features, and randomizing splits. In this way, a random forest probability distribution can be generated that depends on no assumptions. This effectively deals with missing data by optimizing many trees based on starting with different variables. This method is particularly effective for data that are not clearly linear and for categorical variables which aligns well with Complexity Theory. This method comes with built-in cross validation so that overfitting is mostly avoided. Thus, utilizing Random Forests improves the predictive power of the final model.

In alignment with complexity theory, the survey included 193 independent variables. As such, the researcher generated a variable importance plot to identify the most relevant predictor variables. There are two types of variance importance plots. The most common is the "Percent Increase in Mean Square Error" (%IncMSE), which measures how much the mean square error (MSE) increases when a variable is permuted. The other is "Increase in Node Purity" (IncNodePurity) which measures how much node impurity increases when a variable is randomly permuted. The variables with the largest importance will change the predictions in measurable ways if randomly permuted, so we see bigger changes. If you randomly permute a variable that does not gain you anything in prediction, then predictions will not change much and you will only see small changes in MSE and node impurity. In other words, big changes indicate important variables. Of the two plots, IncNodePurity is biased and should only be used if the extra computation time of calculating %IncMSE is unacceptable. Since the calculation time was not an issue, the researcher used a %IncMSE variable importance plot to determine the most important variable. See Figure 3 for a hypothetical example of a %IncMSE plot. In Figure 3, looking at the top right most corner of the plot indicates that variable x_2 would be most important in predicting changes in our final model, variable x_1 would be next most important, etc. In this way, the researcher was able to answer the first research sub-question.

Model Assumptions and Preliminary Correlation Analysis

Following the identification of the most relevant predictor variables, the researcher conducted a preliminary analysis of the model assumptions to check for the normality of each of the variables using a Shapiro-Wilks test ($p > .05$). In addition, the researcher conducted a visual inspection of their histograms, normal Q-Q plots and box

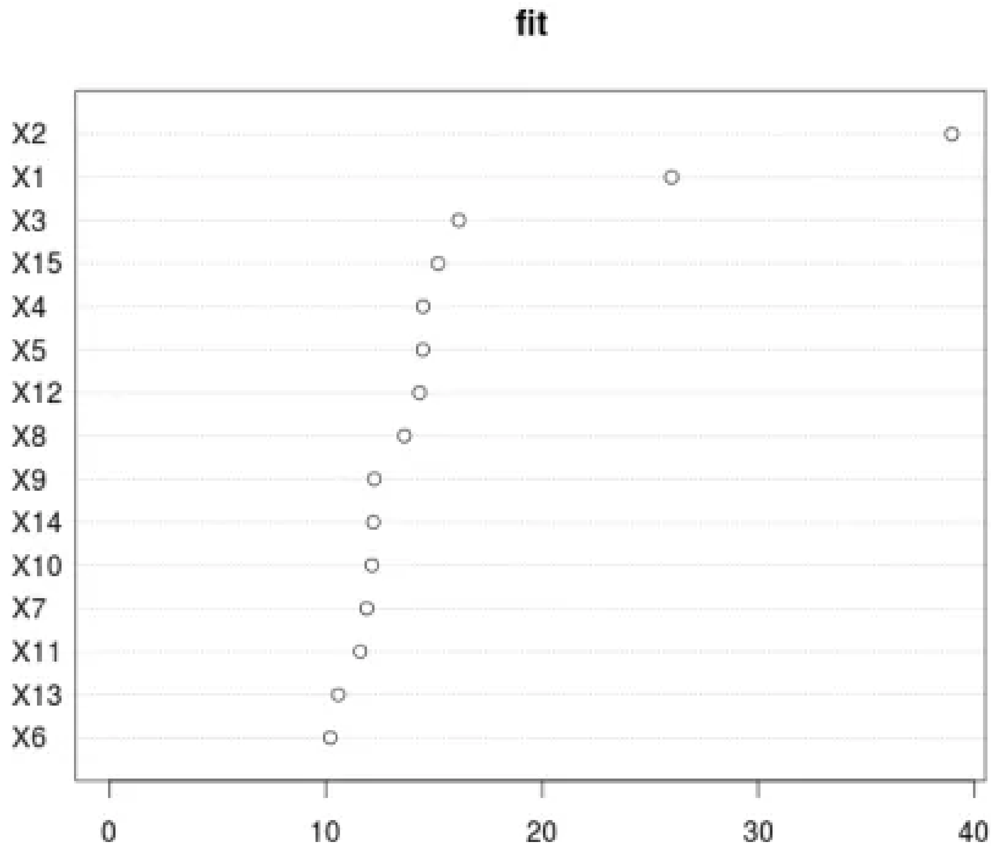

Figure 3. Example of %IncMSE variable importance plot. This figure illustrates how variables that are most important in predicting the dependent variable are located in the most top right of the graph.

plots. Because these data were normally distributed (Cramer, 1998; Cramer & Howitt, 2004; Doane & Seward, 2011; Razali & Wah, 2011; Shapiro & Wilk, 1965), the researcher conducted a preliminary correlation analysis using a two-tailed test with a .05 significance level to determine whether significant Spearman's rho correlations existed between the independent variables. Spearman's rho correlations were chosen over Pearson's correlations because of the categorical variables present in the Principal's Mathematics Questionnaire. Based on these preliminary findings, the focus-group interview protocol outline was revised to explore and explain the quantitative findings.

Network Analysis

Following this, the researcher conducted a network analysis (Wasserman & Faust, 1994) in R using R packages “sna,” “igraph,” “visNetwork,” and “network” (Almende & Benoit, 2016; Butts, 2008, 2015, 2016; Csardi & Nespisz, 2006; R Core Team, 2016). Network analysis investigates the social structures in a CAS using graph theory by characterizing stakeholders as nodes and ties between them as relationships or interactions. Thus, based on the categories developed from the qualitative analysis of the focus-group interviews, the network analysis allowed the researchers to further understand the influences of various stakeholders on each other. This then allowed the researcher to analyze how various stakeholders influence school leaders, or vice versa through the lens of a shared vision to better understand how the school leader may move the CAS towards higher student mathematics achievement. This analysis, superimposed on the SL-CAS Framework, helped to determine the possibility of any interaction effects or multiplicative looping effects among the identified most important independent variables, as described in Complexity Theory. Thus, the researcher could use a more educated approach when selecting variables to be included in the final predicative model relating school leaders’ characteristics with the school-wide average SAGE mathematics proficiency scores at their respective schools.

Initial Regression Model Development and Post-Hoc Regression Analysis

The network analysis allowed the researcher to narrow the search for possible interaction effects and multiplicative looping effects. Using educated guesses, an initial multiple regression model was determined. Following this, the researcher conducted a post-hoc regression analysis joined with a correlation analysis of the independent variables without the moderating dependent variable as proposed by Gilstrap (2013) to determine if any emergent phenomenon were present at higher hierarchical levels of the CAS that would otherwise be rejected using traditional variable reduction. Post-hoc regression analysis is an emergent, recursive, and iterative quantitative method dealing with interaction effects and collinearity among variables that may have been missed in the preliminary multiple regression analysis. In this way, Gilstrap proposed a method in which a researcher notices an interaction that may not be identified as statistically significant, because of multicollinearity, through traditional multiple regression reductionist methods but for which evidence suggests there may be an important connection, or dynamic, that emerges in a quasi-correlation between two entities. For example, if evidence of multicollinearity takes place at a few dimensions of an initially developed regression model, and correlation analysis shows there are no correlations between these variables without the involvement of the dependent variable, this means one of the independent variables may be acting as a moderator variable. When this happened, the researcher moved into descriptive analyses of the phenomenon that are emerging during the model's calculations. This created an iterative and recursive method of observation, consistent with Complexity Theory that allowed the researcher to qualitize the quantitative data and use qualitative methods to contribute to the understanding of the overarching research question about the role school leaders' play in students' mathematics achievement. When this happened, the researcher explored the interaction in a descriptive framework, through an analysis of means, to qualitize the quantitative data using emergence, rather than reduction, to describe the phenomenon. This enabled the researcher to answer the second research sub-question.

Constant Comparative Analysis

At the same time the initial regression model was being developed, the researcher employed traditional constant comparative analysis procedures (Creswell, 2013) utilizing the lens of complexity theory with the qualitative data. The researcher described the focus group samples, including size, the individuals who participated and their background, the location where the focus group interviews took place, and the procedures used for the selection of participants. The interviews were transcribed and coded using three phases of coding: open, axial, and selective (Creswell, 2013) utilizing NVivo11 qualitative analysis software (Edhlund & McDougall, 2016). During the open coding phase, the researcher reviewed the video recordings, audio recordings, transcripts, and field notes for salient categories of information until saturation was reached using constant comparative methods (Creswell, 2013). The initial codes evolved around the SL-CAS theoretical framework and include such categories as: internal operating chaotic units (i.e., stakeholder groups), the influences of such groups on the school leader and vice versa, the presence, or lack thereof, of a shared vision, and decisions regarding resources, curriculum, time, mentoring and coaching, feedback, teacher professional development, and instructional methods. Once the researcher developed an initial set of categories, the researcher used axial-coding categories to connect the open coding categories into over-arching themes. Finally, the researcher used selective coding to build a description, grounded in Complexity Theory, which connected the categories (Creswell, 2013) and answered the third and fourth research subquestions.

Connected Data Analysis to Draw Meta-Inferences

Following the multiple regression model development and constant comparison analyses, the researcher conducted a descriptive analysis of the larger quantitative data set focused on the schools performing HIGHER, AS EXPECTED, and LOWER. The researcher then utilized connected data analysis as proposed by mixed methods techniques to further analyze the data (Creswell & Plano Clark, 2011). Connected data analysis occurs when the quantitative and qualitative strands are mixed during the data analysis phase of the research study (Creswell & Plano Clark, 2011). After independently analyzing the quantitative and qualitative data using traditional methods, the researcher used an interactive strategy of merging the two separate results to facilitate comparisons and interpretations.

Thus, finally, the researcher was able to draw meta-inferences to determine whether the follow-up qualitative data provided a better understanding than just the quantitative data to answer the final research sub-question (Creswell & Plano Clark, 2011). Tashakkori and Teddlie (2008) describe a meta-inference as “an overall conclusion, explanation or understanding developed through an integration of the inferences obtained from the qualitative and quantitative strands of a mixed methods study” (p. 101). Thus, the researcher was first able to make inferences based on independent quantitative and qualitative analyses of the data. Then, through the two strategies of relating the separate results and conducting additional analyses of the transformed data, the researcher was able to answer the final research sub-question and was able to describe, and explain, the overall role that school leaders play in promoting student mathematics achievement.

CHAPTER IV

RESULTS

The purpose of this study was to explore the role the school leader plays in students' mathematics achievement through the lens of Complexity Theory. The results presented in the following sections are based on survey data collected from 158 K-12 Utah school leaders and focus group interviews with 16 of these same K-12 school leaders. The quantitative results are presented first, followed by the qualitative results. Throughout these sections, the quantitative and qualitative results will be iteratively discussed consistent with Complexity Theory and mixed methods data analysis. The section below reports the results answering the first two research sub-questions.

Quantitative Results

Question 1

The first research sub-question was: What characteristics of the school leader are most important in predicting students' mathematics achievement? This section discusses the results of the preliminary quantitative analysis using the statistical strategy of Random Forests. As part of this analysis, a variable importance plot was generated to identify the most relevant predictor variables.

Random forest and variable importance plot analysis. After the survey data collection, the researcher conducted a preliminary analysis using the statistical strategies of Random Forests and variable importance plots to determine which of the independent variables were most important in predicting the dependent variable, school-wide average

SAGE mathematics proficiency scores (Breiman, 2001; Ho, 1995, 2002; Liaw & Wiener, 2002). Figure 4 shows the percent increase in mean square error (%IncMSE) on the variable importance plot which identifies the 30 most important, independent variables out of the 193 possible. Student demographic data were purposefully excluded from this initial analysis to determine which of the characteristics of the school leader were most important in predicting school-wide average SAGE mathematics proficiency scores.

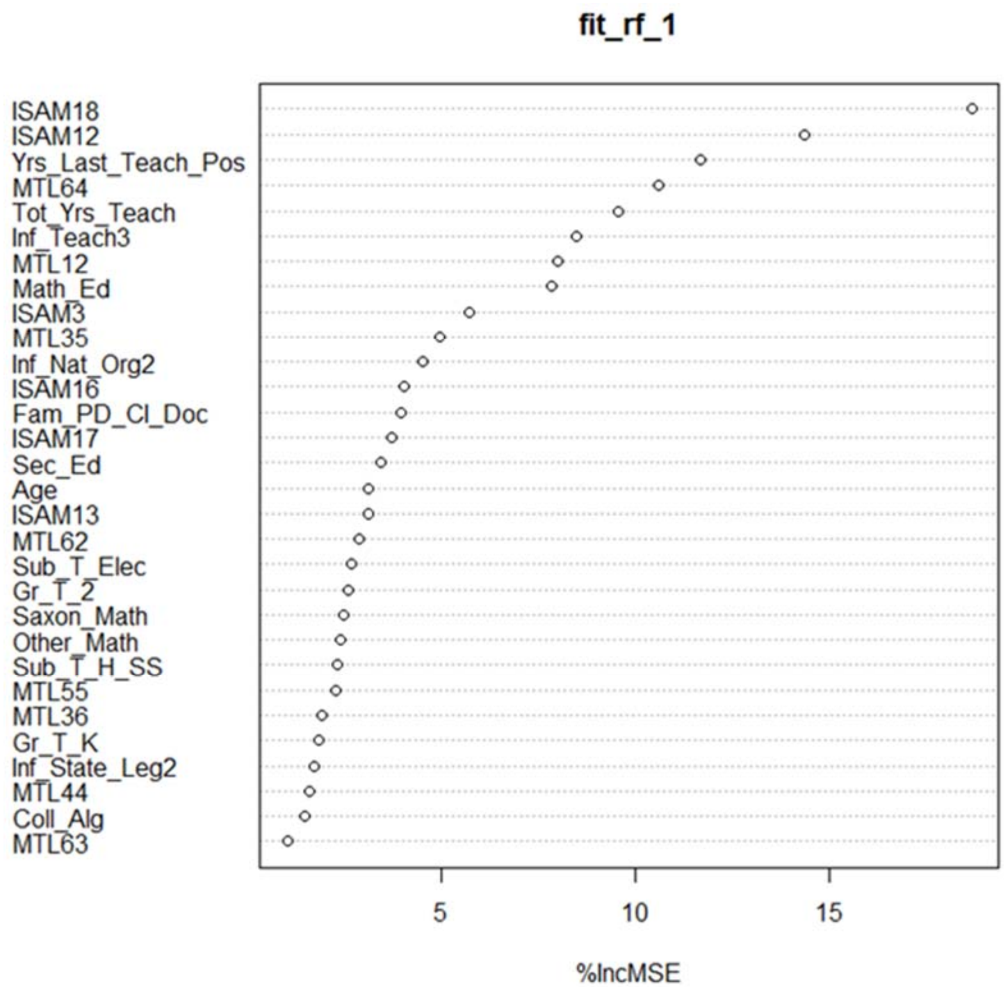

Figure 4. %IncMSE variable importance plot. This figure illustrates the top 30 most important characteristics of school leader variables in order of importance in predicting a school-wide average SAGE mathematics proficiency score.

Figure 4 displays the most important variables at the upper right of the graph indicating greater impact on school-wide average SAGE mathematics proficiency scores when randomly permuted. Thus, in order of importance, the graph indicates “the level of the school leaders’ agreement with the statement: The best way to increase student achievement in mathematics is to educate members of the legislature on the curriculum and research-based instructional strategies” (ISAM18) as most important. This was followed by “the level of the school leaders’ agreement with the statement: The best way to increase student achievement in mathematics is to provide teacher/aide tutoring for students” (ISAM12), “the number of years the school leader was in their last teaching position” (Yrs_Last_Teach_Pos), and “the level of the school leaders’ agreement with the use of mathematical discourse being used at least 50% of the time in the 10-12 mathematics classroom” (MTL64), etc. The variable importance plot thus lays out the 30 characteristics of the school leader that are possibly most important in predicting school-wide average SAGE mathematics proficiency scores from the 193 initially considered.

Table 3 provides a detailed description of these 30 most important variables for predicting the school-wide average SAGE mathematics proficiency score, in order of importance, based on the school leaders that participated in the survey.

As can be seen in Table 3, the most important variable to predicting a school-wide average SAGE mathematics proficiency score is “the school leader’s agreement with this statement: The best way to increase student achievement in mathematics is to educate members of the legislature on the curriculum and research-based instructional strategies” (ISAM18). The second most important variable was “school leader’s agreement with this

Table 3

Description of Top 30 Most Important Characteristics of School Leader Variables in Order of Importance in Predicting a School-Wide Average SAGE Mathematics Proficiency Score

Variable abbreviation	Description
ISAM18	School leader agreement with this statement: "The best way to increase student achievement in mathematics is to educate members of the legislature on the curriculum and research-based instructional strategies."
ISAM12	School leader agreement with this statement: "The best way to increase student achievement in mathematics is to provide teacher/aide tutoring for students."
Yrs_Last_Teach_Pos	Number of years the school leader was in their last teaching position.
MTL64	School leader agreement with this statement: "Discussion of mathematics (mathematical discourse) should be used at least 50% of the time in the 1012 mathematics classroom."
Tot_Yrs_Teach	Numbers of years the school leader taught in some capacity.
Inf_Teach3	School leader perception of the amount of influence of teachers over the instructional methods used in the mathematics classroom at their school.
Math_Ed	School leader earned a major, minor, or special emphasis in mathematics education
MTL12	School leader agreement with this statement: "The use of calculators in early grades impedes the development of automaticity with basic facts."
ISAM3	School leader agreement with this statement: "The best way to increase student achievement in mathematics is to work with university researchers in a collaborative professional development."
MTL35	School leader agreement with this statement: "In grades K9, mathematics instruction should be teacher directed more than 50% of the time."
Inf_Nat_Org2	School leader perception of the amount of influence of national organizations such as NCTM over the implementation of the mathematics curriculum at your school.
ISAM16	School leader agreement with this statement: "The best way to increase student achievement in mathematics is to educate parents on the curriculum and research-based instructional strategies."
ISAM17	School leader agreement with this statement: "The best way to increase student achievement in mathematics is to educate board members on the curriculum and research-based instructional strategies.
Fam_PD_CI_Doc	Amount of school leader familiarity with professional development/materials/readings in mathematics curriculum and instruction.
Sec_Ed	School leader earned a major, minor, or special emphasis in secondary education.

(*table continues*)

Variable abbreviation	Description
ISAM13	School leader agreement with this statement: “The best way to increase student achievement in mathematics is to provide appropriate Tier II and Tier III instruction for students.”
MTL62	School leader agreement with this statement: “In 1012, certain aspects of geometry and measurement are critical foundations of algebra.”
Age	School leader age
MTL55	School leader agreement with this statement: “In 1012, explicit instruction for students who struggle in math is effective in increasing student performance with word problems and computation.”
Gr_T_2	School leader taught second grade at some point in their teaching career.
Sub_T_Elec	School leader taught elective subjects at some point in their teaching career.
Other_Math	School leader earned a major, minor, or special emphasis in some other mathematics related field.
Inf_State_Leg2	School leader perception of the amount of influence of the state legislature over the implementation of mathematics curriculum at your school.
Sub_T_H_SS	School leader taught history/social studies at some point in their teaching career.
Saxon_Math	The school uses Saxon Math curriculum resources as part of their mathematics program.
Gr_T_K	School leader taught kindergarten at some point in their teaching career.
MTL36	School leader agreement with this statement: “In grades K9, questioning should be an important instructional practice in the mathematics classroom.”
MTL44	School leader agreement with this statement: “Rote practice (drill) should be an important instructional practice in the 1012 mathematics classroom.”
Coll_Alg	School leader took college algebra.
MTL39	School leader agreement with this statement: “Cooperative work should be the primary instructional practice in the K9 mathematics classroom.”

statement: The best way to increase student achievement in mathematics is to provide teacher/aide tutoring for students” (ISAM12). The third most important variable was “the number of years the school leader was in their last teaching position” (Yrs_Last_Teach_Pos).

As all the variables are described in Table 3, the results from the variable importance plot indicated a complex landscape of influences on students’ mathematics achievement based on the characteristics of the school leader. The results of the analysis to answer the first research sub-question showed that there were identifiable characteristics of a school leader that are most important in predicting the school-wide average SAGE mathematics proficiency score at the leader's school.

Question 2

This second research question was: What is the relationship between students' mathematics achievement and characteristics of the school leader? There are five subsections to answer this question.

1. The first subsection discusses the preliminary model assumptions based on the 30 most important variables.
2. The second subsection discusses the preliminary correlation analysis in order to generate the data needed for the network analysis.
3. The third subsection discusses the network analysis to determine possible places to look for interaction effects and multiplicative looping effects in accordance with Complexity Theory.
4. The fourth subsection discusses the initial regression model and post-hoc regression analysis conducted to determine emergent phenomenon present at higher hierarchical levels of the CAS that would otherwise be rejected using traditional positivist variable removal in a multiple regression analysis.
5. The final subsection discusses the multiple regression analysis conducted in SPSS to determine trends between the independent and relevant dependent variables and generate a final predictive model for school-wide average SAGE mathematics proficiency scores based on characteristics of the school leaders and student demographics.

Preliminary model assumptions. Based on the 30 most important independent variables and the one dependent variable, the researcher conducted a Shapiro-Wilk's test ($p > .05$; Razali & Wah, 2011; Shapiro & Wilk, 1965) for each variable. In addition, the researcher conducted a visual inspection of their histograms, normal Q-Q plots and box plots to check for normality. For example, in Table 4, this analysis showed that the independent variable, "the school leader's agreement with this statement: 'The best way to increase student achievement in mathematics is to educate members of the legislature on the curriculum and research-based instructional strategies'" (ISAM18), was approximately normally distributed (Cramer, 1998; Cramer & Howitt, 2004; Doane & Seward, 2011).

The researcher completed similar analyses for the 30 most important independent variables and found that all independent variables were approximately normally distributed (see Appendix J for all 30 variables' histograms and Q-Q plots).

Correlation analysis. Next, because the data were normally distributed, the researcher conducted a preliminary correlation analysis using a two-tailed test with a .05 significance level to determine whether significant Spearman's rho correlations existed between the independent variables. This analysis revealed 83 significant correlations; four strong, 28 moderate, and 51 weak (see Appendix K). Table 5 reports the results of the strong measures and Table 6 reports the results of the moderate measures.

Table 4

Normality Tests for the Independent Variable ISAM18

	Shapiro-Wilk						
ISAM18	Statistic	*df*	Sig.	Skewness	Std. error	Kurtosis	Std. error
Strongly disagree	.87	11	.078	-1.21	.66	1.14	1.28
Disagree	.98	25	.946	.04	.46	-.13	.90
Neutral	.98	43	.558	.10	.36	-.75	.71
Agree	.98	51	.387	-.49	.33	.23	.66
Strongly agree	.89	13	.093	.68	.62	-.68	1.19

Table 5

Results of the Correlation Analysis Showing Strong Correlations Between Variables

Variables	ISAM16	ISAM17	Tot_Yrs_Teach
ISAM18	0.544**	0.872**	
ISAM16		0.673**	
Yrs_Last_Teach_Pos			0.798**

Note. See Appendix L for descriptive statistics of each variable.
* $p < .05$.
** $p < .01$ level.

As can be seen in Table 5, "the level of the school leaders' agreement with the statement: The best way to increase student achievement in mathematics is to educate members of the legislature on the curriculum and research-based instructional strategies" (ISAM18) and "the level of the school leaders' agreement with the statement: The best way to increase student achievement in mathematics is to educate board members on the curriculum and research-based instructional strategies" (ISAM17) were the most strongly correlated variables, r(149) = .872, p < .001. This means that the more school leaders agreed with educating members of the legislature on the curriculum and research-based instructional strategies as the best way to increase student achievement, the more they also agreed with the education of board members as the best way to increase student achievement.

As expected, "the total number of years in a school leaders' last teaching position" (Tot_Yrs_Teach) strongly correlated to "the school leaders' total number of years of teaching experience" (Yrs_Last_Teach_Pos), $r(155) = .798$, $p < .001$. "The level of the school leaders' agreement with the statement: The best way to increase student achievement in mathematics is to educate parents on the curriculum and research-based

Table 6

Results of the Correlation Analysis Showing Moderate Correlations Between Measures

Measures	ISAM 12	ISAM3	ISAM 13	MTL 39	ISAM 16	ISAM 17	Age	Inf__ Teach3	T_2	MTL 55	Inf _State _Leg2	T_Elec	T_H_SS	MTL 36	T_K	MTL 44
ISAM 18	0.311^{**}	0.389^{**}	0.266^{**}	0.270^{**}												
ISAM 12			0.397^{**}		0.349^{**}	0.315^{**}										
ISAM 16			0.248^{**}													
ISAM 17			0.316^{**}									0.245^{**}				
ISAM 3					0.395^{**}	0.408^{**}										
Yrs_Last_Teach_Pos							0.331^{**}									
Tot_Yrs_Teach							0.421^{**}		0.289^{**}							
MTL 35							0.269^{**}									
MTL 64								0.251^{*}								
ISAM 13									0.311^{**}					0.245^{**}		
MTL 55									0.281^{**}							
Inf_Nat_Org2										-0.278^{**}	0.392^{**}					
MTL 62										0.358^{**}						
Age										0.249^{*}						
Sec_Ed													0.376^{**}			
T_2														0.361^{**}	0.286^{**}	
Inf_State_Leg2																0.304^{**}

Note. See Appendix L for descriptive statistics of each variable.

* $p < .05$.

**$p < .01$ level.

instructional strategies" (ISAM16) and "the level of the school leaders' agreement with the statement: The best way to increase student achievement in mathematics is to educate members of the legislature on the curriculum and research-based instructional strategies" (ISAM17) were the next most strongly correlated, $r(149) = .673$, $p < .001$. This means that the more school leaders agreed with educating parents on the curriculum and research-based instructional strategies, the more they also agree with the education of board members as the best way to increase student achievement.

Finally, "the level of the school leaders' agreement with the statement: The best way to increase student achievement in mathematics is to educate members of the legislature on the curriculum and research-based instructional strategies" (ISAM18) and "the level of the school leaders' agreement with the statement: The best way to increase student achievement in mathematics is to educate parents on the curriculum and research-based instructional strategies" (ISAM16) were also strongly correlated, $r(149) =.544$, $p < .001$.

ISAM16, 17, and 18 were all variables that dealt with educating various stakeholders in the communities surrounding a school. Tests to see if the data met the assumption of collinearity indicated that multicollinearity was not a concern except for possibly ISAM17 and 18 (ISAM16, Tolerance = .35, VIF = 2.83; ISAM17, Tolerance = .11, VIF = 9.251; ISAM18, Tolerance = .14, VIF = 7.272; Yrs_Last_Teach_Pos, Tolerance = .22, VIF = 4.56; Tot_Yrs_Teach, Tolerance = .18, VIF = 5.60), although even these two variables are within the threshold.

As can be seen in Table 6, moderately strong correlations were found between "a school leaders' total number of years teaching" (Tot_Yrs_Teach) and their "age" (Age), $r(153) = .42$, $p < .001$. A second correlation was between "the level of the school leaders' agreement with the statement: The best way to increase student achievement in mathematics is to work with university researchers in a collaborative professional development" (ISAM3) and "the level of the school leaders' agreement with the statement: The best way to increase student achievement in mathematics is to educate board members on the curriculum and research-based instructional strategies" (ISAM17), $r(149) = .41$, $p <$ .00l. A third correlation was between "the level of the school leaders' agreement with the statement: The best way to increase student achievement in mathematics is to provide teacher/aide tutoring for students" (ISAM12) and "the level of the school leaders' agreement with the statement: The best way to increase student achievement in mathematics is to provide appropriate Tier II and Tier III instruction for students" (ISAM13), $r(149) = .40$, $p < .001$. A fourth correlation was between "the level of the school leaders' agreement with the statement: The best way to increase student achievement in mathematics is to work with university researchers in a collaborative professional development" (ISAM3) and "the level of the school leaders' agreement with the statement: The best way to increase student achievement in mathematics is to educate members of the legislature on the curriculum and research-based instructional strategies" (ISAM16), $r(149) = .40$, $p < .001$. Tests to see if the data met the assumption of collinearity indicated that multicollinearity was not a concern (see Appendix M).

The researcher found moderate correlations between "the level of the school leaders' agreement with the statement: The best way to increase student achievement in mathematics is to educate members of the legislature on the curriculum and research-based instructional strategies" (ISAM18) and "the level of the school leaders' agreement with the statement: The best way to increase student achievement in mathematics is to work with university researchers in a collaborative professional development" (ISAM3), $r(149) = .39$, $p < .001$. A second moderate correlation was between "the school leaders' perception of the amount of influence of national organizations such as NCTM over the implementation of the mathematics curriculum in their school" (Inf_Nat_Org2) and "the school leaders' perception of the amount of influence of the state legislature over the implementation of the mathematics curriculum in their school" (Inf_State_Leg2), $r(146) = .39$, $p < .001$. A third correlation was between "if the school leader earned a major, minor, or special emphasis in secondary education" (Sec_Ed) and "if the school leader taught history/social studies" (Sub_T_H_SS), $r(156) = .38$, $p < .001$. A fourth correlation was between "the school leaders' beliefs that certain aspects of geometry and measurement are critical foundations of algebra in grades10-12" (MTL62) and "the level of the school leaders' agreement with the use of explicit instruction for students who struggle as an importance instructional strategy in the 10-12 mathematics classroom" (MTL55), $r(92) = .36$, $p < .001$. A fifth correlation was between "if the school leader taught 2nd grade" (Gr_T_2) and "the level of the school leaders' agreement with the use of questioning as an importance instructional strategy in K-9 mathematics classrooms" (MTL36), $r(144) = .36$, $p < .001$. A sixth correlation was found between "the level of the school leaders' agreement with the statement: The best way to increase student achievement in mathematics is to provide teacher/aide tutoring for students" (ISAM12) and “the level of the school leaders’ agreement with the statement: The best way to increase student achievement in mathematics is to educate members of the legislature on the curriculum and research-based instructional strategies” (ISAM16), $r(149) = .35$, $p < .001$. A seventh correlation was between “the school leaders’ total number of years of teaching experience” (Yrs_Last_Teach_Pos) and the school leaders’ “age” (Age), $r(154) = .33$, $p < .001$). An eighth correlation was between “the level of the school leaders’ agreement with the statement: The best way to increase student achievement in mathematics is to provide teacher/aide tutoring for students” (ISAM12) and “the level of the school leaders’ agreement with the statement: The best way to increase student achievement in mathematics is to educate members of the legislature on the curriculum and research-based instructional strategies” (ISAM17), $r(149) = .32$, $p < .001$. A ninth correlation was between “the level of the school leaders’ agreement with the statement: The best way to increase student achievement in mathematics is to educate members of the legislature on the curriculum and research-based instructional strategies” (ISAM17) and “the level of the school leaders’ agreement with the statement: The best way to increase student achievement in mathematics is to provide appropriate Tier II and Tier III instruction for students” (ISAM13), $r(149) = .32$, $p < .001$. A 10th correlation was between “the level of the school leaders’ agreement with the statement: The best way to increase student achievement in mathematics is to educate members of the legislature on the curriculum and research-based instructional strategies” (ISAM18) and “the level of the school leaders’ agreement with the statement: The best way to increase student achievement in mathematics is to provide teacher/aide tutoring for students” (ISAM12), *r*(149) = .31, *p* < .001. An 11th correlation was between “the level of the school leaders’ agreement with the statement: The best way to increase student achievement in mathematics is to provide appropriate Tier II and Tier III instruction for students” (ISAM13) and “if the school leader taught 2nd grade” (Gr_T_2), *r*(150) = .31, *p* < .001. Finally, a 12th correlation was between “the school leaders’ perception of the amount of influence of the state legislature over the implementation of the mathematics curriculum in their school” (Inf_State_Leg2) and “the level of the school leaders’ agreement with the use of rote practice (drill) as an importance instructional strategy in the 10-12 mathematics classroom” (MTL44), *r*(99) = .30, *p* = .002. Tests to see if the data met the assumption of collinearity indicated that multicollinearity was not a concern (see Appendix M).

The researcher found moderately weak correlations between “a school leaders’ total number of years teaching” (Tot_Yrs_Teach) and “if the school leader taught 2nd grade (Gr_T_2), *r*(155) = .29, *p* < .001. A second correlation was between “if the school leader taught 2nd grade” (Gr_T_2) and “if the school leader taught Kindergarten” (Gr_T_K), *r*(156) = .29, *p* < .001. A third correlation was between “the level of the school leaders’ agreement with the use of explicit instruction for students who struggle as an importance instructional strategy in the 10-12 mathematics classroom” (MTL55) and “if the school leader taught 2nd grade” (Gr_T_2), *r*(95) = .28, *p* = .005. A fourth correlation was between “the school leaders’ perception of the amount of influence of national organizations such as NCTM over the implementation of the mathematics curriculum in their school” (Inf_Nat_Org2) and “the level of the school leaders’ agreement with the use of explicit instruction for students who struggle as an importance instructional strategy in the 10-12 mathematics classroom" (MTL55), $r(95) = -.28$, $p = .006$. A fifth correlation was between "the level of the school leaders' agreement with the use of direct instruction for at least 50% of the time as an importance instructional strategy in the K-9 mathematics classroom" (MTL35) and the school leaders' "age" (Age), $r(140) = .27$, $p = .001$. A sixth correlation was between "the level of the school leaders' agreement with the statement: The best way to increase student achievement in mathematics is to educate members of the legislature on the curriculum and research-based instructional strategies" (ISAM18) and "the level of the school leaders' agreement with the use of cooperative work as the primary instructional practice in the K-9 mathematics classroom" (MTL39), $r(140) = .27$, $p = .001$. A seventh correlation was between "the level of the school leaders' agreement with the statement: The best way to increase student achievement in mathematics is to educate members of the legislature on the curriculum and research-based instructional strategies" (ISAM18) and "the level of the school leaders' agreement with the statement: The best way to increase student achievement in mathematics is to provide appropriate Tier II and Tier III instruction for students" (ISAM13), $r(149) = .27$, $p = .001$. An eighth correlation was between "the level of the school leaders' agreement with the statement: The best way to increase student achievement in mathematics is to educate members of the legislature on the curriculum and research-based instructional strategies" (ISAM16) and "the level of the school leaders' agreement with the statement: The best way to increase student achievement in mathematics is to provide appropriate Tier II and Tier III instruction for students"

(ISAM13), *r*(149) = .25, *p* = .002. A ninth correlation was between “the level of the school leaders’ agreement with the statement: The best way to increase student achievement in mathematics is to educate members of the legislature on the curriculum and research-based instructional strategies” (ISAM17) and “if the school leader taught an elective” (Sub_T_Elec), *r*(149) = .25, *p* = .002. A tenth correlation was between “the level of the school leaders’ agreement with the use of mathematical discourse being used at least 50% of the time in the 10-12 mathematics classroom” (MTL64) and “the school leaders’ perception of the amount of influence of teachers over the instructional methods used in the mathematics classroom at their school” (Inf_Teach3), *r*(91) = .25, *p* = .015. An eleventh correlation was between “the level of the school leaders’ agreement with the statement: The best way to increase student achievement in mathematics is to provide appropriate Tier II and Tier III instruction for students” (ISAM13) and “the level of the school leaders’ agreement with the use of questioning as an importance instructional strategy in K-9 mathematics classrooms” (MTL36), *r*(141) = .25, *p* = .003. Finally, a twelfth correlation was between the school leaders’ “age” (Age) and “the level of the school leaders’ agreement with the use of explicit instruction for students who struggle as an importance instructional strategy in the 10-12 mathematics classroom” (MTL55), *r*(95) = .25, *p* = .014. Tests to see if the data met the assumption of collinearity indicated that multicollinearity was not a concern (see Appendix M).

Network analysis. The researcher conducted a network analysis in R using R packages “sna,” “igraph,” “visNetwork,” and “network” (Almende & Benoit, 2016; Butts, 2008, 2015, 2016; Csardi & Nespisz, 2006; R Core Team, 2016). The purpose of the network analysis was to determine where to look for the possibility of any interaction effects or multiplicative looping effects among the 30 identified most important independent variables, as described in complexity theory (see Figure 5). In a network analysis, possible relationships are visualized through connecting lines that represent the

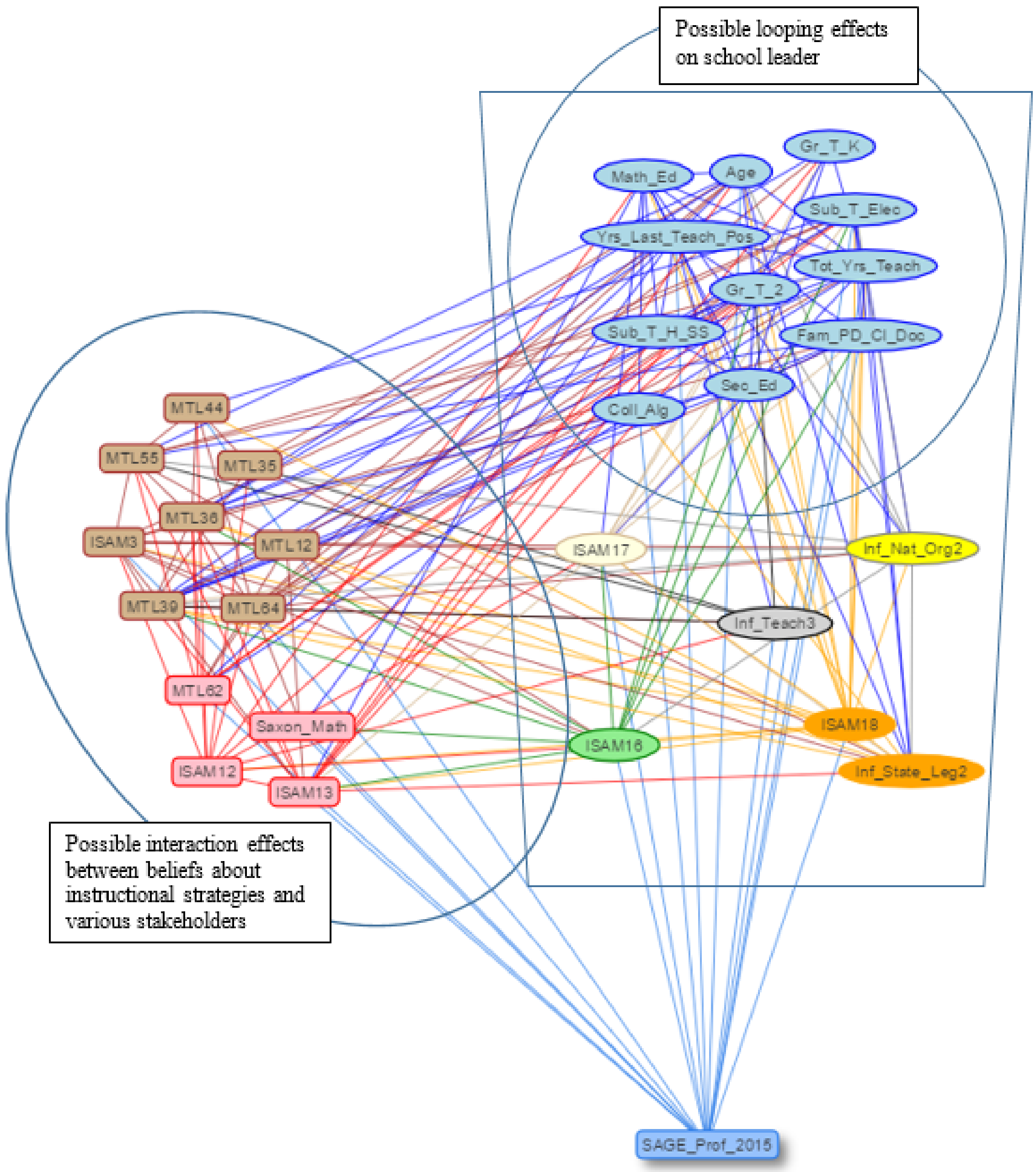

Figure 5. Network analysis. This figure illustrates to the researcher where to look for possible looping and interaction effects referencing SL-CAS conceptual framework.

correlations between variables. This analysis process allows a researcher to use a more educated approach when selecting variables to be included in the final predicative model relating school leaders' characteristics with the school-wide average SAGE mathematics proficiency scores at their respective schools.

In Figure 5, the network analysis shows the correlations between the 30 independent variables and the dependent variable, as shown by the connecting lines. These variables were then visualized within the categories aligned with the SL-CAS framework. For example, when looking at the top right oval, the blue colored variables are all school leader demographic specific variables. Thus, there appears to be multiple types of possible looping effects on the school leader. The researcher then looked specifically at these variable for these types of effects. When looking at the oval to the lower left, the brown and red variables contained in this oval are school leaders' beliefs about instructional strategies or ways to increase student achievement. Creating this type of model allowed the researcher to see where to look for possible interaction effects between beliefs about instructional methods and various stakeholders. In summary, the possible looping effects would be found around the school leaders' own characteristics, such as their age or experiences that may be influencing them more and more strongly over time. In addition, the possible interaction effects would be indicated by beliefs about instructional strategies and various stakeholders in the CAS, such as how strongly a school leader believes in the importance of cooperative work as an effective instructional strategy. Therefore, the researcher began to construct a final predictive model for school-wide average SAGE mathematics proficiency scores using these indicated variables as places in which to look for possible interaction effects and multiplicative looping effects.

First multiple regression model and post-hoc regression analysis. Using educated guesses, an initial regression model was determined and a post-hoc regression analysis was then conducted to determine emergent phenomenon present at higher hierarchical levels of the CAS that would otherwise be rejected using traditional variable reduction (see Figure 6).

Possible collinearity appears to be taking place between the interaction variable (Int_Inf_State_Leg2_MLT39) formed by “the school leaders’ perception of the amount of influence of the state legislature over the implementation of the mathematics curriculum in their school” (Inf_State_Leg2) and “the level of the school leaders’ agreement with the use of cooperative work as the primary instructional practice in the K-9 mathematics classroom” (MTL39). A second possible collinearity appears to be taking place between the interaction variable (Int_Math_Ed_MTL62) formed by “if the school leader earned a major, minor, special emphasis in mathematics education” (Math_Ed) and “the school leaders’ beliefs that certain aspects of geometry and measurement are critical foundations of algebra in grades10-12” (MTL62) and “the percent of ethnic minority students at the school leaders’ school” (%EthMin). A third possible collinearity also appears between “the school leaders’ perception of the amount of influence of teachers over the instructional methods used in the mathematics classroom at their school” (Inf_Teach3) and “the percent of low-socioeconomic students at their school “(%LowSES). A fourth possible collinearity appears between the school leaders’ “age”

Dim	Eigenvalues	Condition Index	C	Int_State_Leg2_MTL39	Inf_State_Leg2	MTL39	Int_Math_Ed_MTL62	Math_Ed	MTL62	Inf_Teach3	Inf_Nat_Org2	Age	Fam_PD_CI_Doc	ISAM18	%Low SES	%Eth Min
			Variance Proportions													
1	12.461	1.000	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
2	.561	4.713	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.01	.04	.23
3	.302	6.424	.00	.01	.01	.00	.00	.00	.00	.00	.05	.00	.00	.00	.00	.06
4	.172	8.501	.00	.01	.00	.00	.00	.00	.00	.00	.45	.00	.00	.01	.05	.00
5	.155	8.955	.00	.00	.01	.00	.00	.00	.00	.00	.11	.00	.02	.15	.02	.05
6	.093	11.551	.00	.00	.00	.00	.00	.00	.00	.00	.07	.00	.34	.05	.38	.32
7	.089	11.856	.00	.01	.00	.01	.00	.00	.00	.00	.09	.01	.37	.01	.33	.25
8	.067	13.631	.00	.01	.04	.04	.00	.00	.00	.00	.01	.01	.00	.01	.07	.03
9	.054	15.203	.00	.00	.01	.03	.00	.00	.00	.00	.08	.00	.18	.69	.07	.00
10	.022	23.779	.00	.00	.00	.00	.01	.00	.01	.00	.00	.63	.00	.03	.00	.01
11	.017	27.014	.01	.02	.05	.00	.01	.01	.01	.05	.07	.22	.04	.01	.00	.02
12	.004	57.649	.00	.83	.80	.84	.00	.00	.00	.19	.03	.00	.04	.00	.00	.00
13	.002	79.223	.24	.10	.09	.06	.05	.04	.03	.73	.02	.11	.00	.02	.02	.00
14	.000	179.547	.75	.00	.00	.00	.93	.94	.94	.03	.01	.01	.00	.02	.01	.01

Figure 6. Post-hoc regression analysis of collinearity diagnostics. This figure illustrates possible emergent phenomenon present at higher hierarchical levels of a complex adaptive system (CAS) that need further comparison with their correlations without the involvement of the dependent variable.

(Age) with itself (indicating the possibility of a nonlinear multiplicative looping effect). And, finally, a fifth possible collinearity appears between the school leaders' "age" (Age) and "the level of the school leaders' agreement with the statement: The best way to increase student achievement in mathematics is to educate members of the legislature on the curriculum and research-based instructional strategies" (ISAM18). Using purely positivist regression reductionist methods, this would indicate possible variable elimination from the final predictive model of the school-wide average SAGE mathematics proficiency as predicted by school leader characteristics and student demographics.

However, a correlation analysis between the variables in the model showed there were no significant correlations between these variables without the involvement of the dependent variable acting as the moderator (see Figure 7).

As proposed by Gilstrap (2013), this provides evidence of possible emerging phenomenon at higher hierarchical levels of the CAS. Combined with the researchers' qualitative data analysis, these variables should not be excluded in the final predictive model to answer the second research subquestion based on complexity theory.

The final multiple regression analysis. The researcher calculated a multiple regression to predict school-wide average SAGE mathematics proficiency scores based on two interactions between the independent variables and seven other independent variables as determined by the qualitative results (see following sections for qualitative results). The first interaction included in the model was between "the school leaders' perception of the amount of influence of the state legislature over the implementation of

		Int_State_ Leg2_ MTL39	Int_Math_ Ed_ MTL62	Inf_ Teach3	Inf_Nat_ Org2	Age	Fam_PD_ CI_ Doc	ISAM 18	%Low SES	%Eth Min
Int_State_ Leg2_MTL39	ρ	1.00								
	p	.								
Int_Math_ Ed_MTL62	ρ	.00	1.00							
	p	.997	.							
Inf_Teach3	ρ	.08	-.02	1.00						
	p	.315	.847	.						
Inf_Nat_Org2	ρ	0.41**	.06	.07	1.00					
	p	.000	.537	.369	.					
Age	ρ	0.18*	0.24*	.05	.12	1.000				
	p	.030	.023	.514	.115	.				
Fam_ PD_CI_Doc	ρ	.15	0.23*	-.03	.08	.06	1.000			
	p	.083	.029	.715	.295	.451	.			
ISAM18	ρ	0.30**	-.15	.02	0.21**	.11	.16	1.00		
	p	.000	.161	.767	.009	.195	.056	.		
%LowSES	ρ	.02	.12	.08	-.02	.11	.14	-.05	1.00	
	p	.818	.251	.308	.851	.171	.091	.548	.	
EthMin	ρ	.00	.04	.05	.12	0.17*	.08	-.01	0.53**	1.000
	p	.982	.687	.576	.134	.033	.313	.904	.000	.

* Correlation is significant at the 0.05 level (2-tailed).
** Correlation is significant at the 0.01 level (2-tailed).

Figure 7. Correlation analysis without involvement of dependent variable. This figure illustrates possible emergent phenomenon present at higher hierarchical levels of a complex adaptive system (CAS) indicating the need to keep these variables in the model based on Complexity Theory

the mathematics curriculum in their school" (Inf_State_Leg2) and "the level of the school leaders' agreement with the use of cooperative work as the primary instructional practice in the K-9 mathematics classroom" (MTL39). The second interaction was between if "the school leader earned a major, minor, special emphasis in mathematics education" (Math_Ed) and "their beliefs about geometry and measurement as critical foundations of algebra in grades 10-12" (MTL62). The other seven independent variables included in the model were:

1. “the school leaders’ perception of the amount of influence of teachers over the instructional methods used in the mathematics classroom at their school” (Inf_Teach3),

2. “the school leaders’ perception of the amount of influence of national organizations such as NCTM over the implementation of the mathematics curriculum in their school” (Inf_Nat_Org2),

3. the school leader’s “age” (Age),

4. “the level of familiarity the school leader has with professional development/materials/readings in mathematics curriculum and instruction” (Fam_DI_CI_Doc),

5. “the level of the school leaders’ agreement with the statement: The best way to increase student achievement in mathematics is to educate members of the legislature on the curriculum and research-based instructional strategies” (ISAM18),

6. “the percentage of low-income students at the school’ (%LowSES), and

7. “the percentage of ethnic minority students at the school” (%EthMin).

In addition, the researcher conducted several tests to check if the data met the assumptions required from the statistical tests, including linearity, normality of errors, and homoscedasticity.

Final model assumptions. The following sections discuss the final model assumptions of linearity, normality, and homoscedasticity.

Linearity. Graphing the standardized residuals against the interaction of the independent variables “between the school leaders’ perception of the amount of influence of the state legislature over the implementation of the mathematics curriculum in their school” (Inf_State_Leg2) and “the level of the school leaders’ agreement with the use of cooperative work as the primary instructional practice in the K-9 mathematics classroom” (MTL39), provides evidence that the assumption of linearity was met (see Figure 8).

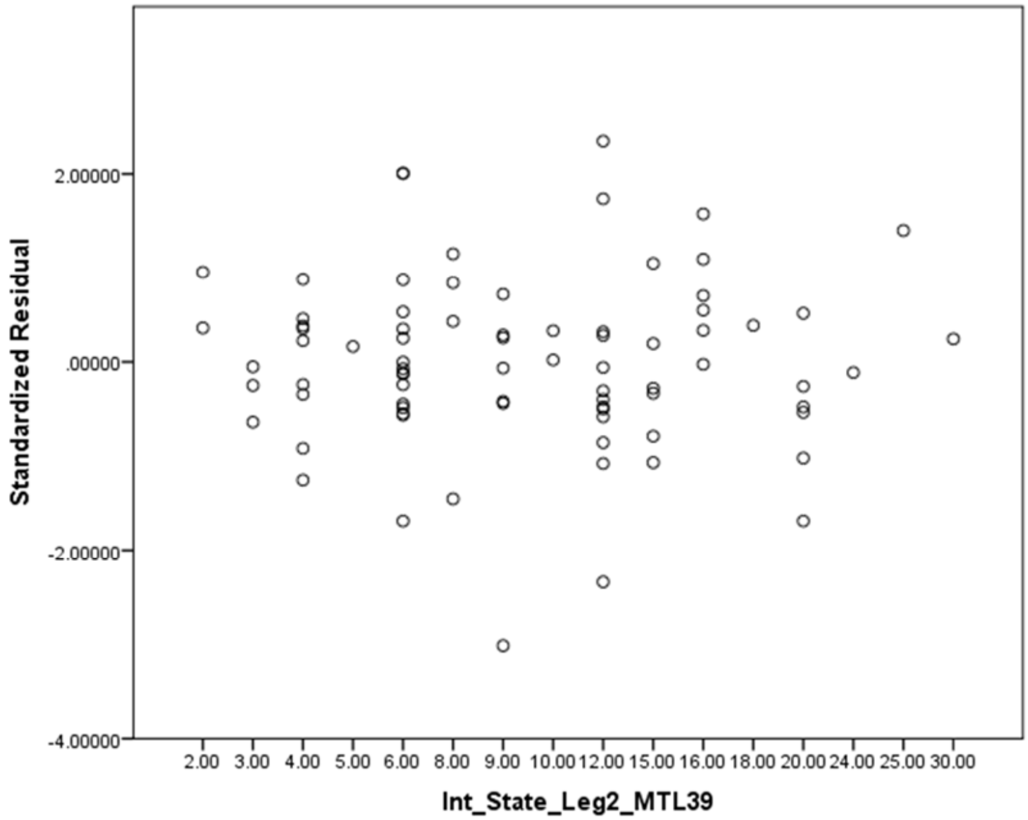

Figure 8. Standardized residual plot against interaction variable (Inf_State_Leg2*MTL39). This figure illustrates linearity because the data are fairly symmetrically distributed without any clear patterns.

Graphing the standardized residuals against the interaction of the independent variables “if the school leader earned a major, minor, special emphasis in mathematics education” (Math_Ed) and “the school leaders’ beliefs that certain aspects of geometry and measurement are critical foundations of algebra in grades10-12” (MTL62), provides evidence that the assumption of linearity was met (see Figure 9).

Normality. The assumption of normality was tested via examination of the standardized residuals. Review of the regression standardized residual histogram and the Normal P-P plot (sees Figures 10 and 11 suggest the assumption of normality is reasonable.

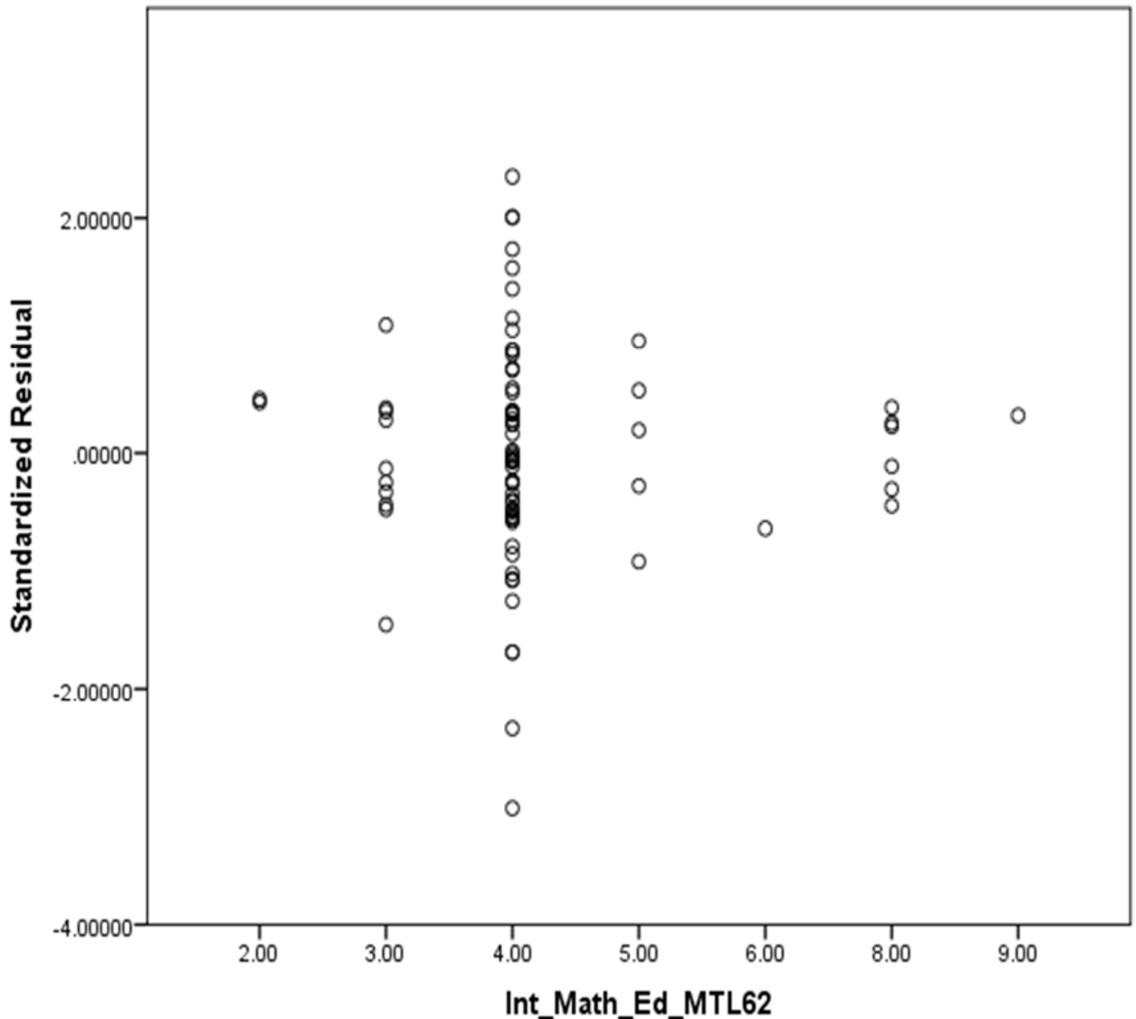

Figure 9. Standardized residual plot against interaction variable (Math_Ed*MTL62). This figure illustrates linearity because the data are fairly symmetrically distributed without any clear patterns.

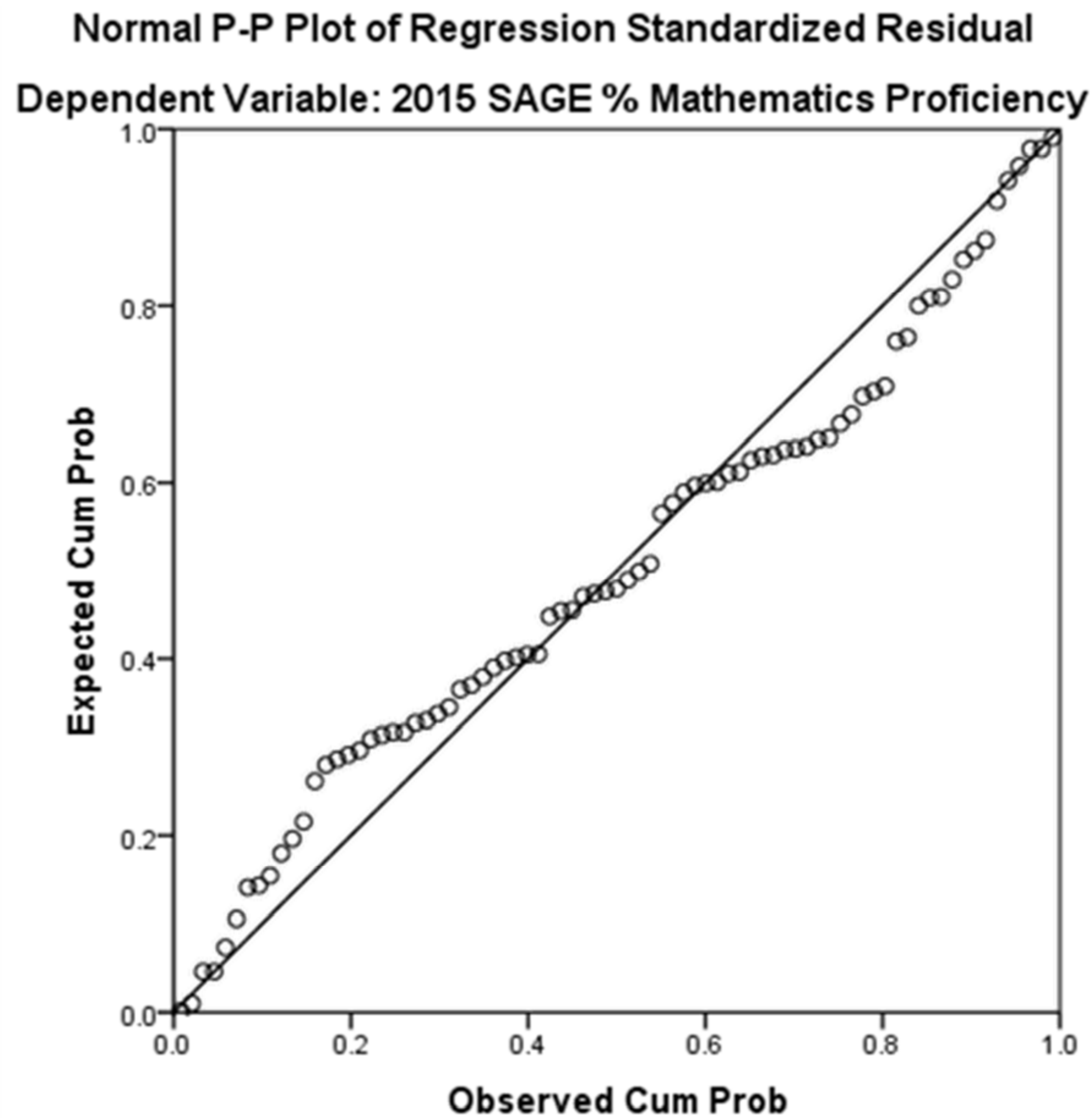

Figure 10. Normal P-P plot. This figure illustrates evidence that the assumption of normality of the final predictive model is reasonable.

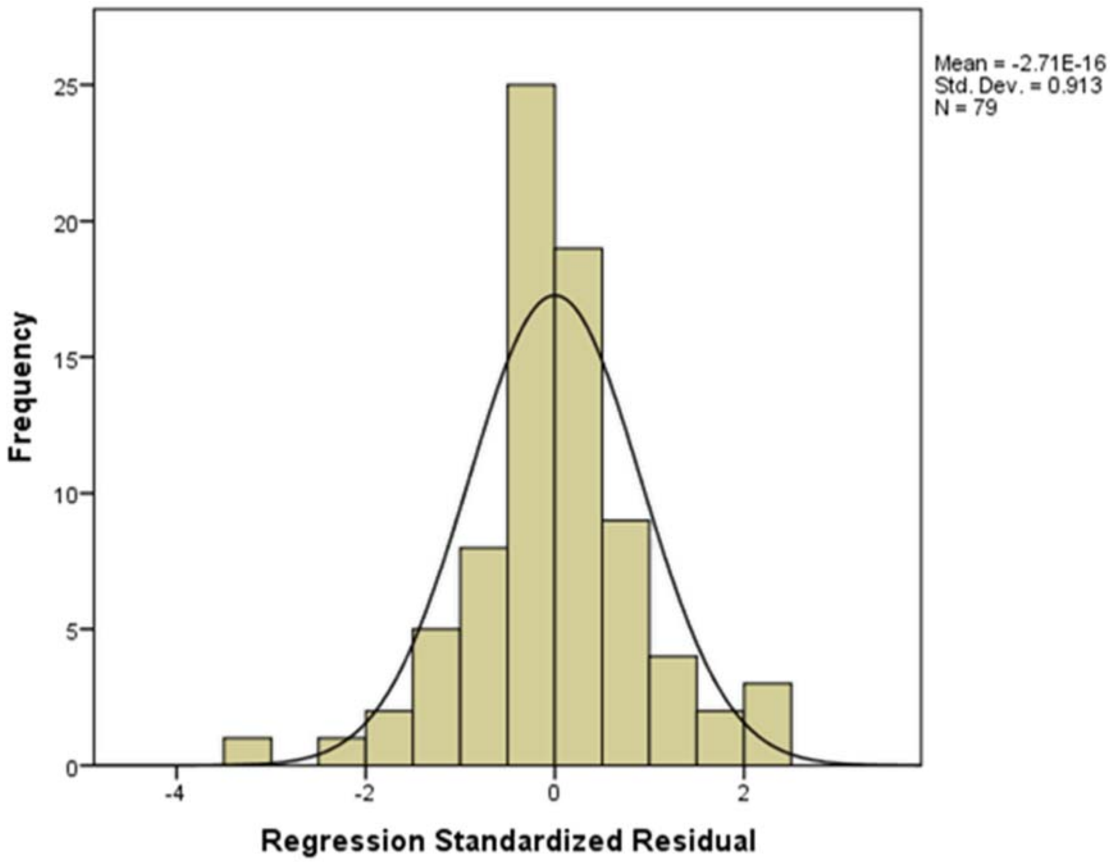

Figure 11. Histogram showing the Standardized Residuals to the 2015 SAGE School-Wide Average Mathematics Proficiency Scores. This figure illustrates evidence that the assumption of normality of the final predictive model is reasonable.

Homoscedasticity. A relatively random display of points where the spread of residuals appears fairly constant over the range of the interaction between the independent variables (Inf_State_Leg2 and MTL39, see Figure 12) provided evidence of homoscedasticity. There are some concerns for homoscedasticity between the variables (Math_Ed and MTL62, see Figure 13) but visual inspection finds the spread of residuals to meet the assumption well enough.

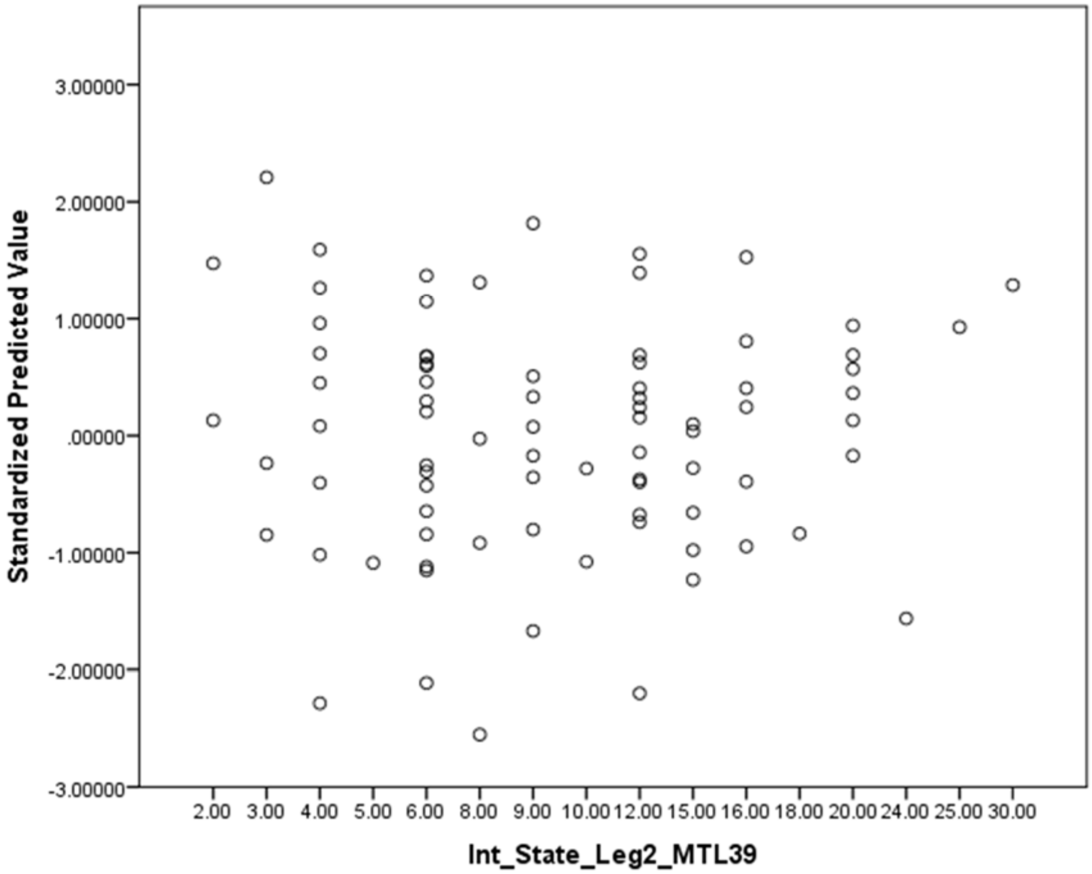

Figure 12. Spread of residuals over the range of interaction for Inf_State_Leg2_MTL39. This figure illustrates evidence that the assumption of homoscedasticity is met.

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Final predictive model based on complexity theory. Based on these assumptions, the researcher found a significant regression equation, $F(13, 65) = 6.91$, $p < .001$, with an R^2 of .580 which accounted for 58.0% of the variance in the model predicting the school-wide average SAGE mathematics proficiency scores based on several characteristics of the school leader and student demographics. Full regression results can be found in Table 7. A significant interaction effect [95% CI: .805, 4.739] was found between "the school leaders' perception of the amount of influence of the state legislature over the implementation of the mathematics curriculum in their school"

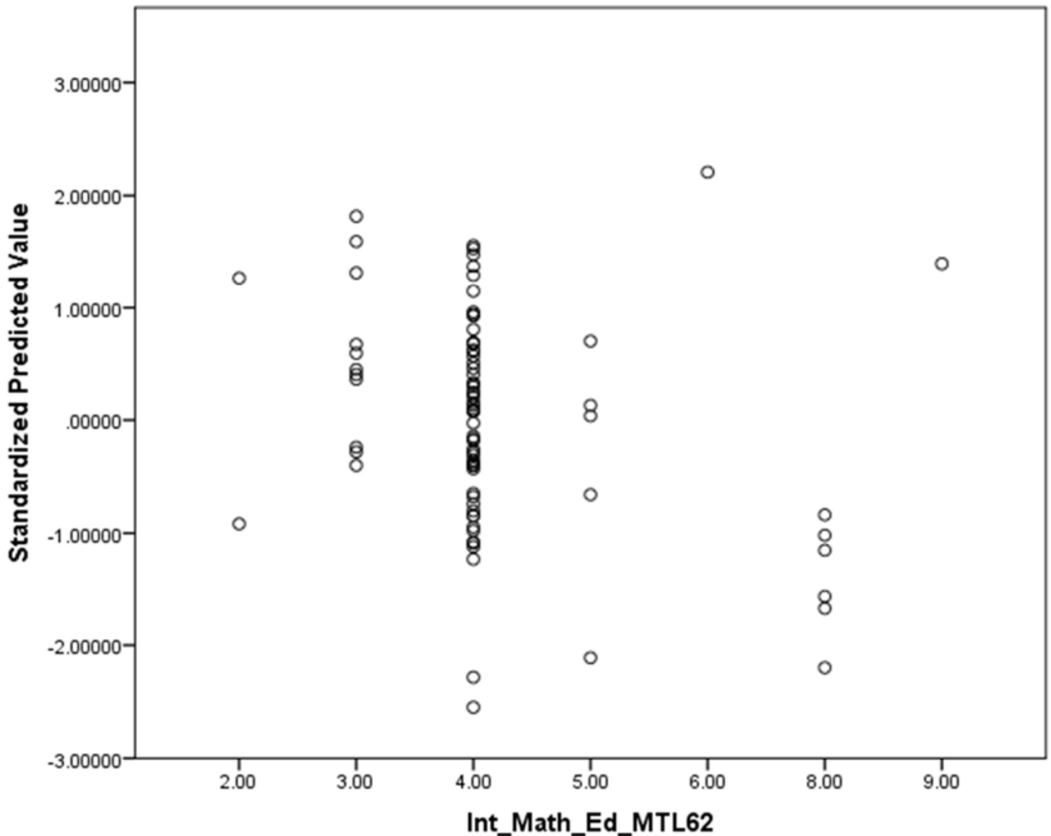

Figure 13. Spread of residuals over the range of interaction for Math_Ed_MTL62. This figure illustrates evidence that the assumption of homoscedasticity is met

(Inf_State_Leg2) and "the level of the school leaders' agreement with the use of cooperative work as the primary instructional practice in the K-9 mathematics classroom" (MTL39). While the interaction effect between "if the school leader earned a major, minor, special emphasis in mathematics education" (Math_Ed) and "their beliefs about geometry and measurement as critical foundations of algebra in grades 10-12" (MTL62) was not significant [95% CI: -29.882, 2.299], based on the post-hoc regression analysis and qualitative analysis (see sections below) which indicated emergent phenomena consistent with Complexity Theory, the researcher decided to leave the interaction in the model.

Table 7

Final Multiple Regression Results Showing Predictive Model Based on School Leader Characteristics and Student Demographics

Measures	*b*	*SE*	*t*	*p*
Intercept	109.69	38.78	NA	NA
Inf_State_Leg2*MTL39	2.77	.99	2.82	.006
Inf_State_Leg2	-8.26	3.63	-2.28	.026
MTL39	-6.93	3.71	-1.87	.066
Math_Ed*MTL62	-13.79	8.06	-1.71	.092
Math_Ed	53.15	28.55	1.86	.067
MTL62	10.76	8.90	1.21	.231
Inf_Teach3	-8.88	3.68	-2.42	.019
Inf_Nat_Org2	-3.22	1.20	-2.69	.009
Age	-.35	.18	-1.89	.064
Fam_PD_CI_Doc	-2.34	1.20	-1.95	.056
ISAM18	2.95	1.40	2.11	.039
%LowSES	-.25	.09	-2.92	.005
%EthMin	-.03	.10	-.32	.75

Note. R^2 = .58.

In addition, due to similar evidence, the independent variables of school leader's "age" (Age), "the level of familiarity the school leader has with professional development/materials/readings in mathematics curriculum and instruction" (Fam_PD_CI_Doc), and "the percent of ethnic minority students" (%EthMin) were also left within the model. Thus, the school-wide average SAGE mathematics proficiency predicted scores are equal to 2.77 (Inf_State_Leg2*MTL39) - 8.26 (Inf_State_Leg2) - 6.93 (MTL39) - 13.79 (Math_Ed*MTL62) + 53.15 (Math_Ed) + 10.76 (MTL62) - 8.88 (Inf_Teach3) - 3.22 (Inf_Nat_Org2) - .35 (Age) - 2.34 (Fam_PD_CI_Doc) + 2.95 (ISAM18) - .25 (%LowSes) -.03 (%EthMin) + 109.69.

The interaction between "the school leaders' perception of the amount of influence of the state legislature over the implementation of the mathematics curriculum in their school" (Inf_State_Leg2) and "the level of the school leaders' agreement with the use of cooperative work as the primary instructional practice in the K-9 mathematics classroom" (MTL39; see Figure 14) indicates that the school-wide average SAGE mathematics proficiency score in the schools where school leaders agreed with (and presumably supported) cooperative work in the K-9 classroom tended to be higher when school leaders perceived the influence of the state legislature over the implementation of the mathematics curriculum was higher. On the other hand, school-wide average SAGE

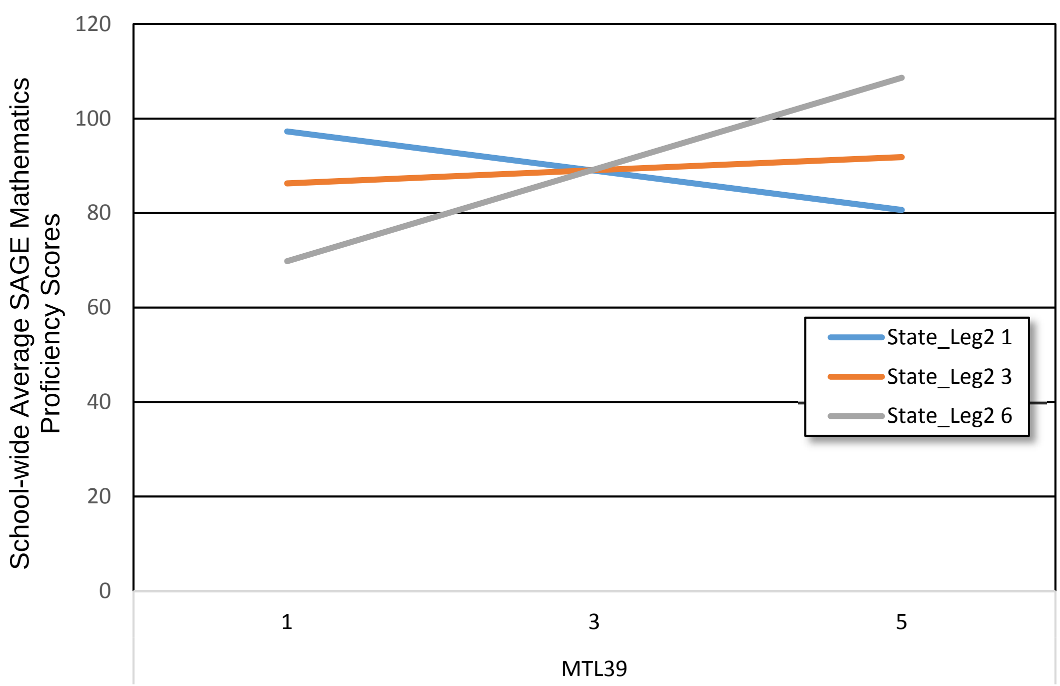

Figure 14. Interaction effects of school leaders' perceptions of the influence of the state legislature on the mathematics curriculum and the school leaders' belief in the value of cooperative work on school-wide average sage mathematics proficiency scores. MTL39 Values: 1. Strongly Disagree with Cooperative Work in Grades K-9. 3. Neutral About Cooperative Work in Grade K-9. 5. Strongly Agree with Cooperative Work in Grades K-9. Influence of State Legislature on Mathematic Curriculum Values: 1. No Influence. 3. Moderate Influence. 6. Very Strong Influence

mathematics proficiency scores in the schools where school leaders did not agree with (and presumably did not support) cooperative work in the K-9 classroom tended to be higher when the school leaders perceived the influence of the state legislature was lower.

The interaction between the variables “if the school leader earned a major, minor, special emphasis in mathematics education” (Math_Ed) and “their beliefs about geometry and measurement as critical foundations of algebra in grades 10-12” (MTL62) was analyzed using dummy variables to compare the school-wide average SAGE mathematics proficiency scores between school leaders with and without a mathematics education degree to their agreement with MTL62. The interaction (see Figure 15) indicated that the

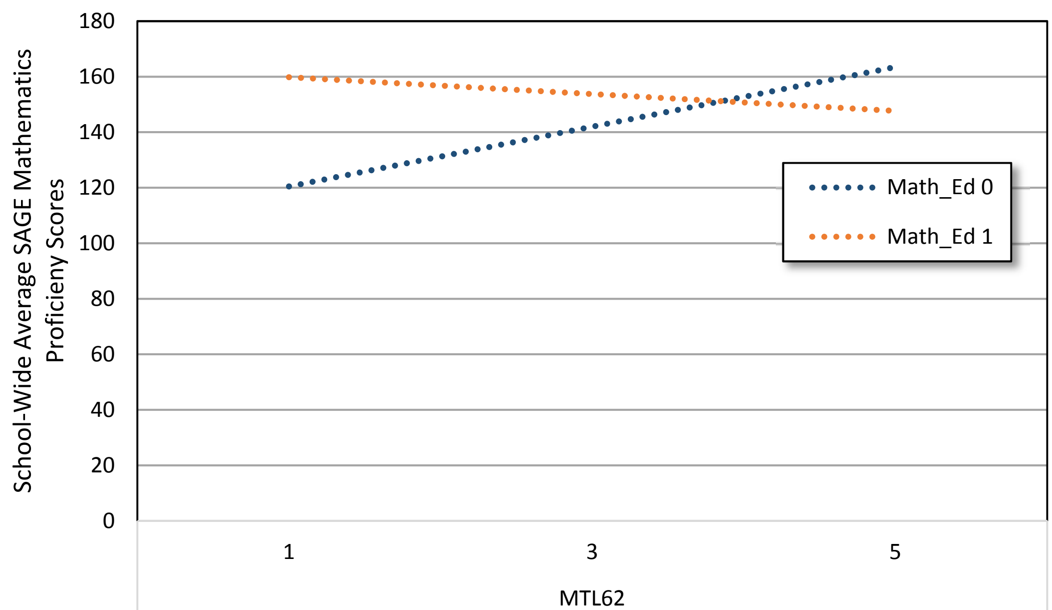

Figure 15. Comparison of school-wide average SAGE mathematics proficiency scores between school leaders with or without a mathematics education degree to agreement with beliefs about geometry and measurement as foundations for algebra in grades 10-12. MTL62: 1. Strongly Disagree that Geometry and Measurement are Foundations of Algebra in Grades 10-12. 3. Neutral that Geometry and Measurement are Foundations of Algebra in Grades 10-12. 5. Strongly Agree that Geometry and Measurement are Foundations of Algebra in Grades 10-12. Math Ed: 0. No Degree. 1. Yes Degree. The dotted line is used to indicate that Math_Ed is a categorical variable.

school-wide SAGE mathematics proficiency score in the schools where school leaders did have mathematics education degrees tended to be higher if they disagreed or were neutral with the statement: “In 10-12, certain aspects of geometry and measurement are critical foundations for algebra”. On the other hand, school-wide SAGE mathematics proficiency scores in the schools where school leaders did not have a mathematics education degree tended to be higher if they strongly agreed with the statement.

Other aspects of the model indicated that for every point higher “school leaders’ perception of the amount of influence of teachers over the instructional methods used in the mathematics classroom at their school” (Inf_Teach3) rose, the school-wide average SAGE proficiency scores dropped by 8.88 points. In addition, for every point higher “school leaders’ perception of the amount of influence of national organizations such as NCTM over the implementation of the mathematics curriculum in their school” (Inf_Nat_Org2) rose, the school-wide average SAGE proficiency scores dropped by 3.22 points. Next, the model predicts that for every year older the school leader’s “age” (Age), the school-wide average SAGE proficiency scores dropped by .35 points. Then, the model predicts that for every point higher “the level of familiarity the school leader has with professional development/materials/readings in mathematics curriculum and instruction” (Fam_PD_CI_Doc), the school-wide average SAGE proficiency scores dropped by 2.34 points. Also, for every point more “the school leader agreed with the statement: ‘The best way to increase student achievement in mathematics is to educate members of the legislature on the curriculum and research-based instructional strategies’” (ISAM18), the school-wide average SAGE proficiency scores rose by 2.95 points. In addition, for every percentage point higher “the percentage of low-income students at the school” (%LowSES), the school-wide average SAGE proficiency scores dropped by .25 points. Finally, the model predicts that for every percentage point higher “the percentage of ethnic minority students at the school” (%EthMin), the school-wide average SAGE proficiency scores dropped by .03 points.

Qualitative Results

Constant comparative analysis procedures were used, utilizing the lens of complexity theory, to answer questions 3 and 4. These results followed from the analysis of the focus group interviews of school leaders representing schools whose school-wide SAGE mathematics proficiency scores were higher, at expected, or lower than their demographics suggest. The following sections discuss the results of this analysis.

Question 3

This section answers the third research question: What relationships with stakeholders in the schools influence school leaders’ decisions? Figures 17-19 (shown and discussed later in this chapter) show the relationships with stakeholders in the schools and how they are influencing school leaders’ decisions disaggregated by school-wide SAGE mathematics proficiency scores.

Relationships between school leaders and stakeholders in schools performing higher than expected. Figure 16 shows the relationships and their influences on school leaders in schools whose school-wide SAGE mathematics proficiency scores were higher than their demographics suggest. The red arrows indicate the influences felt on other

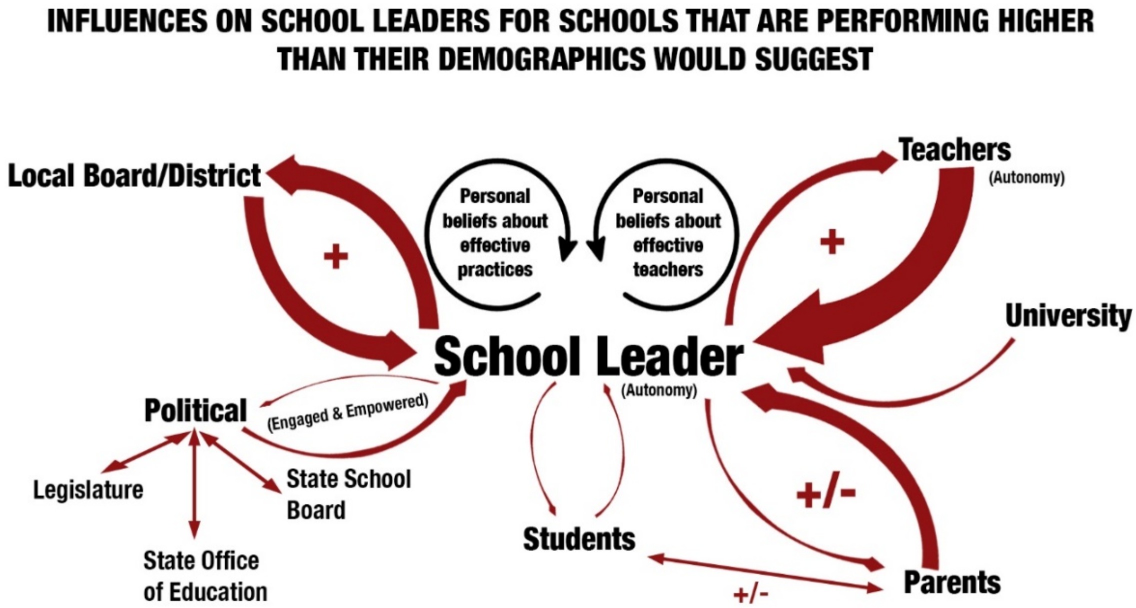

Figure 16. Relationships with stakeholders and school leaders in schools performing higher than their demographics suggest. This figure illustrates the influences in order of most influential as on the school leader as perceived by the school leader. The thicker the arrow, the more the school leader perceived its influence.

stakeholders from the school leader or by the school leader from other stakeholders. The black arrows indicate influences felt by the school leader on themselves. The thickness of the arrows indicates the relative strength of the influences as perceived and described by the school leaders who participated in the focus group interviews. The thickness of the arrows also indicates the identified frequency with which the influences were described by school leaders in comparison to other influences.

As can be seen in Figure 16, the most influential stakeholders on school leader's decisions were generally teachers, the local school board and/or district office, and parents, in that order. As Matt indicated:

> By far the teachers are the most influential with me. I rely on them. I've never been a math teacher. When they say. "This is the way we should be doing things."

> I'll do my due diligence in hearing all the different groups or doing personal research. I trust my teachers. I make a lot of decisions, even decisions that I don't necessarily agree with, based on their recommendation.

Nick agreed, "Definitely the teachers…they're the ones…in the trenches." However, Audra said, "I would say that the board is probably first…. My teachers would be the next …they are the ones that have the knowledge and the understanding of math." Jack concurred with Matt and Nick but included parental influences, "It's usually going to be…the teachers… [also] probably…parents."

School leaders viewed the interactions between teachers and school leaders and the local school board and/or district office primarily as positive in both directions. In every case, school leaders in this group indicated a unified philosophy about effective instructional strategies between themselves and the teachers and the local school board and/or district office. With regards to this, Matt indicated "the two…most powerful influences" were "this professional body which includes district math specialists and school based math teachers who have this philosophy of what math instruction should look like," while Jack said, "I believe that the teachers were pretty free to choose how they taught the math. Some of the influences I guess that lead to that were some of the NCTM documents…the professional teaching standards." Charles stated, "It's interesting. The elementary, for a while, was the top elementary in the state. It's because I have four teachers there that have been there for 20 years together.… They know what it takes."

In addition to this unified philosophy about effective instructional strategies, school leaders consistently described a distributed ownership of data among various stakeholders and a distributed leadership style. Audra gave a detailed explanation of how these worked together in a recent scenario at her school where teachers "gave me three different proposals" and they implemented the first proposal. However, "when we tried that the first year, it didn't work. It was too fast and the kids did not understand the concepts." So she described going back with the math teachers and looking at the plan again and going with the second proposal. She said, "The grades were much higher. We [felt] really happy with that. We are not going to go to plan 3."

School leaders indicated both positive and negative influences by parents, but not in an adversarial way. They viewed parents as partners in the educational effort of students. Audra indicated, "The parents want to have their students get through as much college as possible and so the parents are pushing their kids, sometimes." Matt also indicated how parents were involved, "We had a lot of different groups from the district down to parents up, to decisions in the school that were invested in that process, because that was a specific process."

School leaders were strongly influenced by their own personal beliefs about effective practices and effective teachers, moderately influenced by university sources, and in a smaller way, influenced by students. Taken together, this provided evidence of a shared vision surrounding mathematics education as articulated by the school leader. Table 8 summarizes common characteristics, or themes, among schools performing better than their demographics suggest.

Relationships between school leaders and stakeholders in schools performing about where they are expected. Figure 17 shows the relationships and their influences

Table 8

Shared Vision of Mathematics Education

Characteristics	Description
Unified philosophy about effective instructional strategies	School leaders indicated that teachers, school leaders, and district/office demonstrate a common understanding of effective instructional strategies with respect to mathematics education.
Distributed ownership of data	School leaders indicated that multiple stakeholder groups have regular and consistent access to student mathematics data. Furthermore, this data was routinely discussed and interpreted between stakeholder groups often without the direct facilitation of the school leader themselves.
Distributed leadership model	School leaders indicated that school level decisions with respect to mathematics education were made in collective and cooperative ways, particularly with teachers and parents.
School leader autonomy	School leaders indicated they felt they had the ability to make school level decisions with respect to mathematics education without undue interference from external influences.
Teacher autonomy	School leaders indicated that they felt that the teachers in their school had the ability to make classroom level decisions with respect to mathematics education without undue interference from external influences.
Parents as partners	School leaders indicated a generally positive relationship with parents in which parents and the school were working together for student success in mathematics education.

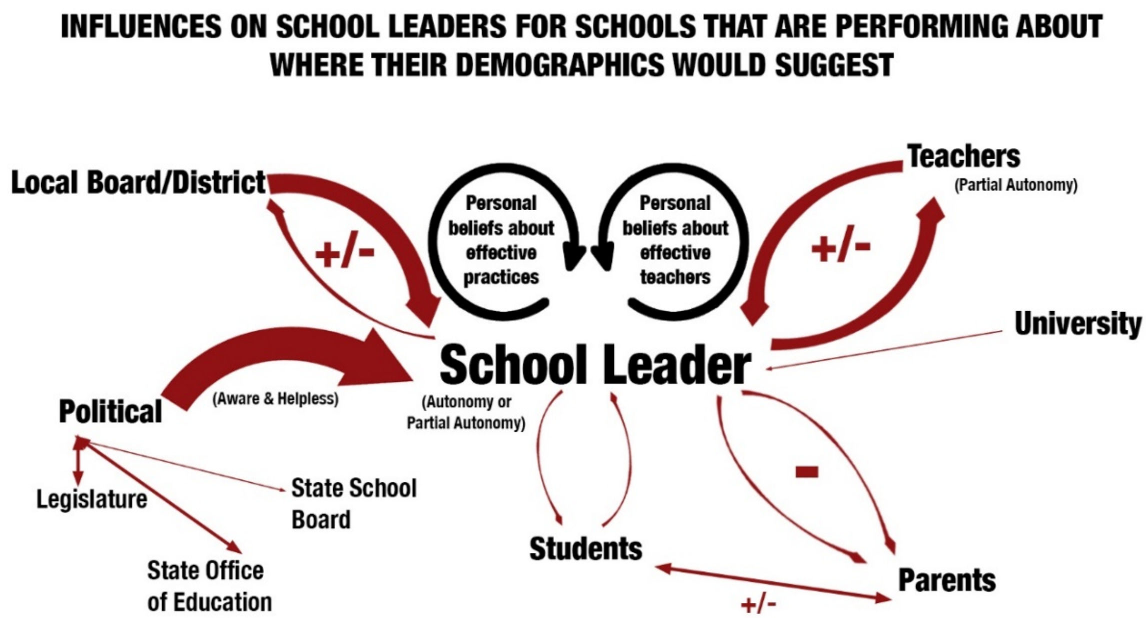

Figure 17. Relationships with stakeholders and school leaders in schools who are performing about where their demographics suggest. This figure illustrates the influences in order of most influential as on the school leader as perceived by the school leader. The thicker the arrow, the more the school leader perceive its influence.

on school leaders in schools whose school-wide SAGE mathematics proficiency scores were about where their demographics suggest.

As can be seen in Figure 17, the most influential stakeholders on school leader's decisions were political groups, particularly the state legislature and the state office of education. These were followed by the local school board and/or district office, teachers, and themselves, in that order. Political influences were particularly strong with this group. School leaders primarily expressed frustration with the state legislature and state office of education, with very little mention of the state school board. These expressions were characterized by a sense of helplessness, and of being acted upon in negative ways without the ability to do anything about it. Candace said, "Well, I still feel like the legislature/state office has that top ranking because they come up with the standards and that's where it all starts. After that, wow, that's a great question." Jay said, "I would say the highest would be the state level. The second would then be me, followed by local or the school board." Susan agreed:

> …but also for me, it's external requirements. The core is the core and we aren't going to change the core for our single campus. I would say the higher-level influences decisions that support implementing resources that achieve the core, the standards."

School leaders perceived the interactions between teachers and school leaders and the local school board and/or district office as both positive and negative. Kay described a negative, "We have very little input at all." Candace added a positive, "[they] just finished writing the textbook for fourth, fifth, and sixth grade, rather than adopting one from a national company or anything like that."

School leaders in this group frequently referred to a non-unified philosophy about effective instructional strategies between themselves and the teachers and/or the local school board and/or district office. Most of these were disagreements between school leaders and one or more teachers at their school. Jay indicated disagreement with a teacher, "…we've had one teacher, who for years has just really struggled, management and discipline as well as getting on the same page and working with some of those other teachers…." Dakota also indicated a similar disagreement, "We're still doing a lot of procedural things, especially in the younger grades." However, Kay indicated disagreement with her district, who advocated teaching multiple solution strategies:

> …everybody learns 3 or 4 different ways to solve the same kind of a problem, which is wonderful. But, really, do you want to do that to a second grader?...it's just very frustrating to me.… I think we need to just back off a bit and quit

> comparing ourselves to Singapore Math and everybody else, because it's not apples with apples. You have to do this and you have to memorize this and you have to do this. That seems to help.

In addition to this nonunified philosophy about effective instructional strategies, school leaders consistently described a directive ownership of data. In this type of data ownership, school leaders described themselves as the primary holders of school data, and they determined how that data was distributed among other stakeholders. As such, school leaders described a more directive leadership style with various attempts to move toward a more distributive leadership style. Charles' statement was typical of what was said:

> Every time we sit down for a PLC, we look at their data and then we talk about it. If there's a particular area they're struggling in, or 70% of the kids in the class didn't do well, then definitely there's an issue there. Why is that? We pick it apart and then we just have conversations about what do you need and let's look at this data. It appears that something happened here, and I try to get them to figure out, because they usually know. "I taught it too fast, or I thought the kids knew more than they really did so now I have to go back and re-teach it," or whatever. Or maybe it's just a little handful of kids that 70% of the kids got it, but 30% didn't. Well, what are we going to do with that 30%?

School leaders primarily indicated negative influences by parents often in an adversarial way. Thus, parents were often viewed as adversarial partners in the educational effort of students. One typical statement included this exchange:

> Susan: If parents don't communicate to their children that persevering through solving math problems that don't come easy, is an important skill to develop, like exercising that muscle. If they just say, "Well it's too hard and I can't help you, this is dumb that you were even assigned this problem if you can't do it on your own," or whatever, if they send a message that they are themselves not good at math or they don't value math, it's harder for the kids to have the buy in...
>
> Kay: I agree with that 100% 'cause I'll have a kid come back and say, "Well I can't do that. My mom couldn't do it either. She said she's always been bad at math. So, I'm bad at math, too." They look to it, sometimes I think as an excuse

for why should I try?

Susan: Or like the parent who writes on the homework assignment, "I'm an engineer and I can't figure out what they're asking. This is dumb."

Kay: Yeah, that helps a lot.

Susan: It's like, "Well get out of your own head and take a step back. What they're asking isn't that hard. It's just a different way than you were ever taught to look at it." This solving problems in a variety of ways that you referenced earlier, that's not the way parents learned math. If their kids aren't learning math the way they learned math, then they think something's wrong.... I think the attitude of the parents definitely sways how willing the kids are to try or not try or complete homework or not.

School leaders were also influenced in a small way by students and slightly by university sources. Taken together, this provides evidence of a disparate vision surrounding mathematics education as articulated by the school leader but with many expressions of trying to move towards a shared vision. Table 9 summarizes common characteristics among schools performing about where their demographics suggest.

Relationships between school leaders and stakeholders in schools performing lower than expected. Figure 18 shows the relationships and their influences on school leaders in schools whose school-wide SAGE mathematics proficiency scores were lower than what their demographics suggest.

As can be seen in Figure 18, the most influential stakeholders on school leader's decisions were the local board and/or district office and parents, in that order. School leaders perceived the interactions between school leaders and the local school board and/or district office as both positive and negative, and these fell into two categories. Those who viewed this influence as primarily negative saw the local school board and/or district office as a sabotaging force or as lacking in support. Grant gave such an example.

Table 9

Disparate Vision of Mathematics Education (Trying to Move Towards a Shared Vision)

Characteristics	Description
Nonunified philosophy about effective instructional strategies	School leaders indicated that one or more individuals from the teachers, school leaders, and district/office stakeholder groups demonstrated differing understandings of effective instructional strategies with respect to mathematics education.
Directive ownership of data	School leaders indicated that a few stakeholder groups, as determined by the school leader, have regular and consistent access to student mathematics data. Furthermore, this data was routinely discussed and interpreted between stakeholder groups often with the direct facilitation of the school leader themselves.
Directive leadership model/attempting to move toward a distributed leadership model	School leaders indicated that school level decisions with respect to mathematics education were made in more top to bottom ways, particularly with teachers and parents.
School leader autonomy or partial autonomy	School leaders indicated they felt they had or sometimes had the ability to make school level decisions with respect to mathematics education without undue interference from external influences.
Teacher partial autonomy	School leaders indicated that they felt that the teachers in their school sometimes had the ability to make classroom level decisions with respect to mathematics education without undue interference from external influences.
Parents as adversarial partners	School leaders indicated a generally negative relationship with parents in which parents and the school were not working together for student success in mathematics education.

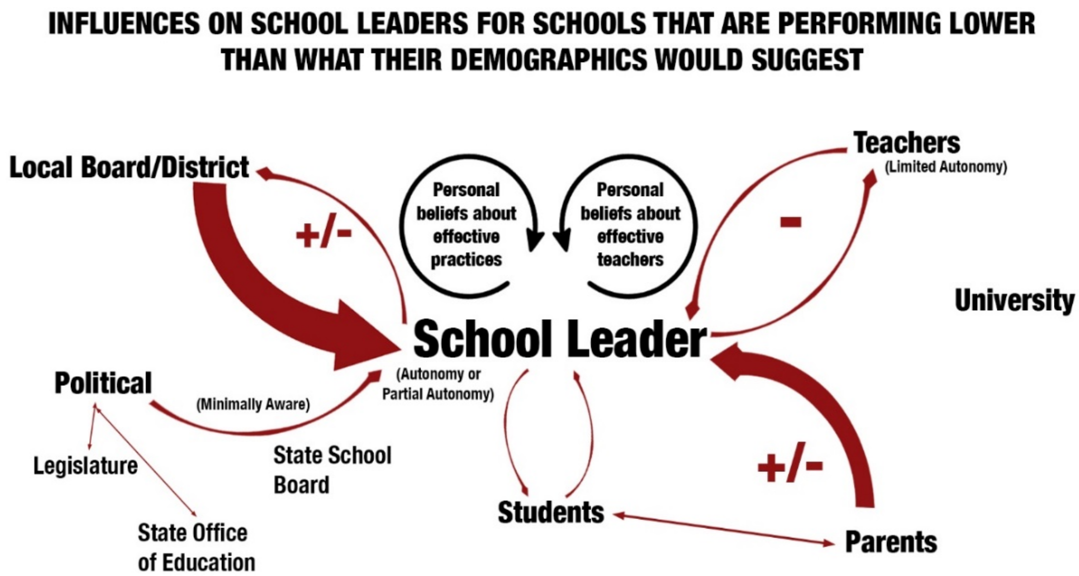

Figure 18. Relationships with stakeholders and school leaders in schools who are performing lower than what their demographics suggest. This figure illustrates the influences in order of most influential as on the school leader as perceived by the school leader. The thicker the arrow, the more the school leader perceived its influence.

"… our district is loud, especially with math, because they don't like that department." Kandy indicated, "We just lack support.… It doesn't exist.… It's like, 'Here you are! Teach!' It's very frustrating. It's frustrating for teachers. It's frustrating for me…getting thrown into the position and not really knowing what I'm doing either." Those who saw this as primarily positive viewed the local school board and/or district office as supportive, especially with respect to curriculum resources. Kelly said, "Probably the loudest voice we have is our district personnel for the math department and math curriculum department, because [our] district has created their own math program, K-6."

School leaders viewed parents both positively and negatively. Those who viewed parents positively perceived them as malleable and persuadable due to their total trust in what the school was doing. An example was this exchange between Arla and Judy:

> Arla: Our parents don't feel empowered about school.… Our parents are almost all refugees and immigrants.… Culturally, they are not used to going to school and telling the school what to do. No parents are saying, "Oh you need to.…"
>
> Judy: They're very trusting.
>
> Arla: Very trusting and respectful.

Those who viewed parents negatively perceived them as unengaged, or as a sabotaging influence, such as Kandy who said:

> Parent involvement, or the lack of…we don't have homework coming back.... and they don't want their kids really to participate in things, because it takes them away from their jobs for one thing, and it takes them away from their family time, which is huge, really important…. So, they're not willing to participate."

School leaders in this groups did not see parents as real partners in the educational process.

In addition, school leaders in this group frequently referred to an unknown or non-unified philosophy about effective instructional strategies between themselves and the teachers while indicating that the teachers did not have a very influential voice at their schools. Judy was one school leader who viewed teachers as ineffective or unknowledgeable:

> When I first got to my school, …I noticed that there was an inordinate amount of time in Tier II interventions, and not necessarily teachers running them. It was lots of staff pulling kids in and out.… So, we spent this last year really trying to get to the root cause of our academic failure.… We even went so far back as, "Here's what a standard is. Let's unpack it. What do kids need to be able to know, understand and do?"… I thought it would take us maybe a couple of months to get my teachers to the point where they were planning real explicit lesson plans that met the requirement of the standard and how they were going to assess them. It took us until March.

And, as with other school leaders in this group, Arla stated that her teachers "don't have that loud of a voice."

School leaders consistently described an underutilized directive ownership of data. In this type of data ownership, school leaders described themselves as the primary holders of school data; however, school leaders were often not able to quickly process or interpret the data in order to distribute it to other stakeholders in a timely way. In addition, school leaders in this group favored a more directive leadership style, with some minimal attempts to move toward a more distributive leadership style as evidenced from this statement by Kandy:

> In my presentation to the board, I made teachers write up strategies. This is what you're going to do to talk through the learning. There will be stations here. How are you going to build your time? What are you going to do with this block? They did that. Now it's just making sure that they're going to follow through on all these directions that they're going to use throughout the year. Anyway, hopefully it works.

Kelly also indicated this directive leadership style when referring to meetings he required teachers to attend to discuss various struggling student scenarios: "because I knew some teachers would never come.… I made sure that everybody came." Judy shared similar sentiments as she referred to conversations with her teachers. "…[T]hen, you have to back up and say, 'Do you even know what your "I dos" should look like, because do you understand what the standard is requiring your students to be able to do?'"

School leaders were influenced in a small way by students and politics. None of the school leaders in this group even mentioned university influences. Taken together, this provides evidence of a disparate vision surrounding mathematics education as articulated by the school leader with some minimal expressions of trying to move towards a shared vision. Table 10 summarizes common characteristics among schools performing about where their demographics suggest.

Table 10

Disparate Vision of Mathematics Education (Minimal Attempts to Move Towards a Shared Vision)

Characteristics	Description
Unknown or nonunified philosophy about effective instructional strategies	School leaders indicated that teachers, school leaders, and district/office did not demonstrate a common understanding of effective instructional strategies with respect to mathematics education.
Underutilized directive ownership of data	School leaders indicated that multiple stakeholder groups did not have regular and consistent access to student mathematics data. Furthermore, this data was not routinely discussed and interpreted between stakeholder groups without the direct facilitation of the school leader themselves.
Directive leadership model/minimal attempts to move toward a distributed leadership model	School leaders indicated that school level decisions with respect to mathematics education are made top to bottom, particularly with teachers.
School leader autonomy or partial autonomy	School leaders indicated they felt they had or sometimes had the ability to make school level decisions with respect to mathematics education without undue interference from external influences.
Teacher limited autonomy	School leaders indicated that they felt that the teachers in their school did not have the ability to make classroom level decisions with respect to mathematics education without undue interference from external influences.
Parents not partners	School leaders indicated a generally absent relationship with parents in which parents.

Question 4

This section answers the fourth research question: What decisions and actions are being made by school leaders? The decisions and actions made by school leaders in each group also had distinct characteristics. Utilizing constant comparative analysis, the researcher identified twelve categories of decisions and actions described by the school leaders with respect to their efforts to increase students' mathematics achievement at their respective schools. Table 11 summarizes the 12 categories of common decisions and actions made by school leaders in each group.

The following sections discuss the 12 common decisions and actions of school leaders from Table 11, based on the school's student performance in mathematics.

Table 11

Types of Common Decisions and Actions Made by School Leaders Across All Groups

Type	Description
1. Personal beliefs about effective practices	These are the decisions and actions about effective practices in the school leaders' schools based on their own personal beliefs.
2. Personal beliefs about effective teachers	These are the decisions and actions surrounding effective teaching in the school leaders' schools based on their own personal beliefs.
3. Personal beliefs about what helps students the most	These are decisions and actions about the use of resources to help students succeed in mathematics at the school leaders' school.
4. Personal beliefs about what hinders students the most	These are decisions and actions about how the use of resources may hinder students' success in mathematics at the school leaders' school.
5. Teacher recruitment and retention	These are decisions and actions surrounding teacher recruitment and retention at the school leaders' school.
6. Mathematical supports for teachers	These are decisions and actions surrounding mathematical supports for teachers at the school leaders' school.
7. Teacher evaluation and feedback	These are decisions and actions surrounding teacher evaluation and feedback practices at the school leaders' school.
8. Data	These are decisions and actions based on the use of data at the school leaders' school.
9. Politics	These are the decisions and actions being made with respect to political influences at the school leaders' school.
10. Curriculum	These are decisions and actions based on the use of curriculum resources at the school leaders' school.
11. Organizational structure	These are decisions and actions about the organizational structure of the school leaders' school.
12. Mathematical supports for students	These are the decisions and actions surrounding mathematical supports for students at the school leaders' school.

Distinctive patterns emerged from each group as school leaders described each type of decisions and actions associated with each category.

Personal beliefs about effective practices. The following section describes the decisions and actions among the three different groups of school leaders, regarding personal beliefs about effective practices.

Among those performing higher than expected. School leaders in the group with higher than expected SAGE mathematics proficiency scores expressed commitment to inquiry-based learning grounded in real-world contexts with a focus on problem solving. The school leaders in this group indicated a belief in conceptual learning joined with procedural learning that stressed multiple solution strategies as evidenced by this representative statement by Matt, "I think in our district, there is more broad acceptance of conceptual and inquiry based, problem-solving based math.… It doesn't look like math looked like when our parents went to school."

In addition, heterogenous grouping with teacher differentiation was favored over ability grouping, as was daily mathematics classes, as evidenced by Jack's remark:

> Sometimes putting them in a homogenous group…with other kids, is as valuable as taking that kid and this kid that are low and sticking them in a low group with low kids. Where they get the most benefit from their learning, probably from being with the kids who have ideas, rather than the kids who don't have ideas.

Among those performing about where expected. School leaders in the group with at expected SAGE mathematics proficiency scores fell into two categories. First, some school leaders believed that students shouldn't need to learn multiple ways to solve problems because it's too hard for them and it's more effective and efficient to teach all students one consistent way to do math problems. This is evident in Kay's statement:

> … They need some kind of algorithm just to get them going, I think, so that they have a consistency where they can go, "Oh, that's where I missed it," instead of, "I'm confused, because this is part of this and this is part of this."

In contrast, the second trend among this group was the importance of stressing positive mindset, alternative strategies, and the importance of mathematical discourse practices as evidenced by Candace:

> I think our number one thing has been a real emphasis on math talk, both for teachers and for students. Talking about the process, the thinking process involved with math. It's not acceptable anymore to just put this problem up on the board or up on the doc cam and have a kid come up and solve it while everybody sits in silence and watches it magically have an answer. We talk a lot, the kids are required to talk through what they are doing to solve a problem. Teachers talk through it. Kids are encouraged to share alternate ideas and ways to solve a problem, as opposed to even what the teacher presented.... I think it's just changing the mindset a bit at a time.

However, all the school leaders in the at expected group believed it was important to group students by ability. Susan described one typical arrangement:

> We have math at the beginning of the day for all elementary classes. That gives students the ability who are advanced to move up in math.… That's a good support. But then immediately following the math block is a math enrichment time.… the kids are grouped depending on if they are already mastering or are proficient with the material…that math enrichment could look very different depending on where the kids are grouped. We have four classes per grade, so a lot of times, two teachers will take the middle average kids on grade level, one will take the high and we try to make that as large of a group as possible, to try to offset and have a smaller group with push in aids for the lowest.

Among those performing lower than expected. School leaders in the group with lower than expected SAGE mathematics proficiency scores reported that effective tier I instruction was most important, that they needed to be using data, that teachers should be collaborating and developing their own curriculum to understand the standards, that mathematics classes should be daily, that there should be a focus on mathematics language and talk but that instruction should focus on basics, and that students should not move ahead until basics are mastered. This is evident in Kandy's statement, "Kids who have learning difficulties…trying to teach them multiple ways, that's the frustration I think…we do have quite a few students who struggle…what is the best method, especially working with those kids…?"

Personal beliefs about effective teachers. The following section describes the decisions and actions among the three different groups of school leaders, regarding personal beliefs.

Among those performing higher than expected. School leaders felt effective teachers were better with more experience and education, they planned their instruction based on their understanding of the student and did not rely too much on a textbook, engaged in regular teacher collaboration looking at data to choose the next step in their instruction, were willing to continually learn, were deeply knowledgeable of the standards, were deeply reflective, and knew a variety of instructional strategies depending on the content, and had high pedagogical content knowledge (PCK). This is evident in the exchange between Matt and Jack:

> Jack: Your teachers with Master's Degrees, when they've done studies, they're actually better teachers. There's something to be said for experience.…
>
> Matt: You're just talking generalities. Generally speaking, more experience, more education is going to give you a better product.
>
> Jack: …There's something to be said about good veteran teachers. When you have new teachers, it's a lot of work to get them there.

Audra had this to add:

> My teachers…are by far my number one influence on why the kids love math and

> they want to continue on.… Those teachers collaborate together, and so they have collaboration time on a weekly basis. And, then, on a daily basis, they have a lunch time together.… And while they're doing that, they are looking at some of the curriculum and changes that are happening there.

Among those performing about where expected. School leaders generally felt it was important for teachers to know the content conceptually, use mathematical discourse, use manipulatives, engage in high quality tasks, have great classroom management and know kids' learning styles. Dakota described her situation:

> …if that Kindergarten teacher would help build that conceptual knowledge and that number sense, then my first-grade teacher could just pick up and take off from where she left off. But she spends a lot of time backtracking and getting the kids having that number sense. That's my hardest. That's been my biggest struggle, is getting teachers to realize that those math talks are important. That tasking is important. You need to slow down and go deeper. It's not just about memorizing facts and getting rid of timed tests. I had a third-grade teacher that insisted on we were still going to time multiplication tests and I showed her the research and tried to convince her that wasn't the best use of her time. She still insisted on it.

Jay added, "I would say classroom management.… If they can't get the whole class to do it, it becomes problematic." Charles further described:

> … effective instruction. I think that's the key to all the problems that we have. I'm trying to teach my teachers that it's a song and dance. If you're playing the right song, the students will dance. If you're not playing the right song, they're not going to dance…[they're] not too interested in learning styles. I think that's a key, to be effective with students.

Among those performing lower than expected. School leaders' beliefs fell into two categories. First, an effective teacher taught inclusively with good differentiation finding one way for students with disabilities as in this representative statement by Arla "… your core instruction needs to be more inclusive and better differentiated." The second trend was that these school leaders collectively felt that effective teachers grouped their students by ability as evidenced by this exchange between Sally and Kandy:

> Sally: Our advanced kids just need to be able to zoom.… We just do that leveling across.… Even our special ed[ucation] kids, for the first time I have two self-contained.… They'll be second grade this year, going back to first grade for math.… They're really low performers. I've seen a great difference in how kids feel about math when they can go to a class.…
>
> Kandy: Where they understand it.

Personal beliefs about what helps students the most. The following section describes the decisions and actions among the three different groups of school leaders regarding what school leaders think helps students improve in mathematics.

Among those performing higher than expected. School leaders in this group indicated that their teachers were what helped students the most, specifically through teacher collaboration and distributed leadership as evidenced by the following exchange:

> Nick: I would say the PLC, the talking, teachers collaborating about what they are doing. They're discussing good strategies that they've taught. They're talking about struggling learners, kids who are excelling. When they all get together, I think that's had the biggest impact and influence on math instruction. First of all, it motivates the teachers to do a good job. They know they're going to be discussing that with their peers. Also, they're getting a lot of good knowledge from each other, taking it back into their classroom.
>
> Interviewer: Okay. How long have those PLCs been functioning, would you say, well?
>
> Nick: Well the district has been practicing it for 10 plus years. We've done a decent job with it for about 5 to 7 years.
>
> Interviewer: This is an initiative that's been in place for a while?
>
> Nick: Yes. We're always improving it and doing new things. This last 2 years, the biggest focus has been adopting GVCs, Guaranteed Viable Curriculum, adopting those, make sure our instruction is aligning with that, and that all kids had that opportunity to meet that GVC. That's kind of been our emphasis lately.
>
> Interviewer: It sounds to me like…your schools have a more distributed

> leadership type of approach.… It sounds like you spent quite a bit of time in that collaboration aspect?
>
> Matt: Yeah, and I wouldn't have made the decision unilaterally. Like I said, I made the decision that I preferred not to make, like I wouldn't have done that. I made the decision that the math teachers made. I would agree that I wanted their input and ultimately, used their input. Their opinions had more leverage in the decision than my own personal opinions.

Among those performing about where expected. School leaders in this group differed on what they felt most helped students succeed in mathematics. Most said teachers, specifically with regards to a positive mindset and enthusiasm for the subject of mathematics as evidenced by the following representative statement by Susan, "I think if the teacher is enthusiastic and passionate about any content area, that is more easily translatable to the kids." Other school leaders indicated such things as specific technology support for students, encouraging mathematical discourse between teachers and students, and the school leader's own personal efforts to engage positively with students. One example is Charles' statement:

> …everybody says, "The school is so much better. The school is so much better." This summer, I had to sit back and say, "Why is it so much better?…" It's just that I've made a presence. I've made a point of being involved with students.… We do a lot of positive affirmation. "I can, I am, I will, I must." I go crazy. We play music.… I want kids to be motivated. Our students are just like any other students. Technology, cell phones, games, all those kinds of things are taking their attention. They're not really motivated to step up and do the educational things they need to do. I'm trying to show them that there's a different.… You can do both.… So, I would say a presence.

Among those performing lower than expected. School leaders in this group offered up a diverse set of ideas. Those mentioned included: the school aligning the curriculum to the standards, hiring quality teachers, getting past the mindset that it was the teachers' fault, leveling students, teacher collaboration, focusing on problem solving, and the school leader's personal mentoring of teachers. One such effort included Judy's experience:

> Honestly, it all went back to, "We're going to look at these math standards, and we're going to look at the vertical alignment. We're going to spend time.…" In fact, I spent extra money and brought teachers in over the summer last summer to do this. Then we did three different sessions during the year of just picking apart those standards and then deciding what the kids have to be able to do in order to master that standard. It was quite painful at first, because teachers just want to get to the work. They want to get to the activities. They were always going, "This is the activity that I'm going to use." I had to keep pulling them back and saying, "But before you know what activity you're going to use to teach this, you have to know exactly what kids have to know to be able to master this." They didn't like it at first. But throughout the year, I watched each teacher that teaches math one by one go, "Oh, this is why they can't pass the test. I didn't teach it that way. Or I didn't teach it at that level."

Personal beliefs about what hinders students the most. The following section describes the decisions and actions among the three different groups of school leaders, regarding what school leaders think hindered students' improvement in mathematics.

Among those performing higher than expected. The school leaders in this group indicated that student mindset, quality of teachers, and/or too little time spent on mathematics instruction all hindered student mathematics success at their schools. This was evident in Matt's statement:

> I would say mindset is probably the biggest external school factor that limits achievement in math.… Kids who think that other kids are good at math, just because they're smart, or that they have the math gene. I think there's a lot of that, where kids don't understand, not just anyone can do this math. It requires work and effort for everyone. At some point, everyone reaches a wall in mathematics, where it's no longer natural and easy.… Everyone eventually hits a wall that requires a little more effort and investment of time and energy to learn the content. I would say that's a big external influence on the math achievement.

Among those performing about where expected. These school leaders indicated student mindset, negative paradigms of parents, negative or incorrect paradigms of teachers, lack of classroom management, and/or lack of ability grouping all hindered student mathematics success. One such exchange is evidence for adversarial parental influence:

> Kay: The student concept, the ones that just have either had a bad experience or don't want to do it, or whatever. That negativity is contagious.
>
> Susan: I would say that and parent influence.… I think the attitude of the parents definitely sways how willing the kids are to try, or not try, or complete homework or not.

Among those performing lower than expected. School leaders in this group indicated a lack of quality textbooks and resources, lack of teacher pedagogical content knowledge (PCK) and/or difficulty in recruiting and retaining high quality teachers. This is indicated by the following statements when asked what hindered students the most:

> Sally: Our textbook.
>
> Grant: Textbook resources, that's a big one. I agree with the teachers. Getting teachers to continue to change for what the kids need to learn, and not just fall back to this way but to adapt with the kids, because kids are different than they were...They learn differently.
>
> Judy: I agree with them. But the bigger problem for me in my school is lack of teacher knowledge and how to teach math.
>
> Arla: Good teachers, I hate to say this, they tend not to teach math. I don't know what that is. Good people that are good at math aren't always very good teachers.
>
> Kelly: I think it's quality teaching, just having those teachers that really understand math and teach it well, so that students are understanding. I think it was Kandy who said that the guy got up and he knew math but he couldn't teach. Just because you know math doesn't necessarily mean you can teach it….

Teacher recruitment and retention. The following section describes the decisions and actions among the three different groups of school leaders, regarding teacher recruitment and retention.

Among those performing higher than expected. Some school leaders indicated no trouble in recruiting and retaining high quality teachers. Others struggled and would keep provisional teachers that were not that strong for various reasons as evidenced by the following statement by Matt.

> I think that's one of my most important responsibilities as a principal, is who I hire.… In some ways, you hire who is available with math. You take who you can get. I think it is important to try and find somebody who is going to be student centered and collaborative and is interested in teaching students, not necessarily teaching curriculum.… I think just as important as hiring is developing people once you have them, and helping them grow and improve and learn. It's really tough to find strong math teachers, I think. There's very few and they're in high demand. I've kept provisional math teachers who were not very strong, and who are now career educators, because I was hesitant to not renew them, because I was worried I wouldn't be able to find anything better.

However, Nick said, "Right now, hiring has been pretty easy.… For me, I haven't struggled too much finding quality teachers…there's not a reason [for] doing ARL."

Among those performing about where expected. School leaders in this group indicated trouble recruiting and retaining high quality teachers. Most indicated they were more likely to go with an ARL teacher as indicated in the following exchange:

> Susan: That's part of why we're facing, we're on the brink of a huge teacher shortage. No one is attracted to the profession, because they feel unsupported and not treated as professionals by society. Parents are a big part of it.
>
> Interviewer: How often do you find yourself needing to go the ARL route?
>
> Kay: This year, everybody is going that route, everybody, in public education. There are so many openings we cannot fill, it's ridiculous. Normally we have in our district a pool of 300 to 600 candidates. This year, we had 30.
>
> Susan: That's a huge difference.… I would say for us it's probably about a third of my hires end up, for secondary, end up being ARL. Elementary, not as many.

Among those performing lower than expected. All the school leaders in this group indicated trouble recruiting and retaining high quality teachers. Many indicated they had to go the ARL route or not fill positions and were not always satisfied with the results, as evidenced by the following exchange:

> Kandy: I have 3 teachers on ARL. They don't know how to teach.… I had one teacher that was just horrid. It really wasn't his fault. He has a business major, or he has an MBA. Just because you're skilled in an area doesn't mean you can step into a classroom and teach kids, or even manage a classroom. That's even harder than trying to teach kids. So, this year, he's an old military guy. He's standing up at the front of the classroom just barking out orders.
>
> Judy: I feel like he was my 5th grade teacher this year. Ex-military, ex-business, not renewed.
>
> Kelly: I think it's more difficult because like every place else in the state, and the nation, there's a teacher shortage.… I think that's what's been difficult, is just finding the teachers throughout the state, because there's not as many teachers coming out of the colleges of education at any of the universities. I remember even 5 years ago, I had 4 or 5 student teachers. This year, I only had 2.

Mathematical supports for teachers. The following section describes the decisions and actions among the three different groups of school leaders, regarding mathematical supports for teachers.

Among those performing higher than expected. School leaders from schools who were performing higher than expected talked about supports for teachers that were sustained, coordinated, longitudinal, and focused on collaboration. These school leaders described teachers as professionals and largely allowed teachers to make decisions about curriculum and professional development in collaboration with the school leader. This was supported by statements like this one by Jack:

> We…do it as a staff. We've done some studies, we looked at literature, we read a book…. Looking at some perspectives of teaching math a little bit differently and then sharing ideas as a staff. So, staff development based upon need within our school.

School leaders in this group described approaches to evaluation and feedback, as a support to teachers, as collegial in nature, and focusing on collaboration and conversations about best practices often utilizing university resources. School leaders discussed actively encouraging and, sometimes, utilizing funding sources for mathematics endorsement courses, advanced degrees, conferences, and long-term professional development that focused on breaking down the core standards, writing common assessments, looking at data, and instructional strategies. This was evident in the description by Matt:

> When we implemented the new core, there was a large amount of time and money spent providing teachers opportunities to break down the new core, talk about planning, and things like that…specific summer days given to every secondary math teacher in the district. That was a lot of money and time invested in that.... They can apply for a grant through the district where they can collaborate for four days over the summer. They get paid…to collaborate those four days. That gives them time to examine their scope in sequence to create common assessments, to identify areas of strength and weakness and things like that. Address those items. Departments that don't get the district grant, then I pay for summer collaboration time out of trust lands.…We send teachers to conferences as requested. As far as in house professional development...mine are already good, so I rely on them to do a lot of the training. They collaborate. We have collaboration time every week, so they can do a lot of looking at data and supporting each other with ideas and things like that, in that venue.

Among those performing about where expected. School leaders from schools who were performing about where expected described a disjointed smorgasbord of offerings to support teachers. School leaders encouraged professional development but the offerings were jumbled, often of short duration, and relied heavily on voluntary access to online sources and on textbook publisher/sales representative trainings. For example, Susan and Kay had the following dialogue:

> Susan: …we usually have a sales rep, or whoever the training person is from that curriculum, come.…We also have a lot of the things that get sent out from, I think it's _______, from …
>
> Kay: His blog.
>
> Susan: Yeah, his blog. He's constantly sending out little nuggets here and there. I pass those on to my teachers and then training that comes up through the professional learning series. Things like that, I offer as an option for teachers to attend.
>
> Interviewer: Is that offered by the state also, the professional learning series?
>
> Susan: Yeah.... A lot of that's online now instead of face to face in person. They have a fall, winter, and spring catalog that they'll send out periodically. I'm always really quick to share that with my faculty, and I encourage them to do things like that.

Dakota and Candace added:

> Dakota: We do have a coach at our school. She's an instructional coach, so that if a teacher is having difficulties or when we have our data meetings, for example, I had a fourth-grade teacher this year who some of his kids just weren't getting division. And so, myself and my instructional coach worked together to do some research to find some different strategies to go in, actually sent him some videos. We have Edivate, so I pulled some videos from there and did some mentoring that way. Then we do have people in the district.
>
> Candace: We also have Edivate available online. The district has an overdrive, so online professional books and that sort of thing. They also have something called Ed Plus which is also an online resource. This is all teacher sought out opportunities.

In addition, teachers were mainly seen as professionals and were moderately to heavily allowed to make decisions about curriculum and professional development in addition to the school leader. School leaders' approaches to evaluation and feedback were centered around accountability with mentoring and coaching provided, if needed. Some collaboration in the form of PLCs was consistent and some was not. Candace indicated a problem with consistent PLCs due to their year-round organizational structure:

> It's been kind of compromised the past couple years, since we've been year-round.… It's been a struggle to interact this past two years as we've been on year-round, because there's always one track off. So, the whole team is not ever there. So, that's been a challenge we've been trying to work through.

Dakota and Charles both talked about their supports through the lens of their small school size:

> Dakota: …I only have one teacher per grade. They really don't have anybody to meet with. But, once a month, we have a lower grade team, Kindergarten through second grade, and then upper grade, third through fifth grade. They meet together once a month and talk about their data and talk about whatever they need to talk about. So, it looks a little different.
>
> Charles: Being rural, our math teacher does not get a lot of time to be trained.… I think we could do a better job district wise.

Among those performing lower than expected. School leaders from schools who were performing lower than expected described few offerings of short duration or a lack of such supports. Often teachers were not seen as professionals and were minimally allowed to make decisions about curriculum and professional development. Teachers' main support was from other teachers but in informal ways. School leaders wanted to encourage professional development but the offerings were slim and, if available, disjointed, and often of short duration. PLCs were inconsistent or not done as Kandy indicated, "it's never been done before. It's something that I want to do. But I don't know how to do that…"

Arla said:

> Well this is making me realize that there's not enough. I think my teachers support each other and that's probably their best source of support.… That process to me is the most powerful thing if you are talking about your teaching, with other people, then you're probably getting better at it. So, we rely on that. We rely on that too much.

Teacher evaluation and feedback. The following section describes the decisions and actions among the three different groups of school leaders, regarding teacher evaluation and feedback.

Among those performing higher than expected. School leaders in this group had well-articulated and specific plans for both formal and informal observations throughout the year with frequent and consistent observations. They used informal observations to focus on positives and build trust, stressed the importance of not being punitive in their evaluations, focused on conversations to encourage reflective thinking, set and reviewed goals, and discussed what good instruction looks like in a collegial way. This was evident in Audra and Jack's statements:

> Audra: I always go into every classroom…with this attitude of, "Wow. Look at all the amazing things that you can learn.… I do go into all of my classrooms…least once a week to do just a 10-minute observation. Then I go in and do a formal evaluation at least twice a year, once 1st semester, once 2nd semester.
>
> Jack: Providing feedback to the teachers and having some of those discussions as a whole staff, when we looked at issues and looked at needs…it's more open and we're looking at improving instruction rather than any kind of evaluation. Evaluation, I guess, because of the legalities and the mandates, is a necessary evil that we have to deal with. For me, I don't like evaluations being punitive at all. It's informative and instructive. The feedback that I provide teachers is the same. It's pretty much, "Here's what I saw. Let's look at it. What does it mean? There are some areas. Could you ask different questions? What questions?" Those kinds of things, so it's instructive to help them improve.… My perspective, I guess, is to help them be reflective and identify needs and things we need to work on as a staff.

Among those performing about where expected. School leaders in this group varied in their responses. Some had well-articulated and specific plans for both formal and informal observations. Some did not. Most articulated the need to hold teachers accountable and discipline if needed but to try mentoring and coaching first. They also indicated the importance of not trying to get rid of teachers. All the school leaders in this group thought it was important to focus on getting data into teachers' hands as part of this process as evidenced by the following:

> Kay: I've got their back, as long as they're doing what they're supposed to be doing. They know that if they're doing what they're not supposed to be doing, that it will be accountable.… That's what I've done…. They know where the line is.… They know if they cross it, that I'm not going to, "Oh let's pretend it didn't happen." I do the discipline I have to do. I hold them accountable for what they're doing with kids and for kids and to kids. They understand that, but they also understand that I'm going to be there for them.…I think admin sets expectations for that collaboration piece and helps break down the barriers of teachers learning from each other.… We have a very specific tool that we use. And [the standards] are spelled out. It's on a rubric. It says, "Not proficient, nearing proficiency, proficient, highly proficient." It gives an account for each standard, what it should look like. I give those to my teachers every year, and at the first of the year.

> Dakota: If there's a particular area they're struggling in, or 70% of the kids in the class didn't do well, then definitely there's an issue there.… We pick it apart and then we just have conversations about what do you need and let's look at this data. It appears that something happened here, and I try to get them to figure out, because they usually know. "I taught it too fast, or I thought the kids knew more than they really did so now I have to go back and re-teach it," or whatever. Or maybe it's just a little handful of kids that 70% of the kids got it, but 30% didn't. Well, what are we going to do with that 30%? It's just really about those conversations and I always ask them, "What do you need from me? How can I help you? Do you want me to do research on this?" or just whatever. They know that that's my role. They know that that's what I'm there for. If I see that they're struggling with something, I say, I try to give them that data, just matter of fact.

Among those performing lower than expected. School leaders' approaches to evaluation and feedback in this group were either not consistent or centered around accountability with mentoring and coaching provided in a more one-directional way rather than as a collegial conversation. Only one had well-articulated and specific plans but several mentioned being able to coach and mentor teachers based on data. Only one mentioned a tool for observation. Most did not articulate any plan. The following statements by school leaders in this group show evidence of this:

> Judy: If I have a teacher that is failing in their math instruction, it's my responsibility to do everything I can to make sure that number one, they know what good instruction looks like, that I'm providing those supports and the training that they need for that, and then I follow through.… For me, I look at it if they failed, then I failed. I didn't do my job.
>
> Sally: When I evaluate, I have subject specific evaluation tools, so in math, mine is about math. It's more that math exploration in order to agree with what the state office wanted.… When I do math, I think the biggest thing is my input. I'm in classrooms a lot. So, the feedback again is math directed, not just teaching directed, although teaching is the most important thing to look at….
>
> Interviewer: You see your role as a feedback role.
>
> Sally: I intervene too, so I am the math coach.… So, I feel like, number one, keeping well trained myself.… So, I think that's my role, is to get really involved that way. When they have questions, I can answer them intelligently. So, I think that's my first role, is being that person that you go to for questions. Then also, I think as an evaluator, helping them learn what to change and what to do better is so important.

Data. The following section describes the decisions and actions among the three different groups of school leaders, regarding the use of data.

Among those performing higher than expected. School leaders in this group facilitated distributed ownership of data. These school leaders distributed data widely with supports in place to make the interpretation of the data easier for teachers, parents, and students. School leaders interacted with school-wide data on a near continual basis and actively engaged in conversations and collaborations with faculty and support staff centered around describing and interpreting a variety of data measures as evidenced by the following statements:

> Audra: My counselors are very good.... They are…looking at their test scores to make sure that they're able to progress, and they're looking at their grades to make sure they are able to progress.… They come in with this grade report and

> they say, “Okay, here are my sophomores.” We typically have 30 kids on my low achievement sophomore list out of the 130. 30 of my sophomores have a D or an F. The counselors are going to talk to the students to see what they can do, but so is my assistant principal. Then junior students, I’ve got 25 students with a D or an F. The counselor is going to talk to them, and so is my other assistant principal. Seniors, I’ve got 10 kids that have a D or an F. Principal you get to talk to those kids.... We will find the kid, whether it’s in the hallway or at lunch or an advisory or during a class break or something...It’s made a huge difference, because then, when the kids see us in the hallway, when we are standing there in between classes, they come up to us without any prompting...They’re now self-reporting back to us. Now I had the seniors last year, and at the end of the school year, we noticed that while we had about 25 students the year before that were on a D or F list at the end of the school year, this year we had five. There was a dramatic decrease.

> Nate: …we practice PLCs. We meet weekly, grade level teams, and they collaborate. A lot of that collaboration is on math instruction. I’d say at least half of it is on math instruction, because what we are doing is we’re preparing common form assessments so all the grade level teachers, they have common form assessment. They’re going and giving that to their kids. They’re coming back, they’re bringing that data, they’re analyzing it…

Among those performing about where expected. School leaders in this group practiced directive ownership of data. School leaders in this group owned that data and selectively or ineffectively disseminated it to other stakeholders. This is evident in Charles’ statement:

> My role is just what I’ve been doing this summer. That’s going through data, trying to analyze data and teachers are very, very busy. They are going to look at data, but they’re not really going to get down to the nitty gritty specifics...We have some things to work on…. I look at SAGE as one. I look at grades as another. I look at attendance as another. I look at ALEKS time on task. That tells me a lot.... Right now, that’s about it. I think we need some more effective assessments. I’ve talked to teachers. Before the school year ended, I talked about some things I wanted them to think about over the summer.

Among those performing lower than expected. School leaders in this group practiced underutilized directive ownership of data. School leaders in this group mainly owned the data themselves. Only one of the school leaders in this group, Judy, mentioned utilizing student data in the decision-making process:

> We're looking at student data every week and we're recording it all on a spreadsheet ahead of time, so when the teachers come in, we've got all their data up there on the board.... For me, my job is to continually remind teachers that it's about the students and the students' progress and the students' success. If that means that I have to take responsibility for their success or failure, I do that.

Politics. The following section describes the decisions and actions among the three different groups of school leaders, regarding politics.

Among those performing higher than expected. School leaders in this group described being engaged and empowered. School leaders were politically engaged and equally aware of the influences by the state legislature, the state office of education, and the state school board. While all shared frustrations and disagreements about various policy decision made by these groups, all indicated an empowerment to navigate policies in a way that they felt best impacted their students. Audra gives a specific account of how she engaged in an empowered way:

> We have a legislator who actually helped pass the Concurrent Enrollment bill to allow Math 1050 teachers to have different standards and qualifications and a degree to be able to teach the Math 1050 course.…When he helped pass this bill last year, in a way, it was really good because it said, "Hey, Math 1050 teachers can just have their level 4 endorsement and then they'll be able to teach." However, there were some ramifications that came down the pike, I guess and when they hit my school, I was able to contact the legislator and say, "Hey, you may not have realized, but there was some unintended consequences with this and when you said that Concurrent Enrollment was able to give the okey-dokey for a teacher in Math 1050 to teach with a level 4 endorsement, from what the university department is saying now, the math department, the math department is kind of making up their own rules of what that means. And so, they're interpreting the law differently." ...My legislator actually came and talked with me, actually on Monday of this week and they are now redoing and revisiting what [was] dictated to my teachers. They're now relooking at that.

Among those performing about where expected. School leaders in this group described being aware and helpless. School leaders were politically aware of the influences by the state legislature and the state office of education but less aware of the influence of the state school board. While all shared frustrations and disagreements about various policy decisions made by these groups, all indicated a sense of helplessness and felt they could not navigate policies in ways that they felt best impacted their students. This is evident in the following conversation:

> Susan: I feel like we're always reacting or responding to what comes down from the state office and legislators, as far as adapting standards, changes to standards...we're influenced by a lot of external things including legislation and the state office, making changes, which happens all the time.... I would say teachers weigh a lot of decisions, but also for me, it's external requirements.... I would say the higher-level influences decisions that support implementing resources that achieve the core, the standards.
>
> Kay: ...If the state would get out of their ivory palace and let real people who are in the trenches have more input, I think our education system would not be as broken as everybody thinks it is.... That's why the state's trying to get rid of public schools. That's the political thinking.
>
> Susan: It's a rollercoaster.
>
> Kay: ...everybody who has been in education very long talks about the pendulum swinging back and forth, because it's really the best analogy there is. It depends on what is going on. You're right, at first, I didn't think of the political aspects. I'm so sick and tired of listening to the radio where so and so says they're going to do this, and so and so says they're going to do this. This guy's done this for education and this guy hasn't.... In our society, just me, I feel like teachers are looked at, "Oh, you can't do anything else so you're a teacher?" The state legislators, sometimes they'll go, "Anybody can walk in and teach." I've heard them say that.
>
> Susan: They should try it sometime.
>
> Kay: They should try it sometime is right.
>
> Susan: ...I think for me, having to react to the yo-yo or the rollercoaster or the pendulum, whatever you want to call it, of, "Let's adopt this set of standards, and then know the assessment's shifting." You spend your limited time and your

> limited resources and your limited finances, to best support your teachers with adapting to that shift. Then to not even have SAGE be around for 3 years before they talk about abolishing it. You think, "That's money that could have gone towards teacher increases that was spend on this assessment and …"
>
> Kay: Millions, millions, millions.
>
> Susan: Then we have to shift again. It's kind of that implementation fatigue. There's the implementation dip that's just a natural part of that change process. I feel like with the state office, you start out okay with a new initiative, and then as soon as something doesn't go right, you're in this dip.
>
> Kay: They drop.
>
> Susan: Instead of giving it time, and support, to get up on the other side, they abandon it and start something different. That to me is implementation fatigue. You're never going to see that success up here, but your schools have to respond to all the changes that get pushed down from the state and the legislature. It's hard to get super invested from the get go with those changes when you wonder how long they're going to last before they just go back or change again or morph again.... I'm all for continuous improvement and trying to better prepare our kids for the college and the world of work, readiness in that area, global citizenship. It seems like we reinvent the wheel so many times.... It's hard to continue to adapt to that, with a lot of effort, when you feel like it's just on sand. It's going to shift again.

Among those performing lower than expected. School leaders in this group were minimally aware of influences from the state legislature and state office of education and not very influenced in day-to-day decision making. None mentioned the state school board. Sally was the only school leader in this group to mention politics:

> It's interesting, because you can go to the state office, you can go to the legislature. They'll list 15 programs to try, and I contacted ____. I said, "I just want to know a good intervention math program. Tell me." He can't list them. There are full math programs, but there's not really intervention programs.

Curriculum. The following section describes the decisions and actions among the three different groups of school leaders, regarding curriculum.

Among those performing higher than expected. School leaders in this group preferred teacher-created materials grounded in a deep understanding of the core standards instead of reliance on a textbook. Matt's statement was typical of this perspective:

> We put a lot of emphasis when we were implementing the new core into the adoption of a textbook. But, almost entirely the reason for doing that was because of parental influence. So, even just four years later, I don't have a single teacher who uses the textbook that we invested hundreds and thousands of dollars as a district. And really, they weren't invested from the beginning in using a textbook. The only reason we were getting a textbook is because parents said, "We need a textbook. We want that resource. We want to be able to look at problems and help our kids at home." And the teachers just don't operate that way much anymore. A lot of what they're doing is creating their own material and looking at problem solving strategies more than just traditional ... The teachers never had any intent of using it and never did.

Among those performing about where expected. School leaders in this group preferred teacher created materials grounded in a deep understanding of the core standards instead of reliance on a textbook but admitted that they were moderately to heavily tied to a textbook either now, or in the immediate past. Candace's statement was typical of the comments in this group:

> We're shifting from following a curriculum per say, like as a textbook, more to focusing on the standards. We've taken this last year and we pulled a team of master teachers to go through and determine what our essential standards were, and then map out how we were going to teach our standards, and then we pulled resources from what curriculum we all had.... We're really trying to switch from strictly following a math program to more focus on standards and standard based learning, and learning progressions. So, that will be really interesting to see how that plays out. The district is setting that up but with the teachers' input, and with the teachers' buy in. They're the ones who said how it should be paced, and what we should focus on.... So, we're hoping that because we've had so much teacher input, that they're going to have more buy in, so that when they take it back into their classrooms, they're really going to work together to follow that curriculum in math. Because, in the past, I think that the district has set out to say all teachers are going to be teaching this at this time.

Among those performing lower than expected. School leaders in this group preferred teacher created materials grounded in a deep understanding of the core standards instead of reliance on a textbook. However, several admitted that they were heavily tied to a textbook or program that they were trying to teach with fidelity. Sally and Judy described their situations:

> Sally: I'm training a third of my staff every summer on Singapore…
>
> Judy: ...our curriculum department...They've been working the last 6 months on re-writing our curriculum guides, which really are more standards based. Then we've gone to common interim assessments, so those guides are written based on those interim assessments. They're also vetting curriculum...for us.

Organizational structure. The following section describes the decisions and actions among the three different groups of school leaders, regarding the organizational structure of the school.

Among those performing higher than expected. School leaders in this group engaged in distributed decision making on scheduling and time allocation as indicated by the following exchange:

> Audra: The actual work itself is teacher driven, however, there are times when I need to go in. For example, when we switched over to the core, from what we had was Algebra 1, Geometry, Algebra 2, and then we went to core.
>
> Interviewer: Sequencing, yeah?
>
> Audra: Yeah, the sequence. It was, "How do we best sequence the secondary Math 1, 2, and 3 now, and then be able to get our kids into 1050?" That came for me as a directive. "Look at this and how you think this is going to be best. Come back to me, let me see how it looks." When my teachers met with that particular directive, they met for probably 2 or 3 weeks, then they came back and said, "Okay, here's a couple of ideas.

Matt added:

> …based on math teachers' feedback, which is one of those things where I made the decision based on what the math teachers recommended, rather than what I

> thought was best. They were like, "No, we need to not have nearly as many labs as we have." I said, "Okay, we'll do it. I don't know if I agree with you, but we'll do it."

Among those performing about where expected. School leaders in this group mainly self-directed scheduling and time allocation decisions with influential input from teachers and the local board and/or district office as evidenced by Candace:

> …but at least on a weekly basis, they'll often come together especially on Fridays, because Fridays are our early out days. So, especially on Fridays, they will ability group kids and then split them up. Somebody will take those that are remaining, either this strategy or high, middle, low, or however they've divided them for this particular week. Some grade levels just aren't there personally or professionally yet.

Among those performing lower than expected. School leaders in this group mainly self-directed scheduling and time allocation decisions with influential input from students, the community, and teachers as evidenced by the following exchange:

> Kandy: Right. Scheduling is probably one of our biggest battles. My issue this year with the block schedule is if our teachers are going to be able to handle that 74 minutes. We're doing a lot of teaching strategies this summer.
>
> Grant: We were on modified block. We had 75 minute periods. We call them modified block periods.
>
> Kandy: Right. We're doing five by five.
>
> Grant: We actually went away from it.
>
> Kandy: We're on pilot this year to try it out. I have to try and make kids be more engaged. At the end of the year I had almost half the senior class checked out because they were done.

In addition, Arla said:

> The math teachers are saying, "What do we do?" It is hard. I don't know if it's hard. It seems to be harder for them. I finally conceded and said, "Alright, 11th and 12th grade math will have levels." But of course, that has an impact for the whole school. I really resist the math department driving the whole school,

> because I think that can happen. So, we're figuring out compromises and ways to make that work.

Mathematical supports for students. The following section describes the decisions and actions among the three different groups of school leaders, regarding mathematical supports for students.

Among those performing higher than expected. School leaders from this group heavily relied on licensed teachers as supports for students with additional support from technology. School leaders routinely chose to invest in licensed faculty as the primary support for students. Tier I instruction was described as excellent across the school with all teachers being Level I or II licensed. School leaders actively promoted and encouraged daily mathematics classes for ALL students rather than every other day classes, if possible. School leaders in this group stressed the importance of exemplary Tier I instruction. Tier II and III supports also favored licensed teachers with aides as a support, as needed. Tier II and III supports were often daily or very intensive. School leaders allocated extra resources to ensure that licensed faculty were driving these efforts as much as possible. Technology was seen as a supplemental support directed primarily by licensed teachers. Students engaged with curriculum that was largely teacher selected and/or produced at all levels of intervention. Evidence for this included these representative descriptions by Audra and Jack:

> Audra: Once school is on, we have before school and after school tutoring for math specifically, and also for physics. For math, we have 2 teachers that are there before school and a student tutor before school. I've got 3 different classrooms set up specifically for tutoring for really 200 kids. There, I typically have about 30 to 40 students in the classes in the mornings. Then in the evenings, I have 2 teachers that are available after school from 4-5. I specifically ask my teachers to do that, and not a student all the time, because I really want the teacher

> to be able to understand what the students are learning, and what they understood in the class, and what maybe needs to be retaught in the class. I pay the teachers out of either USTAR grant or other grants that I get, so that I can pay them their professional wage for a before school and after school hour that they tutor.
>
> Jack: It's teacher based in my school. I have a few classes where there will be an aid depending on the students. If there's a student with an IEP for example, there might be an aid that goes in there to work with the student. But because of resources and also, part of the challenge, you think of interventions.... A lot of the helps are going to be when you do the idea of centers and the teacher has the opportunity to work with individual students to help that student rather than isolate them.

Nate talked about technology use and teacher tutoring at his school:

> We also have a couple different math software programs that we use. Success Maker is the big one that we've used. Then my lower grades have used IXL.... My 3rd, 4th, and 5th grade use a math program different than my lower grades. My school, we're one to one. All the kids have an iPad or a Chromebook. So, our superintendent asked us to pilot a math program that's completely digital. It's called Thrive.... So, within that math program, it gives supports to the kids. The teacher can set their students on 3 different levels depending on where they're at.... They all get the same math problem, but the way the math problem is written and the supports the kid gets from the program is different. So, a kid that is maybe struggling is going to get more hints and tips from the math program, versus a kid who is maybe above level.... Also within the Thrive program, it gives input to the teachers. The teacher carries around their iPad. They have a dashboard. If the kid is struggling with a problem or 2, they get an alert on their iPad.... If everybody is struggling, they pull it back to whole group. If 1 or 2 kids are struggling, they might work with them one on one. If a handful of kids are struggling, they'll pull them back to the table and work with the kids that way.
>
> Interviewer: How long has this been implemented at your school?
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> Nate: One year.
>
> Interviewer: Do you feel like the teachers are pretty comfortable with it, or are they still learning?
>
> Nate: They're comfortable with it. It took a long time, a lot of training, and a lot of support from me and the staff developer, a lot of conversations and dialogue and those kind of things.
>
> Interviewer: That's really interesting.

> Nate: Yeah, it was difficult because new concepts, a new way of teaching, new pedagogy, and it was more the technology that was difficult rather than the math instruction.... One additional support for math is before or after school tutoring. We've been able to get some money through trust lands to pay teachers to do that. So, I have probably 10 out of my 25 teachers. Most of them are meeting after school with struggling kids to basically tutor.
>
> Interviewer: Okay. How long has that been in place at your school?
>
> Nate: 3 years, ever since we started.

Among those performing about where expected. School leaders in this group preferred licensed teachers as the primary support for students but often relied on aides and/or support from technology. School leaders routinely chose to invest in teachers and aides as the primary support for students. Tier I instruction was generally established across the school with a few exceptions. Most teachers were level I or II licensed with a few ARLs. School leaders actively promoted and encouraged daily mathematics classes for lower achieving students rather than every other day classes, if possible. Ability grouping was favored as a support. Tier II and III supports were often weekly instead of daily. Tier II and III supports favored aides, peer tutors, and technology as a support, as needed. Technology was seen as a supplemental support that was either mostly voluntary or limited to select groups of students. Students engaged with curriculum that was moderately textbook driven and supplemented with teacher selected or created materials as evidenced by the following representative statements:

> Kay: In addition to curriculum, we also have ALEKS that we've been using through the STEM grant that's been great.... I forgot to mention one of the things that really supports our math program well is something called ST Math. That's from a STEM grant. We love it because we have so many ELL kids in our school and this has no language involved. It's all character cartoonish kinds of things. They're able to manipulate whatever it is on the computer screen and go up levels according to how fast or how slow they need to go. We've found that that's been

> immensely helpful, especially when it comes to SAGE testing, because when the kids get stuck, they go, “Well I can figure this out. I figure this out every week when I do ST Math.” That’s been a real, real help for us.
>
> Dakota: We have 60 minutes of whole group math instruction and then we also have a Power Hour which is math and reading interventions. Every teacher in my building has at least two paraprofessionals that come in and work with students in that time. Then for Tier III, I do have a 100 to 120 minutes of additional math instruction. That would be focused on where their gaps are, not with what’s going on in the classroom currently, but wherever they have holes, if it’s place value or story problems or whatever. And my special ed[ucation] teacher comes in and I’ll pull out in the afternoon for those kids.... We do have a lot of support with paraprofessionals, because we are a Title I school. So, our kids do get a lot of additional supports that way, one on one or small group support.
>
> Candace: I would have to say we don’t have a ton of supports, which is kind of a shortcoming. We also have paraprofessionals that we pay for using trust lands as associated with our school improvement plan. But, in my observations, I would say we’re using...only about 30% for math instruction support. We use a couple of computer programs as well. We use MobyMax, been using i-Ready with just some of our sixth grade, just through the legislative grant.

Among those performing lower than expected. School leaders in this group often relied on aides or support from technology. High quality Tier I instruction was often not guaranteed. Many relied on ARL teachers to fill their ranks. Tier II and III supports were often monthly instead of weekly. Tier II and III supports favored technology as a support, as needed, or, aides pulled students during Tier I instructional time for these supports. Ability grouping was widely used to offer support. Technology was seen as a Tier I instructional tool that was utilized daily or weekly. Students engaged with curriculum that was heavily textbook driven as indicated by the following:

> Kandy: Something that my secondary teacher has used in secondary 1, 2, and 3 is Kahn Academy and CK12.... She has leveled her classes...We don’t have a way to really intervene...which has been very problematic last year. So, she’s put kids on Chromebooks or iPads and had 3 different sections in her classrooms, which is great differentiation for her...especially high end kids who can find great things for higher math than secondary 3.... It’s been a really good intervention,

technology. That's been great for our math program.

Judy: Does everyone here have a math program, like an adaptive …something? Which one?

Sally: My Math

Kelly: I have IXL.

Judy: That's a good one.

Kandy: We're using ST Math and we're using just standards and creating lots of our own stuff.

Kelly: I've used trust lands [funds] for aids. They will pull some of my students that are struggling. Like I have some Somali families that are doing the basic things, just counting and adding and subtracting with them. Most of the kids are upper grades, 5th and 6th, that these Somali families have. They just work with them to help them get up to par with the rest of the class.

Interviewer: When does that generally happen?

Kelly: Just during the day.

Arla: But what are they missing?

Kelly: I don't know. It's usually during math. They don't pull them out for very long. Maybe 10 minutes.

Sally: I have intervention teams. So, we level, so my TAs for instance in Kindergarten, they'll go in for one half hour. She can level within the class and each of those takes a group. I run a summer school 3 days a week in the month of June, special ed[ucation] kids go free, Title I kids, 50% off. I do all those things to get whoever. I give scholarships to those that need to go. Then I do math tutoring after school once a week for my 5th and 6th. Actually, I've flexed, probably the best thing I did last year. I flexed two of my special ed[ucation] TAs so they are actually after school.

Mixed Results

This section discusses the results to answer the fifth research question: How are school leaders' decisions and actions based on those perceptions associated with students' mathematics achievement?

Effectively Facilitating Communication

When looking at the final predictive model, school-wide SAGE mathematics proficiency scores were highest in schools where school leaders agreed that cooperative work in the K-9 mathematics classroom was an effective instructional strategy and when the state legislature had a higher influence over the implementation of the mathematics curriculum. The school leaders in the focus group representing schools performing higher than their demographics suggest placed a premium on collaboration and engaging in empowered ways with political influences and indicated specific ways in which they saw those aspects effectively happening within their respective schools. Tables 12-14 show that the mean for the perception of the influence of the state legislature was the same for both groups and the belief in collaborative learning as an effective instructional strategy was higher among those in the lower performing schools. However, the mean of the interaction (Inf_State_Leg2*MTL39) is highest among school leaders whose schools are performing higher than expected and lowest among schools performing lower than expected. The variability is also interesting. The range and standard deviation for the lower performing group is much tighter than the higher performing group. This may indicate an emergent phenomenon in schools where school leaders that believe in, and are effective at, mediating the communication between various stakeholders in their CAS are better able to influence the trajectory of the CAS towards higher student mathematics achievement.

Table 12

Descriptive Statistics of Final Model Variables for Schools Performing Higher Than Their Demographics Suggest

Measures	*N*	Range	Min.	Max.	*M*	*SD*	Descriptions of measure
Inf_State_ Leg2* MTL39	44	28	2	30	10.72	6.29	
Inf_State_ Leg2	45	5	1	6	3.07	1.40	1. No influence 2. Very small influence 3. Small influence 4. Moderate influence 5. Strong influence 6. Very strong influence
MTL39	45	3	2	5	3.43	0.90	1. Strongly Disagree 2. Disagree 3. Neutral 4. Agree 5. Strongly Agree
Math_Ed* MTL62	29	7	2	9	4.10	1.35	
Math_Ed	45	2	1	3	1.18	0.54	1. No 2. Yes, Minor/Sp. Emphasis 3. Yes, Major
MTL62	29	3	2	5	3.76	0.58	1. Strongly Disagree 2. Disagree 3. Neutral 4. Agree 5. Strongly Agree
Inf_Teach3	45	3	3	6	5.56	0.72	1. No influence 2. Very small influence 3. Small influence 4. Moderate influence 5. Strong influence 6. Very strong influence
Inf_Nat_ Org2	45	5	1	6	2.56	1.37	1. No influence 2. Very small influence 3. Small influence 4. Moderate influence 5. Strong influence 6. Very strong influence
Age	45	30	33	63	47.73	8.36	
Fam_PD_ CI_Doc	44	5	1	6	3.55	1.28	1. Not familiar 2. Vaguely Familiar 3. Somewhat Familiar 4. Moderately Familiar 5. Mostly Familiar 6. Strongly Familiar
ISAM18	43	4	1	5	3.19	1.05	1. Strongly Disagree 2. Disagree 3. Neutral 4. Agree 5. Strongly Agree
%LowSES	45	88.9	2.9	91.8	36.21	23.27	
%EthMin	45	62.7	0	62.7	6.91	12.74	

Table 13

Descriptive Statistics of Final Model Variables for Schools Performing About Where Their Demographics Suggest

Measures	*N*	Range	Min.	Max.	*M*	*SD*	Descriptions of Measure
Inf_State_ Leg2* MTL39	32	27	3	30	10.31	6.59	
Inf_State_ Leg2	35	5	1	6	3.14	1.54	1. No influence 2. Very small influence 3. Small influence 4. Moderate influence 5. Strong influence 6. Very strong influence
MTL39	32	3	2	5	3.28	0.85	1. Strongly Disagree 2. Disagree 3. Neutral 4. Agree 5. Strongly Agree
Math_Ed* MTL62	18	9	3	12	4.72	2.37	
Math_Ed	35	2	1	3	1.26	0.51	1. No 2. Yes, Minor/Sp. Emphasis 3. Yes, Major
MTL62	18	1	3	4	3.67	0.49	1. Strongly Disagree 2. Disagree 3. Neutral 4. Agree 5. Strongly Agree
Inf_Teach3	35	1	5	6	5.71	0.46	1. No influence 2. Very small influence 3. Small influence 4. Moderate influence 5. Strong influence 6. Very strong influence
Inf_Nat_ Org2	35	5	1	6	2.91	1.38	1. No influence 2. Very small influence 3. Small influence 4. Moderate influence 5. Strong influence 6. Very strong influence
Age	35	37	30	67	49.77	9.10	
Fam_PD_ CI_Doc	35	4	2	6	3.83	1.25	1. Not familiar 2. Vaguely Familiar 3. Somewhat Familiar 4. Moderately Familiar 5. Mostly Familiar 6. Strongly Familiar
ISAM18	33	4	1	5	3.15	1.00	1. Strongly Disagree 2. Disagree 3. Neutral 4. Agree 5. Strongly Agree
%LowSES	35	87.1	9.6	96.7	32.84	17.83	
%EthMin	35	53	0	53	5.36	9.47	

Table 14

Descriptive Statistics of Final Model Variables for Schools Performing Lower Than Their Demographics Suggest

Measures	*N*	Range	Min.	Max.	*M*	*SD*	Descriptions of Measure
Inf_State_ Leg2* MTL39	26	17	3	20	10.46	4.68	
Inf_State_ Leg2	28	5	1	6	3.07	1.36	1. No influence 2. Very small influence 3. Small influence 4. Moderate influence 5. Strong influence 6. Very strong influence
MTL39	26	4	1	5	3.69	0.97	1. Strongly Disagree 2. Disagree 3. Neutral 4. Agree 5. Strongly Agree
Math_Ed* MTL62	14	4	4	8	4.71	1.44	
Math_Ed	28	1	1	2	1.11	0.32	1. No 2. Yes, Minor/Sp. Emphasis 3. Yes, Major
MTL62	14	1	4	5	4.14	0.36	1. Strongly Disagree 2. Disagree 3. Neutral 4. Agree 5. Strongly Agree
Inf_Teach3	28	2	4	6	5.82	0.48	1. No influence 2. Very small influence 3. Small influence 4. Moderate influence 5. Strong influence 6. Very strong influence
Inf_Nat_ Org2	28	5	1	6	3.00	1.41	1. No influence 2. Very small influence 3. Small influence 4. Moderate influence 5. Strong influence 6. Very strong influence
Age	27	30	36	66	49.81	9.05	
Fam_PD_ CI_Doc	27	4	2	6	4.22	1.15	1. Not familiar 2. Vaguely Familiar 3. Somewhat Familiar 4. Moderately Familiar 5. Mostly Familiar 6. Strongly Familiar
ISAM18	26	4	1	5	3.27	1.00	1. Strongly Disagree 2. Disagree 3. Neutral 4. Agree 5. Strongly Agree
%LowSES	28	83.6	16.4	100	49.64	23.33	
%EthMin	28	88.7	4.8	93.5	26.5	22.79	

When looking at the final predictive model, school-wide SAGE mathematics proficiency scores seemed to be positively impacted as school leaders' agreement with the statement: "The best way to increase student achievement in mathematics is to educate the members of the legislature on the curriculum and research based instructional strategies." (ISAM18). The post-hoc regression analysis shows evidence of an emergent phenomenon between (ISAM18) and the interaction variable (Inf_State_Leg2*MTL39) in a CAS such as a school (see Figures 6 and 7). This provides further evidence of the emergent phenomenon in schools where school leaders that believe in, and are effective at, mediating the communication between various stakeholders in their CAS are better able to influence the trajectory of the CAS towards higher student mathematics achievement.

Shared Vision of Mathematics Education

When looking at the final predictive model, school-wide SAGE mathematics proficiency scores were lowest in schools where school leaders did not have a mathematics education degree and strongly disagreed that geometry and measurement concepts formed foundational aspects of algebra. The school leaders in the higher performing schools described a more unified instructional philosophy towards mathematics education which included a commitment to inquiry-based learning grounded in real-world contexts with a focus on problem solving. The kinds of connections between geometric and algebraic concepts indicated in this interaction would be more likely to emerge with these types of instructional methods. Tables 12-14 indicate that the likelihood of a school leader having some type of a mathematics education degree

(Math_Ed) was higher among those schools performing higher or as expected than in those schools performing lower than expected. Interestingly, the average among the school leaders in the lower performing group, with respect to agreement that there are connections between geometry and algebra (MTL62), was higher than the other two groups. In addition, the post-hoc regression analysis provided evidence of an emergent property between this interaction and the percent of ethnic minority (%EthMin) students in the school. The mean percent of ethnic minority students was much higher among schools performing lower than their demographics suggest. This may indicate an emergent phenomenon in schools where school leaders believe there are important foundational connections between geometry and algebra and the percent of ethnic minority students. However, the focus group with school leaders from lower performing schools indicated a nonunified instructional philosophy among key stakeholders in their CAS. This may indicate an emergent phenomenon in schools where there is non-unified instructional philosophy and non-unified commitment to inquiry-based learning grounded in real-world contexts with a focus on problem solving, especially in schools with higher percentages of ethnic minority students in their CAS. When this emergent phenomenon of a disparate vision is present, school leaders may be less able to influence the trajectory of the CAS towards higher student mathematics achievement.

In the final predictive model, school-wide SAGE mathematics proficiency scores seemed to be negatively impacted as the school leaders' perception of the influence of national organizations such as NCTM over the implementation of the mathematics curriculum in their school rose. Tables 12-14 show that school leaders from schools performing lower than expected had the highest mean with respect to this measure. The focus group with school leaders from lower performing schools often indicated their belief in supporting instructional strategies as promoted by these types of national organizations but repeatedly expressed their frustration in effectively seeing these types of practices in their schools. Again, this provides evidence of the importance of a shared vision for mathematics education. When this shared vision is missing, school leaders are less able to influence the trajectory of the CAS towards higher student mathematics achievement.

When looking at the final predictive model, school-wide SAGE mathematics proficiency scores seemed to be negatively impacted as the school leaders' familiarity with professional development/materials/readings in mathematics curriculum and instruction (FAM_PD_CI_DOC) increases. Tables 12-14 reveal that school leaders from schools performing lower than expected had the highest mean with respect to this measure. The focus group with school leaders from lower performing schools often indicated their belief in supporting instructional strategies as promoted by these types of documents, but repeatedly expressed their frustration in effectively seeing these types of practices in their schools. Again, this provides evidence of the importance of a shared vision for mathematics education. When this shared vision is missing, school leaders are less able to influence the trajectory of the CAS towards higher student mathematics achievement.

Recruiting and Retaining High-Quality Teachers

When looking at the final predictive model, school-wide SAGE mathematics proficiency scores seemed to be negatively impacted as the school leaders' perception of the influence of the teacher over the instructional methods used in the mathematics classroom at their schools (Inf_Teach3) rose. Tables 12-14, show that school leaders from schools performing lower than expected had the highest mean on this measure. From the post-hoc regression analysis there is evidence of a possible emergent phenomenon between the influence of the teachers and the percent of low-socioeconomic students at the school. The mean percent of low-socioeconomic students is much higher among the schools performing lower than their demographics suggest. The focus group with school leaders from lower performing schools indicated more difficulty in recruiting and retaining high-quality teachers in their CAS. When this emergent phenomenon is present, school leaders are less able to influence the trajectory of the CAS towards higher student mathematics achievement.

Evidence of Multiplicative Looping Effect

When looking at the final predictive model, school-wide SAGE mathematics proficiency scores seemed to be negatively impacted as the age of their school leader increases. Indeed, Tables 12-14 show that the mean age of the school leader is highest among schools that are performing lower than their demographics suggest. From the post-hoc regression analysis there is evidence of a possible multiplicative looping effect where the school leaders' influence on themselves increases exponentially as they age.

Over-Arching Research Question

The overarching research question was: What is the school leaders' role in students' mathematics achievement in the context of complexity theory? All school leaders, across all focus groups, indicated it was their role as the school leader to build the capacity of faculty and students in mathematics. However, their decisions and actions in that role were different depending on their schools' mathematics performance group.

Among those performing higher than expected. Those from schools performing higher than their demographics suggest felt that their role in building the capacity of faculty and students in mathematics was best achieved through facilitating a shared vision of mathematics education. Matt and Jack said,

> Jack: My role as I see it is to enable the teachers to teach, in the most effective way possible, which means if I get the right training, more opportunities to collaborate, resources, leave allocated money from trust lands, so that they can purchase resources to teach with …
>
> Matt: I think that all ties back into the broader picture of culture. What's the culture like at our school? Is our culture a culture of teaching out of the textbook? I covered the material, I went through every page of the textbook. Or is that you understand the state standards, and that you have a variety of strategies to teach those standards, that you've assessed the students on those standards and re-taught or remediated or stretched those students based on what the students are giving you.

Among those performing about where expected. Those school leaders from schools performing about where their demographics suggest felt that their role was best achieved by setting expectations driven by data and holding faculty accountable. Kay said:

> I think admin sets expectations for that collaboration piece and helps break down the barriers of teachers learning from each other. I think our teachers are the most powerful resource, better than any curriculum, better than any set of standards,

> better than any budget line item. I think teachers are our most valuable asset and resource. The more we can get them helping each other, I think admin can directly make time for that. Give them space and time, to explore together, to learn together, but also being supportive if they try something new and they fail. You can learn just as much, if not more, from that, as if you're always doing the right thing. I think making taking risks a safe thing to do, definitely is a top down...not really directive, but comes from the top down, that security and giving them that space. I think that's the rule of admin, and purchasing decisions, that's very much within my circle of influence, and having teachers feel supported. Ultimately, driving questions in faculty meetings, in grade level team meetings, one on one with teachers about, "How do you know your students are learning? What do you do when they're not? What do you do if they already know?" Helping facilitate those conversations. When they know that that's important to me, then they take it more seriously, instead of just following some kind of pacing guide or something like that.

Among those performing lower than expected. Those school leaders from schools performing lower than their demographics suggest felt their role was best achieved by coaching and mentoring, evaluating and giving feedback in a one-directional way as evidenced in this exchange.

> Judy: I see myself primarily as an instructional leader. When I go in and look at a student's records and I'm seeing that they're not progressing at all, or in our PLC room, we have a hotlist for each grade level. We're tracking certain data throughout the year. It's me that's always saying, "Let's look at your hotlist. How did your kids on your hotlist do on this particular thing?" For me, my job is to continually remind teachers that it's about the students and the students' progress and the students' success.
>
> Kandy: I think for me, I don't think that I can provide instruction especially for secondary 1, 2, and 3 math, because I'm not proficient there.
>
> Judy: It's different secondary than it is elementary.
>
> Kandy: Exactly. I certainly can help with modeling teaching strategies or providing, and hopefully, I can help provide instruction for them. If they need that, that's my goal, that's what I want to use community council money for. That's what I want to use district resources for, is provide that training that those teachers might need, or especially step in with my ARL teachers and hopefully we can get some decent teaching strategies, model them for them, provide observation opportunities, those types of things.

> Kelly: I think my aim is to make sure that my teachers again are getting the quality teaching and training. I was just thinking, I probably need to have...it's been 2 years since I had math coaches come in and do the PD. I think I'll contact the district again this year and say, "Can we do that again once a month?" Just as a refresher for all of the teachers, because that's my role that I feel, is to make sure that these teachers are understanding math and how to teach it well.

Conclusion. Examining the quantitative and qualitative data through the lens of complexity theory, these results suggest that the school leaders' first role in promoting higher student mathematics achievement is to directly and indirectly facilitate a shared vision of mathematics education between stakeholders in the CAS. The results also imply that this is particularly important for the administration (including the local school board/ district) and faculty, utilizing university resources, and partnering with parents, while engaging in empowered political discourse. The results also show that the school leader's second role is to actively work to recruit and retain the highest quality teachers possible. This is especially important for schools where there are higher percentages of low-socioeconomic and ethnic minority populations.

CHAPTER V

DISCUSSION

School leaders are often tasked with improving student mathematics achievement in their schools. This study focused on understanding, pragmatically, the role of the school leader in student mathematics achievement through the lens of Complexity Theory. As such, the *School Leadership in a Complex Adaptive System (SL-CAS) Framework* (see Figure 19) provides a means for examining the complexity of the school leader's role within a schools' CAS thus allowing the researcher to describe the complex feedback loops generating emergent phenomenon at higher hierarchical levels of organization that would otherwise escape analysis of the problem.

The purpose of this study was to explore the role the school leader plays in students' mathematics achievement through the lens of Complexity Theory. This discussion of the results has three sections. The first section describes the role the school leader plays in students' mathematics achievement and the implications of these results for both researchers and educators. The final two sections identify limitations of the study and suggestions for future research, respectively.

Role the School Leader Plays in Students' Mathematics Achievement

The Relationship Between Mathematics Achievement and Characteristics of the School Leader

The first result answered the question: What characteristics of the school leader are most important in predicting students' mathematics achievement? This result

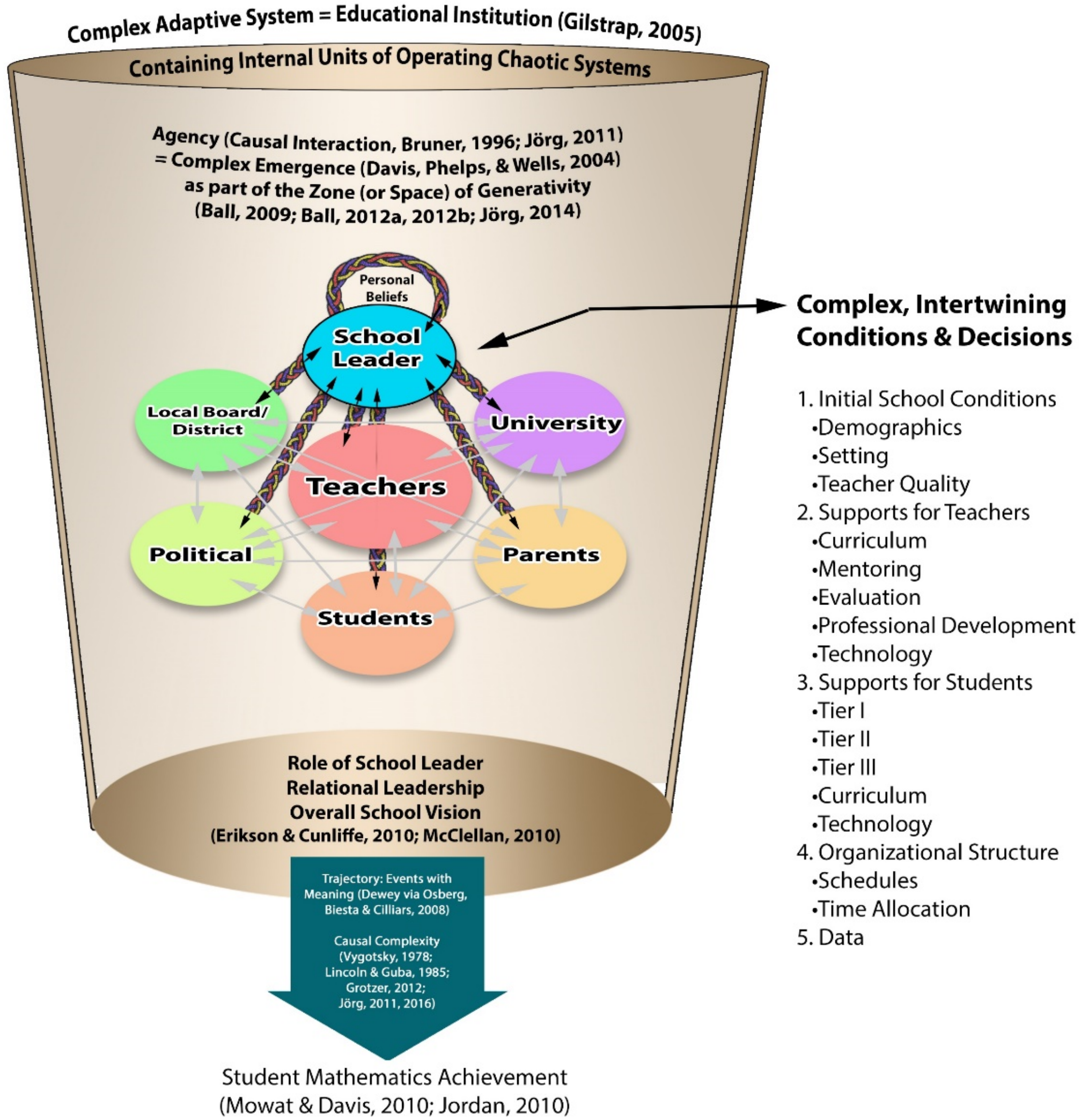

Figure 19. Conceptual framework of school leadership in a complex adaptive system (SL-CAS). This figure illustrates the dynamic organizational system known as a school with internal units of operating chaotic systems, complex feedback loops, and a school's trajectory with respect to student mathematics achievement emphasizing the role of the school leader.

indicated a complex landscape of influences on students' mathematics achievement based on the characteristics of the school leader. It also indicated that there were identifiable characteristics of a school leader that were most important in predicting the school-wide average SAGE mathematics proficiency score at the school leader's school.

This result implies that researchers can consider a multitude of independent variables (almost two hundred, in this case) when considering a school as a complex adaptive system. This is important because traditional linear regression models have relied in the past on simplifications of the complexities of actual school organizations providing an incomplete, or oversimplified picture, at best (Fleener, 2016; Jörg, 2016). By utilizing Random Forests and variable importance plots (Breiman, 2001; Ho, 1995, 2002; Liaw & Wiener, 2002), new possibilities for analysis become possible and allow for researchers to consider all the variables that impact schools and student mathematics achievement.

The second result answered the question: What is the relationship between students' mathematics achievement and characteristics of the school leader? The result indicated that a significant final model to predict school-wide average SAGE mathematics proficiency scores based on characteristics of the school leader and student demographics, encapsulating emergent phenomenon and multiplicative looping effects at higher hierarchical levels of organization, was possible through the lens of Complexity Theory. The final model included two interactions between the independent variables and seven other individual independent variables. The first interaction included in the model was between "the school leaders' perception of the amount of influence of the state legislature over the implementation of the mathematics curriculum in their school" (Inf_State_Leg2) and "the level of the school leaders' agreement with the use of cooperative work as the primary instructional practice in the K-9 mathematics classroom" (MTL39). The second interaction was between if "the school leader earned a major, minor, or special emphasis in mathematics education" (Math_Ed) and "their beliefs about geometry and measurement as critical foundations of algebra in grades 10-12" (MTL62). This second interaction was included due to the analysis procedures suggested by Gilstrap (2005) in which an emergent phenomenon appeared between this interaction and the percentage of ethnic minority students (%EthMin) in the school. The other seven independent variables included in the model were:

1. "the school leaders' perception of the amount of influence of teachers over the instructional methods used in the mathematics classroom at their school" (Inf_Teach3),
2. "the school leaders' perception of the amount of influence of national organizations such as NCTM over the implementation of the mathematics curriculum in their school" (Inf_Nat_Org2),
3. the school leader's "age" (Age),
4. "the level of familiarity the school leader has with professional development/materials/readings in mathematics curriculum and instruction" (Fam_DI_CI_Doc),
5. "the level of the school leaders' agreement with the statement: 'The best way to increase student achievement in mathematics is to educate members of the legislature on the curriculum and research-based instructional strategies'" (ISAM18),
6. "the percentage of low-income students at the school' (%LowSES), and
7. "the percentage of ethnic minority students at the school" (%EthMin).

The results show a multiplicative looping effect on the school leaders' age in which school leaders increasingly influenced themselves as they aged. Thus, this was justification for keeping the school leader's age in the model. As such, this result suggests the importance of the continuing professional development of a school leader in mathematics education related areas.

Other research that support these findings has shown that federal legislation can be linked to changes in student mathematics achievement as shown by Dee and Jacob's (2011) research on the impact of No Child Left Behind legislation on student achievement. In addition, research has indicated links to teacher quality, poor school funding, child poverty, school composition, and student mathematics achievement (Adnot, Dee, Katz, & Wyckoff, 2017; Claro, Paunesku, & Dweck, 2016; Entwisle & Alexander, 1992; Payne & Biddle, 1999). Furthermore, recent studies have also shown links between teacher and school leader professional development and student mathematics achievement (Amsterdam, 2001; Batchelder & Christian, 2000; Corcoran et al., 2012).

The result indicates that researchers can empirically determine emergent phenomenon and multiplicative looping effects at higher hierarchical levels of organization as proposed by complexity theorists (Alhadeff-Jones, 2013; Davis & Sumara, 2008; Gilstrap, 2013; Holland, 2006; Jäppinen, 2014; Koopmans, 2014). It also indicates that these results may provide a model to predict school-wide average SAGE mathematics proficiency scores thus providing another way to analyze the ways in which school leaders promote and influence student mathematics achievement. The final predictive model indicated school leader influences on community environment and instructional roles. This is in agreement with Anderson's (2008) study of 96 public primary schools in four Latin American cities. The final model also indicated agreement with Batchelder and Christian's (2000) study of the role of the school leader in an implementation of district-wide standards in which improved mathematics instruction was influenced by school culture, principal support, and teacher collaboration. Further, the predictive model includes an interaction variable containing a measure of the school leaders' content knowledge which concurs with Nelson's (2010) study in which was shown that combinations of school leaders' mathematics knowledge for teaching and their beliefs about mathematics learning and teaching effected principals' goals for mathematics instruction and their approaches to the supervision of teachers.

This result is important because it provides empirical evidence of the application of quantitative and qualitative methods advocated by complexity theorists and researchers such as Koopmans (2014), Fleener (2016), and Gilstrap (2013). This research adds to the body of research modelling schools as CAS and provides empirical evidence of emergent phenomenon and multiplicative looping effects theorized as present in a complex adaptive system, Thus, student mathematics achievement within schools can be effectively modelled and understood through the lens of Complexity Theory.

Relationships with Stakeholders in the Schools and the Influence on School Leaders' Decisions

The third result answered the question: What relationships with stakeholders in the schools influence school leaders' decisions? The result showed that the relationships the school leaders perceived with stakeholders, and the strength of influence of these relationships on the school leader, differed in the schools based on school performance. For example, schools performing higher than expected showed the teachers were the most influential stakeholders on school leaders with respect to mathematics education in their schools followed by the local school board and/or district office and then parents. These relationships were mostly described as positive in nature with parents seen as partners. However, in schools performing as expected, the most powerful influences indicated by the school leader were political, followed by the local school board and/or district office, then teachers, then themselves. These relationships were described both positively and negatively with parents seen in a more adversarial way. Finally, in schools performing lower than expected, the local school board and/or district office was the most influential stakeholders on school leaders with respect to mathematics education in their schools, followed by parents. These relationships were described in both positive and negative ways but were unique in the lack of support expressed by several school leaders in this group. These differences in relational influences and patterns may shed light on the differences found in student mathematics achievement and how a school leader's characteristics may play into the development of these relationships.

Among those performing higher than expected. School leaders in schools performing higher than their demographics would suggest indicated that teachers were the most influential stakeholder on their decisions with respect to mathematics education at their schools. These relationships were primarily described as positive with the strength of the teachers' influences often outweighing the self-influences of the school leader. The second most influential stakeholder was the school leaders' local school board and/or district office. Again, leaders described this relationship as equally positive in both directions. The third most influential stakeholder on the school leaders' decisions was from parents. While leaders described the relationship with parents in both positive and negative ways, parents were characterized as partners with the school in their student's mathematics success. In addition, school leaders described an engaged and empowered relationship with political stakeholders such as the legislature, state office of education, and/or state school board and established relationships with university resources. A shared vision of mathematics education emerged from the conversations as school leaders described a generally unified philosophy about effective instructional strategies, especially between teachers, administration, and the local school board/district office. In addition, school leaders described a distributed leadership model, and perceptions of school leader and teacher autonomy.

Among those performing about where expected. School leaders in schools performing about where their demographics would suggest indicated that political stakeholders such as the legislature and/or state office of education were the most influential stakeholders on their decisions with respect to mathematics education at their schools. However, school leaders expressed frustration at their almost hyper-awareness of these influences while feeling helpless in the face of what they perceived as top-down decision making. The second most influential stakeholder was the school leaders' local school board and/or district office. This relationship was characterized in both positive and negative ways with several expressing a loss of autonomy because of some negatively perceived influences. The third most influential stakeholder on the school leaders' decisions was from teachers. While school leaders depicted these relationships in both positive and negative ways, most descriptions were of good, high-quality teachers with a few exceptions. In contrast to the school leaders at schools performing higher than expected, relationships with parents were repeatedly described as adversarial partners with the school in their student's mathematics achievement. Often leaders described parental mindset as one of the most hindering aspect to students' success. Unique to this group, school leaders also indicated the importance of their own influence on themselves in their decision-making process. In addition, a few mentioned influences by university resources. A disparate vision of mathematics education (with school leaders trying to move their schools towards a shared vision) emerged from the conversations as school leaders described a non-unified philosophy about effective instructional strategies, especially between one or more of teachers, administration, and the local school board/district office. In addition, school leaders described a directive leadership model with attempts to move toward a distributed leadership model and a perception of teacher partial autonomy.

Among those performing lower than expected. School leaders in schools performing lower than their demographics would suggest indicated that the local school board and/or district office were the most influential relationships on their decisions with respect to mathematics education at their schools. School leaders described influences from these relationships as both positive and negative with a more top-down approach that left some feeling they had only partial autonomy in their decision-making. The second most influential stakeholder was parents. School leaders described this relationship both positively and negatively, depending on the amount of parental involvement. Many expressing frustrations at the lack of parental involvement, such that parents were often not seen as partners in their students' mathematics success. In contrast to the school leaders at schools performing higher than, and about where expected, teachers were not described as very influential on the school leaders' decision-making. A disparate vision of mathematics education (with school leaders making minimal attempts to move their schools towards a shared vision) emerged from the conversations as school leaders described an unknown or non-unified philosophy about effective instructional strategies that was wide-spread, especially between administration and teachers. In addition, school leaders described a directive leadership model with minimal attempts to move toward a distributed leadership model and perception of teacher partial autonomy.

The result indicates that one reason schools may perform better than their demographics would suggest is due to the school-wide emergent property of a shared vision of mathematics education which is evidenced by a unified philosophy about effective instructional strategies, especially between administrators, teachers, and the local school board and/or district office. While the results do not indicate which came first, this shared vision also accompanies a distributed ownership of data and a distributed leadership model in conjunction with school leader and teacher autonomy and parental partnership. This result is important as it confirms the research in line with transformational leadership theory in which shared vision is one of the five fundamental practices that empower leaders to achieve their goals (Kouzes & Posner, 1987, 2002). Johnson (2013) and Vale et al.'s (2010) results indicate shared vision occurs as school leaders help facilitate a compelling prospect through a process of visualizing positive outcomes and effective communication with other stakeholders. The evidence from the school leaders at schools performing higher than expected expressed the relational aspect of their leadership activity as described by Eriksen and Cunliffe's (2010) research. They described collaboration activities in distributed leadership as the most import aspect of what helped students succeed in mathematics. This research study adds to the body of literature in confirming the importance of shared vision to outperforming demographics.

Decisions and Actions Being Made by School Leaders

The fourth result answered the question: What decisions and actions are being made by school leaders? This result showed there were twelve types of decisions and actions made by school leaders with distinct patterns that emerged, depending on school performance. The 12 types of decisions and actions included: (1) personal beliefs about effective practices, (2) personal beliefs about effective teachers, (3) personal beliefs about what helps students succeed the most in mathematics, (4) personal beliefs about what hinders students the most in mathematics, (5) teacher recruitment and retention, (6) mathematical supports for teachers, (7) teacher evaluation and feedback, (8) data, (9) politics, (10) curriculum, (11) organizational structure, and (12) mathematical supports for students. As can be seen in Table 15, distinctive patterns emerged for these twelve types of decisions and actions, from each group of school leaders, depending on school performance.

Table 15

Differences in Decisions and Actions Based On School Performance by School Leaders

Type of decision/action	Higher	As expected	Lower
1. Personal beliefs about effective practices	Inquiry-based learning grounded in real-world context with a focus on problem solving; Heterogenous grouping with differentiation	Both groups favor ability grouping; 1. More in favor of traditional methods 2. Inquiry-based learning grounded in real-world context with a focus on problem solving	Tier I instruction most important; data; teacher collaboration; focus on basics
2. Personal beliefs about effective teachers	They have experience, education, plan based on student needs, collaborate with others, utilize data effectively, are knowledgeable of standards, deeply reflective, high pedagogical content knowledge (PCK)	They know content conceptually, have great classroom management, and utilize learning styles	1. They can differentiate and find the one right way for students with disabilities. 2. They ability group and utilize multiple strategies depending on the group.
3. Personal beliefs about what helps students the most	Teachers, specifically collaboration and distributed leadership	Teachers, specifically positive mindset; Specific technology support; Specific instructional strategy; School leader	Aligning curriculum w/standards; Hiring quality teachers; Ability grouping; Collaboration; Problem solving; School leader
4. Personal beliefs about what hinders students the most	Student mindset; Quality of teachers; Time	Student mindset; Parental and teacher negative mindset; Lack of classroom management; Lack of ability grouping	Lack of quality textbook; Lack of teacher pedagogical content knowledge; Difficult to recruit and retain high quality teachers
5. Teacher recruitment and retention	All teachers level I/II licensed; Some to no difficulty recruiting	Most teachers level I/II licensed with some ARL; Some to heavy difficulty recruiting	High ARL teacher ratio; Heavy difficulty recruiting
6. Mathematical supports for teachers	Sustained, coordinated, longitudinal	Disjointed Smorgasbord	Few of short duration or none
7. Teacher evaluation and feedback	Well-articulated, specific plans, collaboration, trust	Hold teachers accountable; Discipline, if needed; Coach and mentor, if needed.	Few well-articulated and specific plans; Coach and mentor teachers
8. Data	Distributed ownership, widely and efficiently accessible	Directive ownership, selectively and/or inefficiently available	Underutilized directive ownership

(*table continues*)

Type of decision/action	Higher	As expected	Lower
9. Politics	Engaged and empowered	Aware and helpless	Minimally aware
10. Curriculum	Teacher created materials; Textbook as resource	Moderately to heavily tied to textbook; Teacher created materials as resource	Heavy reliance on textbooks/specific program
11. Organizational structure	Distributed decision making	Decisions mainly made by school leader with input from teachers and the local school board and/or district office	Decisions made mainly by school leader with input from students, community, and teachers
12. Mathematical supports for students	Heavy on licensed teachers with support from technology; Tier I is strongly established across the school	Split between licensed teacher and aides with support from technology; Tier I generally established with a few exceptions	Heavy on aides and/or volunteers and technology; Tier I is often not well established

This result indicates several reasons in conjunction with each other that may result in schools performing higher or lower than their demographics may suggest. This research study supports Dufour and Marzano's (2011) findings in *Leaders of Learning: How District, School, and Classroom Leaders Improve Student Achievement* that indicate school leader's "influence on student achievement passes through teachers". School leaders in schools performing higher than their demographics would suggest universally indicated personal beliefs in inquiry-based mathematics learning grounded in real-world contexts with a focus on problem solving. They also indicated that they believed that collaborative practices have had the greatest positive impact on student success in mathematics. In their guiding principles for school mathematics as part of *Principles to Actions: Ensuring Mathematical Success for All*, the National Council for Teachers of Mathematics (NCTM) stated that "an excellent mathematics program requires effective teaching that engages students in meaningful learning through individual and collaborative experiences that promote their ability to make sense of mathematical ideas and reason mathematically" (NCTM, 2014, p. 5). It is reasonable to imply that school leaders with personal beliefs aligned with this philosophy would encourage mathematical supports for teachers such as professional development aligned with helping teachers employ effective instructional strategies focused on inquiry, real-world contexts, problem solving, and collaboration. A focus on such instructional strategies as effective ways to increase student achievement in mathematics is supported by research. Hiebert and Grouws (2007) discussed the importance of "facilitating students' conceptual development (and perhaps mathematical proficiency)—explicit attention to connections among ideas, facts, and procedures, and engagement of students in struggling with important mathematics (p. 391)." This result also supports a body of research on the effectiveness of inquiry-based methods in mathematics instruction (Blazar, 2015; Rittle-Johnson & Star, 2007, 2009).

In addition, Ottmar, Rimm-Kaufman, Larsen, and Berry (2015) found that third-grade students showed greater gains in achievement scores when their teachers used standards-based mathematics practices. While all school leaders indicated the importance of teachers effectively grounding their instruction in the state standards, only the higher performing group indicated that this was consistent across the teachers at their schools. School leaders from the higher performing group consistently supported teacher created materials as the primary curriculum source with textbooks used as an additional resource. School leaders supported their teachers in developing a longitudinally deep understanding of the standards and to use that understanding to create materials appropriate for their students, based on their students' needs. In Huizinga, Handelzalts, Nieveen, and Voogt's (2014) explorative study of six teachers and six facilitators engaged in curriculum design, they found that teachers had gaps in curriculum design expertise, pedagogical content knowledge, and curricular consistency expertise. These could be overcome through tailored support to teachers over a long period of time. Campbell et al. (2014) found significant relationships between teachers' mathematical content and pedagogical content knowledge, teachers' perceptions, and student achievement. This is important because school leaders from schools performing higher than expected indicated a longitudinal approach to professional development that was grounded in sustained, longitudinal, teacher-coordinated needs, distributed ownership of data, and teacher evaluation grounded in distributed leadership. This supports the most recent research in the field and effects on student achievement (Hallinger, Heck, & Murphy, 2014; Loucks-Horsley, Stiles, Mundry, Love, & Hewson, 2010; Ronfeldt, Farmer, McQueen, & Grissom, 2015). This implies that school leaders would have greater success in improving student mathematics achievement by facilitating long-term teacher collaboration practices utilizing distributed ownership of data and distributed leadership

School Leaders' Decision and Actions and Students' Mathematics Achievement

The fifth result answered the question: How are school leaders' decisions and actions based on those perceptions associated with students' mathematics achievement? This result showed three emergent phenomena and one multiplicative looping effect impacting student mathematics achievement based on school leader decisions and action.

Evidence of the first emergent phenomenon was found in schools performing higher than their demographics suggested. In these schools, school leaders not only believed in, but were effective at, mediating the communication between various stakeholders in their CAS. This emergent phenomenon enabled the school leader to better influence the trajectory of the CAS towards higher student mathematics achievement. Evidence of the second emergent phenomenon of a shared vision of mathematics education was also found in schools performing higher than their demographics would suggest. When this shared vision was missing, school leaders in this study were less able to influence the trajectory of the CAS towards higher student mathematics achievement. Evidence of the third emergent phenomenon centered around the recruitment and retention of high-quality teachers and the percent of low-SES students. When the ratio of less qualified teachers was high, this seemed to create an unwanted emergent phenomenon for the school leaders that exacerbated the low achievement of disadvantaged children. When this emergent phenomenon was present, school leaders were less able to influence the trajectory of the CAS towards higher student mathematics achievement. In addition, there was evidence of a possible multiplicative looping effect where the school leaders' influence on themselves increased exponentially as they aged. Schools who were performing lower than their demographics would suggest also had the highest mean age of the school leader.

These results are important because they imply several reasons for schools performing higher or lower than their demographics suggest. Effective communication as an important change agent in schools is widely supported in the research on adaptive leadership (Heifetz, 1994; Heifetz et al., 2009; Heifetz & Laurie, 1997; Heifetz & Linsky, 2002; Heifetz & Sinder, 1988) as a subset of complexity leadership theory (Hazy & Uhl-Bien, 2014; Uhl-Bien & McKelvey, 2007) in which leadership is described as a dynamic process originating in the tensions produced as stakeholders struggle over conflicting needs, ideas, and preferences. Thus, a school leader who is effective at mediating communication channels between various stakeholders has a better chance of inspiring effective change across multiple hierarchical levels, including self, organizational, community, and societal. Evidence of these influences were empirically shown in this study as the school leader's decisions and actions were used to promote higher student mathematics achievement.

As discussed previously, these results stress the importance of a shared vision of mathematics education in promoting higher student achievement of mathematics for thee school leaders in this study. This continues to support the research on shared vision that is important in almost every organizational structure and crosses disciplines as an avenue for improvement (Alt, Díez-de-Castro, & Lloréns-Montes, 2015; Chorpita & Daleiden, 2014; Roueche, Baker, & Rose, 2014; Strese, Keller, Flatten, & Brettel, 2016). Thus, a shared vision of mathematics within a school is essential to beating demographics in student mathematics achievement.

Furthermore, Henry et al. (2014) reported that compared with undergraduate-prepared teachers from in-state public universities, out-of-state undergraduate-prepared teachers were less effective in elementary grades and high school, alternative entry teachers were less effective in high school, and Teach for America corps members were more effective in STEM subjects and secondary grades. Schools leaders from schools performing lower than expected described frequent instances of needing to hire out-of-state prepared and alternatively licensed teachers. School leaders from schools performing higher indicated less difficulty in hiring high-quality teachers. Thus, this study supports prior research on the importance of recruiting and retaining high-quality teachers in promoting student mathematics achievement, especially as a way to close the gap between advantaged and disadvantaged students (Boonen, van Damme, & Onghena, 2014; Goldhaber, Lavery, & Theobald, 2015; Stronge, 2013).

School Leaders' Role in Student Mathematics Achievement

The over-arching research question was: What is the school leaders' role in students' mathematics achievement in the context of complexity theory? This result found that all school leaders indicated it was their role as the school leader to build the capacity of faculty and students in mathematics as a way to promote higher student mathematics achievement. However, their decisions and actions, with respect to that role, were different depending on which group they represented. School leaders at schools performing higher than expected discussed the importance of facilitating a shared vision of the culture and philosophy of mathematics education as they worked to build the capacity of faculty and students. On the other hand, school leaders at schools performing as expected discussed setting high expectations driven by data and holding faculty accountable as they worked to build the capacity of faculty and students. Finally, school leaders at schools performing lower than expected talked about coaching and mentoring, evaluating and giving feedback in a one-directional way as they worked to build the capacity of faculty and students.

This result is important because it suggests that the way in which school leaders approach building the capacity of faculty and students in mathematics may have an effect on student mathematics achievement. In trying to promote performance higher than their demographics would suggest, school leaders would do best to facilitate a shared vision of mathematics education between stakeholders in the CAS, particularly between the administration (including the local school board/district) and faculty, utilizing university resources, and partnering with parents, while engaging in empowered political discourse. A school leader's second role is to actively work to recruit and retain the highest quality teachers possible. This is especially important for schools where there are higher percentages of low-socioeconomic and ethnic minority populations.

Limitations

As with all studies, there were limitations that affect the generalizability of these results. The three main limitations were convenience sampling, lack of longitudinal data, and that the results looked only through the perspective of the school leader. This study attempted to utilize population sampling. However, the researcher only received an 18.6% response rate. Thus, the results are not generalizable to the larger population of school leaders, only to those who participated in the study. Without random sampling, it is possible that the findings may differ with other populations of school leaders in the state of Utah, or elsewhere. In addition, only 1 year of student achievement data were used to create the predictive model. A CAS is dynamic and changes over time. Thus, the results may change if the schools were studied over several years. Finally, this study focused on the perspectives of the school leader. Other factors may influence the CAS such as the perspectives of teachers, board member, parents, students, etc. However, these factors were beyond the scope of this study.

Suggestions for Future Research

This study provided an in-depth analysis of the role of the school leader and explained differences in student mathematics achievement based on emergent phenomenon at higher hierarchical levels of organization within a school formed by school leader characteristics and student demographics. Future research could include other stakeholder perspectives to build a broader explanation of the role of the school leader in student mathematics achievement through the lens of complexity theory. The SL-CAS framework provides a theoretical foundation that could be utilized through the perspectives of other stakeholders. In addition, future research could use longitudinal data and random sampling techniques to improve the generalizability of the predictive model. Finally, researchers could better explore how to model multiplicative looping effects such as those proposed by Jörg (2016) and with respect to the generative nature of causation (Grotzer, 2012; Jörg, 2016).

Conclusion

In an era where school leaders are being held increasingly accountable for student mathematics achievement, this study serves to inform school leaders on the role the school leader plays in students' mathematics achievement. This study found that school leaders can directly and indirectly influence schools to perform higher than their demographics would suggest through the facilitation of a shared vision of mathematics education between stakeholders in the school modelled as a CAS, particularly between the administration (including the local school board/district) and faculty, by utilizing university resources and partnering with parents, and engaging in empowered political discourse while actively working to recruit and retain the highest quality teachers possible. Some of the key characteristics of developing this shared vision were school leaders who facilitated communication among various stakeholders and who recruited and retained the highest quality teachers. This was especially important for schools where there were higher percentages of low SES and ethnic minority populations. Overall, schools that performed higher than expected showed evidence of a shared vision of mathematics education between various stakeholders, provided sustained, coordinated, and longitudinal mathematical supports for teachers, engaged in distributed ownership of data, and provided supports for students that were heavily reliant on licensed teachers and technology. Schools that performed as expected did not have evidence of a shared vision of mathematics education between various stakeholders, provided a disjointed smorgasbord of mathematical supports for teachers, engaged in directive ownership of data, and provided supports for students that relied on an overall balance of licensed teachers and aides/volunteers and technology. Finally, schools that performed lower than expected also did not have evidence of a shared vision of mathematics education between various stakeholders, provided few mathematical supports for teachers, engaged in underutilized directive ownership of data, and provided supports for students that relied heavily on aides/volunteers and technology. These results show that school leaders' patterns of decisions and actions can directly and indirectly influence student achievement in mathematics at their schools. This study also gives direction to researchers interested in modelling a school as a complex adaptive system through the utilization of the SL-CAS framework and analysis methods consistent with complexity theory.

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APPENDICES

Appendix A

IRB Approval

Institutional Review Board

USU Assurance: FWA#00003308

UtahState University
OFFICE OF RESEARCH AND GRADUATE STUDIES

Expedite #6 & #7

Letter of Approval

FROM:

Melanie Domenech Rodriguez, IRB Chair

Nicole Vouvalis, IRB Administrator

To:	Patricia Moyer-Packenham, Emma Bullock
Date:	March 07, 2016
Protocol #:	7314
Title:	An Explanatory Sequential Mixed Methods Study Of The School Leaders' Role In Students' Mathematics Achievement Through The Lens Of Complexity Theory
Risk:	Minimal risk

Your proposal has been reviewed by the Institutional Review Board and is approved under expedite procedure #6 & #7 (based on the Department of Health and Human Services (DHHS) regulations for the protection of human research subjects, 45 CFR Part 46, as amended to include provisions of the Federal Policy for the Protection of Human Subjects, November 9, 1998):

#6: Collection of data from voice, video, digital, or image recordings made for research purposes.

#7: Research on individual or group characteristics or behavior (including, but not limited to, research on perception, cognition, motivation, identity, language, communication, cultural beliefs or practices, and social behavior) or research employing survey, interview, oral history, focus group, program evaluation, human factors evaluation, or quality assurance methodologies.

This approval applies only to the proposal currently on file for the period of one year. If your study extends beyond this approval period, you must contact this office to request an annual review of this research. Any change affecting human subjects must be approved by the Board prior to implementation. Injuries or any unanticipated problems involving risk to subjects or to others must be reported immediately to the Chair of the Institutional Review Board.

Prior to involving human subjects, properly executed informed consent must be obtained from each subject or from an authorized representative, and documentation of informed consent must be kept on file for at least three years after the project ends. Each subject must be furnished with a copy of the informed consent document for their personal records.

4460 Old Main Hill Logan, UT 84322-4460 PH: (435) 797-1821 Fax: (435) 797-3769 WEB: irb.usu.edu EMAIL: irb@usu.edu

Appendix B

Survey Informed Consent

Department of
Teacher Education and Leadership (TEAL)
2805 Old Main Hill
Logan UT 84322-2805
Telephone: (435) 797-0389

INFORMED CONSENT

AN EXPLANATORY SEQUENTIAL MIXED METHODS STUDY OF THE SCHOOL LEADERS' ROLE IN INFLUENCING MATHEMATICS LEARNING IN THE CONTEXT OF COMPLEXITY THEORY

Introduction/ Purpose Dr. Moyer-Packenham and doctoral candidate, Emma Bullock, in the Department of TEAL at Utah State University are conducting a research study to find out more about the role school leaders play in promoting student mathematics learning. You have been asked to take part because you are a K-12, Utah public school leader/principal. There will be approximately 374 total participants in this phase of the research study.

Procedures If you agree to be in this research study, you will participate in one 20 minute survey. Participation is voluntary. The survey instrument that will be used is the Principal's Mathematics Questionnaire which aligns with the SL-CAS theoretical framework. This survey of school leaders will begin with a portion where participants are asked to give IRB consent to participate in the survey. The survey will include questions covering general demographics, teaching experiences, administrative experiences, mathematics demographics, and perceived influence on mathematics curriculum and instruction, mathematics curriculum, and mathematics teaching and achievement. This survey is adapted from Williams' (2010) Principal's Elementary Mathematics Questionnaire and will be distributed via SurveyMonkey.

Risks Participation in this research study may involve some added risks or discomforts. These include the small risk of loss of confidentiality, discomfort with the survey questions, and possible unforeseen risks that could occur. However, the researcher will take all steps necessary to reduce these risks. You may view SurveyMonkey's Security Statement at the following link:
https://www.surveymonkey.com/mp/policy/security/

Benefits There are no expected direct benefits. Possible indirect benefits may be reflection on current practice for the immediate participants. On a broader scale, this study serves to inform future research on aspects of school leadership through the lens of complexity theory, including the use of the *School Leadership in a Complex Adaptive System (SL-CAS) Framework* to understand the role school leaders play in students' mathematics achievement, for possible goals other than students' mathematics achievement, and the use of other stakeholders as the units of analysis. This study is significant because schools are being held increasingly accountable for students' mathematics achievement. School leaders and researchers need to understand how to make decisions that will allow for the most effective use of resources, time, and professional development within the complex realities that exist in schools to achieve higher mathematics achievement for all students. The knowledge gained from this study will give direction to researchers and school leaders on the nature of complex adaptive school systems and address pragmatically the understanding of the school leaders' actions to effectively move a CAS toward the goal of a shared vision which promotes higher student mathematics achievement.

Explanation & offer to answer questions Dr. Patricia Moyer-Packenham and Emma Bullock has explained this research study to you and answered your questions. If you have other questions or research-related problems, you may Emma Bullock at (801) 808-6985 or ekpbullock@gmail.com or Dr. Patricia Moyer-Packenham at (435) 797-2597.

Compensation All participants who complete the survey will receive a $5 gift card of their choice to one of the following vendors: Subway, Kneaders, McDonald's, or Wendy's. Participants will need to provide their first and last name and an address for the gift card to be mailed.

Voluntary nature of participation and right to withdraw without consequence Participation in research is entirely voluntary. You may refuse to participate or withdraw at any time without consequence or loss of benefits. *Please contact* Emma Bullock at (801) 808-6985 or ekpbullock@gmail.com to be withdrawn from this study.

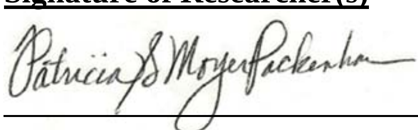
Confidentiality Research records will be kept confidential, consistent with federal and state regulations. Only the investigator will have access to the data which will be kept in a secure USU Box.com file. While the investigators will know your identities, to protect your privacy, personal, identifiable information will be removed from study documents and replaced with a study identifier for all publication of results. Identifying information will be stored separately from data and will be kept separately in a secure USU Box.com file. All personally identifiable data will be stored until the completion of the study (March 30th, 2018) and then destroyed and investigators will keep all knowledge of participation confidential and sign confidentiality agreements. De-identifiable data will be kept indefinitely.

IRB Approval Statement The Institutional Review Board for the protection of human participants at Utah State University has approved this research study. If you have any questions or concerns about your rights or a research-related injury and would like to contact someone other than the research team, you may contact the IRB Administrator at (435) 797-0567 or email irb@usu.edu to obtain information or to offer input.

Copy of consent Participation in the survey will be acknowledgement of consent to participate. If you would like a hard copy of your consent, please contact Emma Bullock at ekpbullock@gmail.com and one will be sent to you.

Investigator Statement "I certify that the research study has been explained to the individual, by me or my research staff, and that the individual understands the nature and purpose, the possible risks and benefits associated with taking part in this research study. Any questions that have been raised have been answered."

Signature of Researcher(s)



Dr. Patricia Moyer-Packenham *Date*

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Signature of Participant By signing below, I verify that I am 18 years of age or older and consent to participate in this study.

Participant's signature Date

Appendix C

Focus Group Informed Consent

Department of
Teacher Education and Leadership (TEAL)
2805 Old Main Hill
Logan UT 84322-2805
Telephone: (435) 797-0389

INFORMED CONSENT

AN EXPLANATORY SEQUENTIAL MIXED METHODS STUDY OF THE SCHOOL LEADERS' ROLE IN INFLUENCING MATHEMATICS LEARNING IN THE CONTEXT OF COMPLEXITY THEORY

Introduction/ Purpose Dr. Patricia Moyer-Packenham and doctoral candidate, Emma Bullock, in the Department of TEAL at Utah State University is conducting a research study to find out more about the role school leaders play in promoting student mathematics learning. You have been asked to take part because you are a K-12, Utah public school leader/principal. There will be approximately 18-24 total participants in this phase of the research study.

Procedures If you agree to be in this research study, you will participate in one 2-hour, video-taped, and audio-recorded, focus-group interview session. This session will be held at a neutral site. Participation is voluntary. The bulk of the interview will consist of questions about the influence of various stakeholders at your school and student mathematics learning. Video-taping will occur from the moment participants enter the room until the moment they leave which means participants will be video-taped prior to the official start of the interview and after the official end of the interview as long as they are in the interview room. The researcher will share all data and results with you prior to publication. In addition, the researcher will take all necessary measures to assure anonymity of the participants in publications of the results. You may withdraw your participation at any time without negative consequences.

Risks Participation in this research study may involve some added risks or discomforts. These include the small risk of loss of confidentiality, discomfort with the research process, and possible unforeseen risks that could occur. However, the researcher will take all steps necessary to reduce these risks.

Benefits Expected possible direct benefits are increases in knowledge of how to best directly or indirectly promote student mathematics learning at your school. Possible indirect benefits may be reflection on current practice. On a broader scale, this study serves to inform future research on aspects of school leadership through the lens of complexity theory, including the use of the *School Leadership in a Complex Adaptive System (SL-CAS) Framework* to understand the role school leaders play in students' mathematics achievement, for possible goals other than students' mathematics achievement, and the use of other stakeholders as the units of analysis. This study is significant because schools are being held increasingly accountable for students' mathematics achievement. School leaders and researchers need to understand how to make decisions that will allow for the most effective use of resources, time, and professional development within the complex realities that exist in schools to achieve higher mathematics achievement for all students. The knowledge gained from this study will give direction to researchers and school leaders on the nature of complex adaptive school systems and address pragmatically the understanding of the school leaders' actions to effectively move a CAS toward the goal of a shared vision which promotes higher student mathematics achievement.

Explanation & offer to answer questions Emma Bullock has explained this research study to you and answered your questions. If you have other questions or research-related problems, you may contact Dr.

Patricia Moyer-Packenham at (435) 797-2597 or patricia.moyer-packenham@usu.edu or Emma Bullock at (801) 808-6985 or ekpbullock@gmail.com.

Extra Cost(s) Participants may need to travel within the State of Utah to attend the Focus Group. Travel reimbursement will be provided to all participants at $0.54/mile round trip. Total reimbursable miles will be determined between the researcher and participant beforehand in writing via an email using a Google Maps.

Compensation All focus group participants will receive a $25 gift card as compensation for their participation.

Voluntary nature of participation and right to withdraw without consequence Participation in research is entirely voluntary. You may refuse to participate or withdraw at any time without consequence or loss of benefits. *Please contact* Emma Bullock at (801) 808-6985 or ekpbullock@gmail.com to be withdrawn from this study.

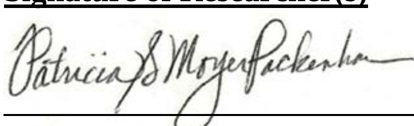
Confidentiality Research records will be kept confidential, consistent with federal and state regulations. Only the investigator will have access to the data which will be kept in a locked file cabinet or on a password protected computer in a locked room. To protect your privacy, personal, identifiable information will be removed from study documents and replaced with a study identifier. Identifying information will be stored separately from data and will be kept. All video-recordings will be stored using USU Box.com files and personally identifiable information will be beeped out from the recordings and removed from all transcripts and replaced with identifiers and/or pseudonyms. All personally identifiable data, including video or audio recordings, will be stored until the completion of the study (March 30th, 2018) and then destroyed.

IRB Approval Statement The Institutional Review Board for the protection of human participants at Utah State University has approved this research study. If you have any questions or concerns about your rights or a research-related injury and would like to contact someone other than the research team, you may contact the IRB Administrator at (435) 797-0567 or email irb@usu.edu to obtain information or to offer input.

Copy of consent You have been given two copies of this Informed Consent. Please sign both copies and keep one copy for your files.

Investigator Statement "I certify that the research study has been explained to the individual, by me or my research staff, and that the individual understands the nature and purpose, the possible risks and benefits associated with taking part in this research study. Any questions that have been raised have been answered."

Signature of Researcher(s)



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Date

Signature of Participant By signing below, I verify that I am 18 years of age or older and consent to participate and maintain full confidentiality of other focus-group participants.

Participant's signature

Date

Appendix D

Revised Principal's Mathematics Questionnaire

Principal's Mathematics Questionnaire

Please provide some demographic information about yourself and your school.

3. What is the current approximate enrollment of your school?

[ ]

4. Your age:

[ ]

5. Your Gender:

- ◯ Female
- ◯ Male

6. Ethnicity: Are you Hispanic/Latino?

- ◯ Yes
- ◯ No

7. Race: Select one or more of the following racial groups.

- ☐ American Indian or Alaskan Native
- ☐ Asian
- ☐ Black or African American
- ☐ Native Hawaiian or other Pacific Islander
- ☐ White

8. What is you highest level of education?

- ◯ Bachelors
- ◯ Masters
- ◯ Specialist or plus 30
- ◯ Doctorate

9. Do you currently have, or have you ever had, a Utah teachers license?

- ◯ Yes
- ◯ No

10. What type of Utah teacher license area of concentration(s) do you have?

[ ]

11. What type of Utah teacher endorsement(s) do you have?

[ ]

12. Do you currently have, or have you ever had, a Utah administrator's license?

- ◯ Yes
- ◯ No

13. What type of Utah administrative certification(s) do you currently have?

- ◯ K-12 Adminstrative License
- ◯ District or Charter Specific Adminstrative License

Please tell us about your teaching experience with information about the teaching position you held longest first.

14. What grades did you teach in your longest held teaching position? (Check all that apply.)

- ☐ I never held a teaching position.
- ☐ Pre-kindergarten
- ☐ Kindergarten
- ☐ 1st
- ☐ 2nd
- ☐ 3rd
- ☐ 4th
- ☐ 5th
- ☐ 6th
- ☐ 7th
- ☐ 8th
- ☐ 9th
- ☐ 10th
- ☐ 11th
- ☐ 12th
- ☐ Post Secondary

15. What subjects did you teach in your longest teaching position? (Check all that apply.)

- ☐ English/Language Arts
- ☐ Mathematics
- ☐ Science
- ☐ History/Social Studies
- ☐ Other (please specify)
- ☐ Health/Physical Education
- ☐ Business
- ☐ Music/Art
- ☐ Foreign Language
- ☐ Career and Technical
- ☐ Special Education

16. How many years did your longest teaching position last?

17. Have you had more than one teaching position?

- ◯ Yes
- ◯ No

Please tell us about your teaching experience with information about the teaching position you held longest first.

14. What grades did you teach in your longest held teaching position? (Check all that apply.)

- ☐ I never held a teaching position.
- ☐ Pre-kindergarten
- ☐ Kindergarten
- ☐ 1st
- ☐ 2nd
- ☐ 3rd
- ☐ 4th
- ☐ 5th
- ☐ 6th
- ☐ 7th
- ☐ 8th
- ☐ 9th
- ☐ 10th
- ☐ 11th
- ☐ 12th
- ☐ Post Secondary

15. What subjects did you teach in your longest teaching position? (Check all that apply.)

- ☐ English/Language Arts
- ☐ Mathematics
- ☐ Science
- ☐ History/Social Studies
- ☐ Other (please specify)
- ☐ Health/Physical Education
- ☐ Business
- ☐ Music/Art
- ☐ Foreign Language
- ☐ Career and Technical
- ☐ Special Education

16. How many years did your longest teaching position last?

17. Have you had more than one teaching position?

- ◯ Yes
- ◯ No

18. How many total years of teaching experience do you have (including ones listed in the above question(s))?

[ ]

19. How many total years have you taught mathematics? (choose 0, if you have never taught mathematics)

[ ]

Please tell us about your administrative experience with information about your current position first.

20. What position do you currently hold in your school? (check all that apply)

- ☐ Principal
- ☐ Headmaster/Headmistress
- ☐ Superintendent
- ☐ Assistant Principal
- ☐ Director
- ☐ Executive Director
- ☐ Assistant Director
- ☐ Other (please specify)

[ ]

21. What grade levels are taught at your current school? (check all that apply)

- ☐ Pre-kindergarten
- ☐ 4th
- ☐ 9th
- ☐ Kindergarten
- ☐ 5th
- ☐ 10th
- ☐ 1st
- ☐ 6th
- ☐ 11th
- ☐ 2nd
- ☐ 7th
- ☐ 12th
- ☐ 3rd
- ☐ 8th

22. How many years have you been in your current position at this school?

[ ]

23. Did you have an administrative position before your current position?

- ○ Yes
- ○ No

24. How many total years of administrative experience do you have (including ones listed in the above question(s))?

[ ]

25. Which of the following mathematics courses did you complete as an undergraduate or graduate student? (checl all that apply)

- ☐ College Algebra
- ☐ Geometry
- ☐ Linear Algebra
- ☐ Calculus
- ☐ Statistics
- ☐ Probability
- ☐ Mathematics Teaching Methods
- ☐ Mathematics for Elementary Teachers
- ☐ Other (please specify)

26. Did you have a major, minor, or special emphasis in any part of the following subjects as part of your undergraduate and/or graduate coursework? (select all that apply)

	No	Yes, a minor or special emphasis	Yes, a major
Mathematics Education	○	○	○
Mathematics	○	○	○
Other mathematics-related subject such as chemistry or physics.	○	○	○
Elementary Education	○	○	○
Secondary Education	○	○	○

Other (please specify)

This page will allow you to identify who you perceive has the most influence over various aspects of your school's mathematics curriculum.

27. Please rate the amount of influence each of the following have over the content of the mathematics curriculum at your school. (select one circle per line)

	No Influence	Very small influence	Small influence	Moderate Influence	Strong Influence	Very Strong Influence
You, the principal	○	○	○	○	○	○
Teachers	○	○	○	○	○	○
Parents	○	○	○	○	○	○
Students	○	○	○	○	○	○
School Board and/or District Office	○	○	○	○	○	○
Utah State Office of Education	○	○	○	○	○	○
State Legislature	○	○	○	○	○	○
Federal Legislature	○	○	○	○	○	○
National Organizations such as NCTM (National Council of Teachers of Mathematics)	○	○	○	○	○	○

28. Please rate the amount of influence each of the following have over the <u>implementation</u> of the mathematics curriculum at your school. (select one circle per line)

	No Influence	Very small Influence	Small influence	Moderate influence	Strong influence	Very strong Influence
You, the principal	○	○	○	○	○	○
Teachers	○	○	○	○	○	○
Parents	○	○	○	○	○	○
Students	○	○	○	○	○	○
School Board and/or District Office	○	○	○	○	○	○
Utah State Office of Education	○	○	○	○	○	○
State Legislature	○	○	○	○	○	○
Federal Legislature	○	○	○	○	○	○
National Organizations such as NCTM (National Council of Teachers of Mathematics)	○	○	○	○	○	○

29. Please rate the amount of influence each of the following have over the <u>instructional</u> methods used in the mathematics classrooms in your school. (select one circle per line)

	No Influence	Very small influence	Small influence	Moderate influence	Strong influence	Very strong Influence
You, the principal	○	○	○	○	○	○
Teachers	○	○	○	○	○	○
Parents	○	○	○	○	○	○
Students	○	○	○	○	○	○
School Board and/or District Office	○	○	○	○	○	○
Utah State Office of Education	○	○	○	○	○	○
State Legislature	○	○	○	○	○	○
Federal Legislature	○	○	○	○	○	○
National Organizations such as NCTM (National Council of Teachers of Mathematics)	○	○	○	○	○	○

This page will provide you the opportunity to identify which curriculum documents you are familiar with and have influenced your understanding of mathematics curriculum and instruction. It is OK if you are not familiar with a document or have not used it.

30. Please rate your familiarity with the following mathematics curriculum documents and reports and the extent to which it has influenced your understanding of mathematics curriculum and instruction.

	I've never heard of this document or report/ Not Familiar	I've heard of this document or report/ Vaguely Familiar	I've discussed this document or report/ Somewhat Familiar	I've read this document or report/ Moderately Familiar	I've read, and used, this document or report/ Mostly Familiar	I've read, and refer to, this document or report frequently/ Strongly Familiar
2000 NCTM Principles and Standards	○	○	○	○	○	○
2014 NCTM Principles to Actions	○	○	○	○	○	○
Common Core State Standards Initiative	○	○	○	○	○	○
2008 Final Report of the National Advisory Panel	○	○	○	○	○	○
Your school's mathematics textbook(s)	○	○	○	○	○	○
University course/materials/readings in mathematics curriculum and instruction	○	○	○	○	○	○
Professional development/materials/readings in mathematics curriculum and instruction	○	○	○	○	○	○

31. What mathematics curriculum is used at your school? (check all that apply)

- ☐ Everyday Math
- ☐ Go Math
- ☐ Harcourt Math
- ☐ Saxon Math
- ☐ Singapore Math
- ☐ Other (please specify)
- ☐ Scott Foresman-Addison Wesley Mathematics
- ☐ Houghton Mifflin Math
- ☐ Utah State Core Mathematics Standards
- ☐ Common Core Mathematics Standards
- ☐ Not sure

32. To what extent do you agree with the following statements as they relate to mathematics teaching and learning.

	Strongly Disagree	Disagree	Neither Disagree Nor Agree	Agree	Strongly Agree
Topics in mathematics curriculum should be revisited year after year without bringing them to closure.	○	○	○	○	○
The practice of teaching by telling should be used as the primary instructional practice in the mathematics classroom.	○	○	○	○	○
Parents' mathematical knowledge is important for students' achievement.	○	○	○	○	○
School boards', legislators', state office of education personnel's, and district office personnel's mathematical knowledge is important for students' achievement.	○	○	○	○	○
Some children are not ready or are too young to learn certain mathematics content.	○	○	○	○	○
Publishers should produce shorter and more focused mathematics textbooks.	○	○	○	○	○
Mathematics curriculum should include an increased use of touch-screen apps and computer apps/websites.	○	○	○	○	○

33. To what extent do you agree with the following statements as they relate to mathematics teaching and learning.

	Strongly Disagree	Disagree	Neither Disagree Nor Agree	Agree	Strongly Agree
Knowledge of fractions (proportional reasoning) is the most important foundational skill developed among students.	○	○	○	○	○
Mathematics curriculum should make appropriate and ongoing use of computers.	○	○	○	○	○
Our current curriculum provides sufficient practice to ensure fast and efficient solving of mathematics facts.	○	○	○	○	○
Mathematics instruction should be student centered more than 50% of the time.	○	○	○	○	○
The use of calculators in early grades impedes the development of automaticity with basic facts.	○	○	○	○	○
Writing about mathematics should be the primary instructional practice in the mathematics classroom.	○	○	○	○	○
Content integration should take place at least 50% of the time in the mathematics classroom.	○	○	○	○	○

Please skip this page if you are not an administrator at a school with any grades K-9.

34. To what extent do you agree with the following statements as they relate to mathematics teaching and learning in grades K-9?

	Strongly Disagree	Disagree	Neither Disagree nor Agree	Agree	StronglyAgree
Teachers' mathematical content knowledge is important for students' achievement.	○	○	○	○	○
School leaders/principal's mathematical knowledge is important for students' achievement.	○	○	○	○	○
Written practice should be an important instructional practice in the K-9 mathematics classroom.	○	○	○	○	○
Children should not be taught that there is only one answer or one method to solve mathematics problems.	○	○	○	○	○
There should be a streamlined and a well-defined set of the important topics that are taught in early/middle grades.	○	○	○	○	○

Please skip this page if you are not an administrator at a school with any grades K-9.

35. To what extent do you agree with the following statements as they relate to mathematics teaching and learning in grades K-9?

	Strongly Disagree	Disagree	Neither Disagree Nor Agree	Agree	StronglyAgree
The K-9 mathematics curriculum should be conceptually oriented.	○	○	○	○	○
Proficiency with whole numbers, fractions, and certain aspects of geometry and measurement are the foundations for algebra.	○	○	○	○	○
The K-9 mathematics curriculum should include a broad rage of content.	○	○	○	○	○
Conceptual understanding, computational and procedural fluency, and problem solving skills are equally important and mutually reinforce each other.	○	○	○	○	○
Rote practice (drill) should be an important instructional practice in the K-9 mathematics classroom.	○	○	○	○	○

Please skip this page if you are not an administrator at a school with any grades K-9.

36. To what extent do you agree with the following statements as they relate to mathematics teaching and learning in grades K-9?

	Strongly Disagree	Disagree	Neither Disagree Nor Agree	Agree	Strongly Agree
Mathematics curriculum should emphasize the development of children's mathematical thinking and reasoning abilities.	○	○	○	○	○
Children's belief in their mathematics ability affects their persistance in mathematics learning.	○	○	○	○	○
Problem-solving approaches to instruction should be used as the primary instructional practice in the K-9 mathematics classroom.	○	○	○	○	○
Mathematics preparation of elementary/middle school teachers must be strengthened to improve teacher effectiveness.	○	○	○	○	○
Manipulative materials should be used as the primary instructional practice in the K-9 mathematics classroom.	○	○	○	○	○

Please skip this page if you are not an administrator at a school with any grades K-9.

37. To what extent do you agree with the following statements as they relate to mathematics teaching and learning in grade K-9?

	Strongly Disagree	Disagree	Neither Disagree Nor Agree	Agree	Strongly Agree
Proficiency with whole numbers is a critical foundation for algebra.	○	○	○	○	○
Certain aspects of geometry and measurement are critical foundations of algebra.	○	○	○	○	○
Rote memorization of rules should be the primary instructional practice in the K-9 mathematics classroom.	○	○	○	○	○
Discussion of mathematics (mathematical discourse) should be used at least 50% of the time in the K-9 mathematics classroom.	○	○	○	○	○
Students learn mathematics by building on prior knowledge.	○	○	○	○	○

Please skip this page if you are not an administrator at a school with any grades K-9.

38. To what extent do you agree with the following statements as they relate to mathematics teaching and learning in grades K-9?

	Strongly Disagree	Disagree	Neither Disagree Nor Agree	Agree	StronglyAgree
Mathematics instruction should be teacher directed more than 50% of the time.	○	○	○	○	○
Questioning should be an important instuctional practice in the K-9 mathematics classroom.	○	○	○	○	○
Computer based drill and practice and tutorials can improve student performance in specific areas of mathematics.	○	○	○	○	○
Justification of thinking should be a primary instructional practice in the K-9 mathematics classroom.	○	○	○	○	○
Cooperative work should be the primary instructional practice in the K-9 mathematics classroom.	○	○	○	○	○

Please skip this page if you are not an administrator at a school with any grades 10-12.

39. To what extent do you agree with the following statements as they relate to mathematics teaching and learning in grades 10-12?

	Strongly Disagree	Disagree	Neither Disagree Nor Agree	Agree	Strongly Agree
There should be a streamlined and a well-defined set of the important topics that are taught in the high school grades.	○	○	○	○	○
Proficiency with whole numbers, fractions, and certain aspects of geometry and measurement are the foundations for algebra.	○	○	○	○	○
The 10-12 mathematics curriculum should include a broad rage of content.	○	○	○	○	○
Conceptual understanding, computational and procedural fluency, and problem solving skills are equally important and mutually reinforce each other.	○	○	○	○	○
Rote practice (drill) should be an important instructional practice in the 10-12 mathematics classroom.	○	○	○	○	○
Students should develop immediate recall of arithmetic facts.	○	○	○	○	○
Mathematics curriculum should emphasize the development of children's mathematical thinking and reasoning abilities.	○	○	○	○	○

Please skip this page if you are not an administrator at a school with any grades 10-12.

40. To what extent do you agree with the following statements as they relate to mathematics teaching and learning in grades 10-12?

	Strongly Disagree	Disagree	Neither Disagree Nor Agree	Agree	Strongly Agree
Teachers' mathematical content knowledge is important for students' achievement.	○	○	○	○	○
Children's belief in their mathematics ability affects their persistance in mathematics learning.	○	○	○	○	○
Problem-solving approaches to instruction should be used as the primary instructional practice in the 10-12 mathematics classroom.	○	○	○	○	○
School leaders/principal's mathematical knowledge is important for students' achievement.	○	○	○	○	○
Mathematics curriculum should actively involve children in doing mathematics.	○	○	○	○	○
Teachers' regular use of ongoing assessments can improve student learning in mathematics.	○	○	○	○	○

Please skip this page if you are not an administrator at a school with any grades 10-12.

41. To what extent do you agree with the following statements as they relate to mathematics teaching and learning in grades 10-12?

	Strongly Disagree	Disagree	Neither Disagree Nor Agree	Agree	Strongly Agree
Written practice should be an important instructional practice in the 10-12 mathematics classroom.	○	○	○	○	○
Mathematics curriculum should emphasis the application of mathematics.	○	○	○	○	○
Explicit instruction for students who struggle with math is effective in increasing student performance with word problems and computation.	○	○	○	○	○
Worksheets should be an important instructional practice in the 10-12 mathematics curriculum.	○	○	○	○	○
Mathematics curriculum in grades 10-12 should include an increased use of calculators..	○	○	○	○	○
Children should not be taught that there is only one answer or one method to solve mathematics problems.	○	○	○	○	○

Please skip this page if you are not an administrator at a school with any grades 10-12.

42. To what extent do you agree with the following statements as they relate to mathematics teaching and learning in grade 10-12?

	Strongly Disagree	Disagree	Neither Disagree Nor Agree	Agree	Strongly Agree
Mathematics preparation of high school teachers must be strengthened to improve teacher effectiveness.	○	○	○	○	○
Manipulative materials should be used as the primary instructional practice in the 10-12 mathematics classroom.	○	○	○	○	○
Proficiency with whole numbers is a critical foundation for algebra.	○	○	○	○	○
Certain aspects of geometry and measurement are critical foundations of algebra.	○	○	○	○	○
Rote memorization of rules should be the primary instructional practice in the 10-12 mathematics classroom.	○	○	○	○	○
Discussion of mathematics (mathematical discourse) should be used at least 50% of the time in the 10-12 mathematics classroom.	○	○	○	○	○

Please skip this page if you are not an administrator at a school with any grades 10-12.

43. To what extent do you agree with the following statements as they relate to mathematics teaching and learning in grades 10-12?

	Strongly Disagree	Disagree	Neither Disagree Nor Agree	Agree	Strongly Agree
Mathematics instruction should be teacher directed more than 50% of the time.	○	○	○	○	○
Students learn mathematics by building on prior knowledge.	○	○	○	○	○
Questioning should be an important instuctional practice in the 10-12 mathematics classroom.	○	○	○	○	○
Computer based drill and practice and tutorials can improve student performance in specific areas of mathematics.	○	○	○	○	○
Justification of thinking should be a primary instructional practice in the 10-12 mathematics classroom.	○	○	○	○	○
Cooperative work should be the primary instructional practice in the 10-12 mathematics classroom.	○	○	○	○	○

This page will allow you to share your perceptions about supports for increasing student achievement in mathematics. There are no wrong answers. Please read each question carefully and decide whether you agree or disagree with the statement. If you are not familiar with the content of the question, select "not familiar".

44. The best way to increase student achievement in mathematics is to....

	Strongly Disagree	Disagree	Neither Disagree Nor Agree	Agree	StronglyAgree
Provide teachers with long-term professional development differentiated according to needs.	○	○	○	○	○
Pay for teachers to take more university mathematics content courses.	○	○	○	○	○
Work with university researchers in a collaborative professional development.	○	○	○	○	○
Have teachers engage in Japanese lesson study.	○	○	○	○	○
Improve professional learning communities (PLCs).	○	○	○	○	○

45. The best way to increase student achievement in mathematics is to....

	Strongly Disagree	Disagree	Neither Disagree Nor Agree	Agree	Strongly Agree
Use a distict/charter mathematics specialist/coach/mentor to work individually, or in groups, with teachers, as needed.	○	○	○	○	○
Have teachers attend national professional organizations' conferences such as the annual or regional NCTM.	○	○	○	○	○
Have teachers attend state professional organizations' conferences such as the annual UCTM (Utah Council of Teachers of Mathematics) or UAPCS (Utah Association of Public Charter Schools) conferences.	○	○	○	○	○
Conduct regular, comprehensive teacher evaluations.	○	○	○	○	○
Provide mathematics family nights for parents and students.	○	○	○	○	○
Provide peer tutoring for students.	○	○	○	○	○

46. The best way to increase student achievement in mathematics is to....

	Strongly Disagree	Disagree	Neither Disagree Nor Agree	Agree	StronglyAgree
Provide teacher/aide tutoring for students.	○	○	○	○	○
Provide appropriate Tier II and Tier III instruction for students.	○	○	○	○	○
Use some form of heterogeneous, ability, achievement, muli-grade, accelerated or differentiated grouping for primary mathematics instruction.	○	○	○	○	○
Provide web-based/computer-based/app-based tutoring for students.	○	○	○	○	○

47. The best way to increase student achievement in mathematics is to....

	Strongly Disagree	Disagree	Neither Disagree Nor Agree	Agree	StronglyAgree
Educate parents on the curriculum and research-based instructional strategies.	○	○	○	○	○
Educate board members on the curriculum and research-based instructional strategies.	○	○	○	○	○
Educate members of the legislature on the curriculum and research-based instructional strategies.	○	○	○	○	○
Provide specialized, intensive instruction for sub-populations of students such as SpEd, ELL, low SES, Migrant, Homeless, etc.	○	○	○	○	○
Use common assessments and analyze student data on a regular basis.	○	○	○	○	○

Appendix E

Survey Recruitment Email

Dear Principal/School Leader,

You are being invited to take part in a research project examining the school leaders' role in student mathematics achievement. The data are being gathered by using on-line surveys. The surveys will take no more than 20 minutes for you to complete. To thank you for your time, you will receive a $5 gift card to a vendor of your choice (Subway, Kneaders, McDonalds, or Wendy's). The survey begins with a consent form informing you more about the study and is followed by a series of questions to gather some demographic data and a brief survey regarding your perception of influences on (a) the content of mathematics curriculum, (b) the implementation of the mathematics curriculum, and (c) the instructional methods used to teach mathematics, your perceptions about teaching and achievement in mathematics, and your perceptions about supports for increasing student achievement of mathematics.
Here is the link:
https://www.surveymonkey.com/r/SQYRT8H
Please take no more than 20 minutes to complete the survey.

If you have any questions, please contact Emma Bullock at ekpbullock@gmail.com or 801-808-6985 or Dr. Patricia Moyer-Packenham at patricia.moyer-packenham@usu.edu or 435-797-2597.

Appendix F

Focus Group Recruitment Dialogue

(adapted from Vaughn, Schumm, & Sinagub, 1996)

Hello, _______? This is Emma Bullock from Utah State University. I am currently enrolled as a PhD student in the Mathematics Education and Leadership Program at Utah State University. I would like to take a few minutes of your time to tell you about a research study I am conducting and to solicit your help.

First, let me tell you how you were selected. I am very interested in conducting this study and including K-12 public school leaders in the State of Utah. You were identified from your participation in the *Principal's Mathematics Questionnaire* as a school leader who might be interested in providing information to a research study on the role school leaders play in promoting student mathematics achievement.

The purpose of this study is to determine the complex influences that impact the decisions made my school leaders with respect to the allocation of resources, curriculum, time, mentoring and coaching, feedback, professional development, and the support of instructional methods. We are also interested in how these decisions influence student mathematics achievement.

You were carefully selected for participation in this study and I am very hopeful that you will agree to be part of a group of school leaders who will share with us their perceptions on these issues. What is very important is that there are no right or wrong answers, but what I am interested in is what you think and how things are going for you related to this issue. Your contribution is very important because I am going to summarize the responses of more than 20 school leaders and use this information (of course, all identifying information will be kept strictly confidential), along with survey data from hundreds of principals across the State of Utah to assist school leaders in determining the most effective ways to promote student mathematics achievement. Furthermore, the information will be provided to other agencies, such as the State Department of Education, which might find it useful in supporting K-12 school leaders. The contribution that you will make is essential to our better understanding of this important topic, and we feel that you are uniquely suited to assist us. In addition, you will be compensated for your time and travel if you choose to participate. All your mileage for travel expenses will be reimbursed (at $0.54/mile), you will receive a $25 VISA gift card, and a one night hotel will be provided if you live more than 50 miles away from the interview site. You may have some questions, and I will do my best to answer them.

Appendix G

Focus Group Confidentiality Agreement

Department of
Teacher Education and Leadership (TEAL)
2805 Old Main Hill
Logan UT 84322-2805
Telephone: (435) 797-0389

CONFIDENTIALITY AGREEMENT

AN EXPLANATORY SEQUENTIAL MIXED METHODS STUDY OF THE SCHOOL LEADERS' ROLE IN INFLUENCING MATHEMATICS LEARNING IN THE CONTEXT OF COMPLEXITY THEORY

I understand that any information concerning the identities and information shared by people participating in project-related focus groups is to be kept confidential at all times.

The only exceptions to the above confidentiality policy are as follows:

1. When researchers with Utah State University are bound by the law to report suspected child abuse, elder abuse, and/or the abuse of a person with a disability and/or homicide or homicidal or suicidal threats.
2. Researchers with Utah State University will comply with court orders and properly issued subpoenas.
3. When researchers with Utah State University are bound by state law requirements to report abusive, illegal, or sexually exploitive acts.
4. Researchers with Utah State University may discuss confidential information about focus group and individual interviews with other project staff who have signed confidentiality agreements.

I have read, understood, and agree to comply with the confidentiality policy described above.

____
Print Name

____
Signature

Date: ______________________________

Appendix H

Focus Group Interview Protocol

adapted from (Vaughn, Schumm, & Sinagub, 1996)

1. Introduction
    a. Welcome
    b. Statement of the purpose of the interview
    c. Guidelines to follow during the interview
2. Warm-Up
    a. Set the tone
    b. Set participants at ease
3. Clarification of Terms
    a. Establish the knowledge base of key terms through questions
    b. Provide definition of key terms
        i. Influence
        ii. Student Mathematics Achievement
        iii. Resource Allocation
        iv. Curriculum
        v. Time
        vi. Mentoring and Coaching
        vii. Feedback
        viii. Professional Development
        ix. Support for Instructional Strategies
4. Establish Ease and Nonthreatening Questions
    a. Tell me about the influence of various stakeholders at your school.
    b. What type of organizational structures/groups exist for teachers, students, parents, community members, etc. at your school?
        i. What do you perceive contributed to the organization of these groups?
        ii. What has changed over time about these groups at your school?
        iii. How have these groups helped contribute to decisions with respect to the allocation of resources (i.e., choices about curriculum, time allocation, feedback, teacher professional development, instructional methods, etc.)?
        iv. How do you feel the decisions made by these stakeholder groups influence your decisions and actions at your school?
    c. Tell me about the mathematics supports for teachers.
        i. What has contributed to the development of these supports in your school?
    d. Tell me about the mathematics supports for students.
        i. What has contributed to the development of these supports in your school?
5. Establish More Difficult Questions
    a. Do you feel there is a shared vision with respect to student mathematics learning within your school?
        i. Are there particular events, or decisions, that have occurred as a result of this shared vision?

        ii. Do you perceive this shared vision, or the lack of it as influencing students' mathematics learning at their school?
    b. What do you feel has helped to promote student mathematics learning the most at your school?
        i. What stakeholder groups do you feel have contributed to these decisions?
    c. What so you feel has hindered student mathematics learning the most at your school?
        i. What stakeholder groups do you feel have contributed to these decisions?
    d. What you feel is your role in promoting student mathematics learning?
        i. Who influences you in your role as a school leader? Whom do you feel you influence?
6. Wrap-Up
    a. Identify and organize the major themes from the participant's responses.
    b. Ensure that any conversational points not completed are mentioned.
7. Member Check
    a. Determine how each member perceives selected issues
8. Closing Statements
    a. Request anonymity of information
    b. Answer any remaining questions
    c. Express thanks.

Appendix I

Cronbach Alphas for Revised Principal's Mathematics Questionnaire

Table I-1

Cronbach's Alpha for Influence on Mathematics Curriculum and Instruction Portion

Question	Cronbach's Alpha	Cronbach's Alpha if item deleted
-Please rate the amount of influence each of the following have over the content of the mathematics curriculum at your school.	0.695	0.772
-Please rate the amount of influence each of the following have over the implementation of the mathematics curriculum at your school.	0.687	0.715
-Please rate the amount of influence each of the following have over the instructional methods used in the mathematics classrooms in your school.	0.790	0.822

Table I-2

Corrected Item-Total Correlation and the Effect of Deletion on Cronbach's Alpha for Influence on Content

Sub-Item	Corrected item-total correlation	Cronbach's alpha if item deleted
You, the principal	.505	.646
Teachers	.189	.696
Parents	.472	.655
Students	.393	.665
School District*	-.072	.772
School Board	.360	.671
USOE	.426	.662
State Legislature	.409	.664
Federal Legislature	.572	.629
National Organizations (i.e., NCTM, etc.)	.523	.639

* indicates greatest effect on alpha towards .7 threshold

Table I-3

Corrected Item-Total Correlation and the Effect of Deletion on Cronbach's Alpha for Influence on Implementation

Sub-item	Corrected item-total correlation	Cronbach's alpha if item deleted
You, the principal	.378	.664
Teachers	-.085	.705
Parents	.244	.681
Students	.128	.699
School District*	.218	.715
School Board	.505	.630
USOE	.336	.667
State Legislature	.363	.661
Federal Legislature	.715	.612
National Organizations (i.e., NCTM, etc.)	.766	.573

* indicates greatest effect on alpha towards .7 threshold

Table I-4

Corrected Item-Total Correlation and the Effect of Deletion on Cronbach's Alpha for Influence on Instructional Methods

Sub-item	Corrected item-total correlation	Cronbach's alpha if item deleted
You, the principal	.485	.771
Teachers	-.432	.827
Parents	.641	.755
Students	.496	.770
School District*	.146	.822
School Board	.568	.758
USOE	.421	.777
State Legislature	.845	.733
Federal Legislature	.820	.733
National Organizations (i.e., NCTM, etc.)	.644	.746

* indicates greatest effect on alpha towards .7 threshold

Table I-5

Cronbach's Alpha for Mathematics Curriculum Portion

Question	Cronbach's alpha	Cronbach's alpha if item deleted
Please rate your familiarity with the following mathematics curriculum documents and reports. Please rate the extent the following documents, university courses, or professional development have influences your understanding of mathematics curriculum and instruction.	0.926	0.927

Table I-6

Cronbach's Alpha for Grades K-4 for Mathematics Teaching and Learning Portion

Question	Cronbach's alpha	Cronbach's alpha if item deleted
To what extent to you agree with the following statements as they relate to mathematics teaching and learning (K-4): [V282-V293]	0.769	0.814
To what extent to you agree with the following statements as they relate to mathematics teaching and learning (K-4): [V318-V338]	0.991	0.991
To what extent to you agree with the following statements as they relate to mathematics teaching and learning (K-4): [V381-V391]	0.955	0.956
To what extent to you agree with the following statements as they relate to mathematics teaching and learning (K-4): [V414-V423]	0.723	0.807

Table I-7

Cronbach's Alpha for Grades 5-9 for Mathematics Teaching and Learning Portion

Question	Cronbach's alpha	Cronbach's alpha if item deleted
To what extent to you agree with the following statements as they relate to mathematics teaching and learning (K-5): [V294-V305]	0.951	0.952
To what extent to you agree with the following statements as they relate to mathematics teaching and learning (K-5): [V339-V359]	0.989	0.990
To what extent to you agree with the following statements as they relate to mathematics teaching and learning (K-5): [V393-V402]	0.643	0.750
To what extent to you agree with the following statements as they relate to mathematics teaching and learning (K-5): [V424-V433]	0.875	0.896

Table I-8

Cronbach's Alpha for Grades 10-12 for Mathematics Teaching and Learning Portion

Question	Cronbach's alpha	Cronbach's alpha if item deleted
-To what extent to you agree with the following statements as they relate to mathematics teaching and learning (K-5): [V306-V317]	0.988	0.990
-To what extent to you agree with the following statements as they relate to mathematics teaching and learning (K-5): [V360-V380]	0.993	0.994
-To what extent to you agree with the following statements as they relate to mathematics teaching and learning (K-5): [V403-V413]	0.982	0.984
-To what extent to you agree with the following statements as they relate to mathematics teaching and learning (K-5): [V434-V443]	0.984	0.986

Table I-9

Cronbach's Alpha Across Grade Spans with Accompanying Means and Standard Deviations

Question	Cronbach's alpha	Cronbach's alpha if item deleted (most different grade span)	K-4 Mean *SD*	5-9 Mean *SD*	10-12 Mean *SD*
There should be a streamlined and a well-defined set of important topics that are taught in early grades.	-0.040	0.532 (K-4)	5.11 2.028	5.40 1.897	3.30 2.869
The mathematics curriculum should be conceptually oriented.	-0.073	0.517 (K-4)	4.75 2.053	4.80 1.814	2.80 2.974
Topics in mathematics curriculum should be revisited year after year without bringing closure to them.*	0.701	0.710 (K-4)	4.89 1.364	4.50 1.900	3.00 2.667
The practice of teaching by telling should be used as the primary instructional practice in the mathematics classroom.*	0.700	0.787 (5-9)	2.44 0.882	2.10 1.101	1.60 1.578
Proficiency with whole numbers, fractions, and certain aspects of geometry and measurement are the foundations for algebra.	0.226	0.452 (K-4)	5.11 1.965	4.80 1.874	3.20 2.821
The mathematics curriculum should include a broad range of content.	0.436	0.823 (K-4)	2.89 2.008	3.40 1.838	2.70 2.497
Conceptual understanding, computational and procedural fluency, and problem solving skills are equally important and mutually reinforce each other.	0.334	0.562 (K-4)	5.78 0.441	4.60 2.459	3.40 2.951
Rote practice (drill) should be an important instructional practice in the mathematics classroom.	0.499	0.688 (K-4)	4.56 1.014	3.60 1.713	2.10 1.969
Students should develop immediate recall of arithmetic facts.	0.591	0.739 (10-12)	4.78 1.394	4.00 2.000	2.30 2.263
Mathematics curriculum should emphasize the development of children's mathematical thinking and reasoning abilities.	0.363	0.435 (K-4)	5.89 0.333	5.20 1.874	3.50 3.028
Children's belief in their mathematics ability effects their persistence in mathematics learning.	0.488	0.593 (K-4)	5.89 0.333	4.70 2.497	3.50 3.028
Problemsolving approaches to instruction should be used as the primary instructional practice in the mathematics classroom.	0.230	0.539 (K-4)	4.44 1.944	4.30 1.703	3.40 2.951
Teachers' mathematical content knowledge is important for students' achievement.	0.567	0.674 (10-12)	4.44 2.555	4.71 2.215	2.57 3.207

(*table continues*)

Question	Cronbach's alpha	Cronbach's alpha if item deleted (most different grade span)	K-4 Mean *SD*	5-9 Mean *SD*	10-12 Mean *SD*
Teachers' mathematical pedagogical content knowledge is important for student achievement.	0.464	0.564 (10-12)	4.56 2.603	5.14 2.268	2.57 3.207
School leaders/principal's mathematical content knowledge is important for students' achievement.	0.526	0.694 (10-12)	3.89 2.369	4.00 2.00	2.00 2.646
School leaders/principal's mathematical pedagogical content knowledge is important for student achievement.	0.520	0.575 (10-12)	4.11 2.472	4.33 2.251	2.00 2.646
Parents' mathematical knowledge is important for students' achievement.*	0.747	0.768 (10-12)	3.00 2.000	3.43 1.813	1.71 2.360
Individuals who work at the district office's mathematical content knowledge is important for students' achievement.*	0.721	0.766 (10-12)	3.56 2.351	4.00 2.082	2.29 2.870
Individuals on school boards' mathematical content knowledge is important for students' achievement.*	0.834	0.882 (10-12)	2.78 2.048	2.86 1.676	1.57 2.149
Individuals who work at the State Office of Education' mathematical knowledge is important for student's achievement.*	0.760	0.807 (10-12)	3.33 2.345	3.29 2.059	1.71 2.430
Legislator's mathematical knowledge is important for student's achievement. *	0.750	0.786 (10-12)	3.11 2.147	2.57 1.718	2.57 2.149
Mathematics curriculum should actively involve children in doing mathematics.	0.435	0.509 (10-12)	4.56 2.603	4.86 2.193	2.43 3.047
Teacher's use of regular ongoing assessments can improve student learning in mathematics.	0.495	0.564 (10-12)	4.56 2.603	5.00 2.236	2.57 3.207
Written practice should be an important instructional practice in the mathematics classroom.	0.483	0.577 (10-12)	4.22 2.489	4.71 2.138	2.43 3.047
Some children are not ready or are too young to learn certain mathematics content.*	0.714	0.802 (K-4)	2.67 1.936	2.17 1.941	1.29 2.215
Mathematics curriculum should emphasize the application of mathematics.	0.612	0.579 (K-4)	4.22 2.489	4.29 2.360	2.43 3.047
Explicit instruction for students who struggle with math is effective in increasing student performance with word problems and computation.	0.371	0.577 (10-12)	4.33 2.500	4.71 2.138	2.43 3.047
Worksheets should be an important instructional practice in the mathematics curriculum.	0.534	0.680 (10-12)	2.78 1.641	3.00 1.414	1.57 1.988
Publishers should produce shorter and more focused mathematics textbooks.*	0.716	0.714 (10-12)	3.89 2.421	3.86 1.952	2.29 2.928

(*table continues*)

Question	Cronbach's alpha	Cronbach's alpha if item deleted (most different grade span)	K-4 Mean *SD*	5-9 Mean *SD*	10-12 Mean *SD*
Mathematics curriculum should include an increased use of calculators.	0.460	0.554 (10-12)	2.67 1.871	3.29 1.704	2.00 2.646
Mathematics curriculum should include an increased use of touchscreen apps and computer apps/websites.*	0.738	0.725 (10-12)	3.67 2.345	4.00 2.236	2.29 2.870
Knowledge of fractions (proportional reasoning) is the most important foundational skill developed among students.*	0.825	0.856 (10-12)	2.78 2.167	3.29 2.289	1.71 2.628
Children should not be taught that there is only one answer or one method to solve mathematics problems.	0.421	0.510 (10-12)	3.67 2.693	4.14 2.545	1.17 2.401
Mathematics preparation of teachers must be strengthened to improve teacher effectiveness.	0.600	0.600 (5-9)	5.00 2.236	6.00 0.000	3.00 3.286
Manipulative materials should be used as the primary instructional practice in the mathematics classroom.	-0.162	0.320 (10-12)	4.29 2.215	3.50 1.049	2.00 2.449
Proficiency with whole numbers is a critical foundation for algebra.	0.309	0.575 (5-9)	4.86 2.193	5.33 0.816	2.33 2.733
Mathematics curriculum should make appropriate and ongoing use of computers.*	0.803	0.819 (K-4)	4.29 2.138	4.50 1.378	2.67 2.994
Certain aspects of geometry and measurement are critical foundations of algebra.	0.565	0.633 (K-4)	3.86 2.193	4.50 1.517	2.17 2.714
Rote memorization of rule should be the primary instructional practice in the mathematics classroom.	0.451	0.737 (5-9)	2.86 1.952	2.67 0.816	1.17 1.329
Our current curriculum provides sufficient practice to ensure fast and efficient solving of mathematics facts.*	0.792	0.811 (K-4)	3.14 1.864	4.00 1.265	2.00 2.530
Discussion of mathematics (mathematical discourse) should be used at least 50% of the time in the mathematics classroom.	-0.245	0.480 (10-12)	3.29 1.604	4.17 0.983	2.00 2.121
Students learn mathematics by building on prior knowledge.	0.288	0.469 (5-9)	4.00 2.769	5.83 0.408	2.83 3.125
Mathematics instruction should be student centered more than 50% of the time.	-0.500	1.000 (10-12)	3.86 2.734	5.40 0.894	2.50 2.811
Cooperative work should be the primary practice in the mathematics classroom.	0.487	0.642 (5-9)	3.00 1.826	3.83 1.169	2.17 2.714
Mathematics instruction should be teacher directed more than 50% of the time.*	0.773	1.000 (10-12)	4.00 1.581	4.25 1.708	2.75 2.500

(*table continues*)

Question	Cronbach's alpha	Cronbach's alpha if item deleted (most different grade span)	K-4 Mean *SD*	5-9 Mean *SD*	10-12 Mean *SD*
Questioning should be an important instructional practice in the mathematics classroom.	-0.330	0.930 (10-12)	5.40 0.894	5.25 0.957	4.00 2.708
Computerbased drill and practice and tutorials can improve student performance in specific areas of mathematics.	-0.294	-.0294 (K-4)	4.60 0.894	4.75 0.500	3.75 2.500
Justification of thinking should be a primary instructional practice in the mathematics classroom.	0.028	0.500 (10-12)	4.80 0.447	5.25 0.500	4.25 2.872
Proficiency with fractions (proportional reasoning) is a critical foundation of algebra.*	0.708	0.978 (10-12)	4.20 1.483	4.50 1.732	3.50 3.000
The use of calculators impedes the development of automaticity with basic facts.*	0.765	0.963 (K-4)	4.40 2.074	3.50 1.732	2.50 2.517
Writing about mathematics should be the primary instructional practice in the mathematics classroom.*	0.877	0.925 (K-4))	4.60 0.894	3.25 1.500	2.75 2.217
U.S. mathematics textbooks are extremely long.*	0.774	0.983 (10-12)	4.80 1.643	5.00 2.000	3.50 3.000
Content integration should take place at least 50% of the time in the mathematics classroom.*	0.825	0.978 (10-12)	4.60 1.517	4.25 1.708	3.25 2.754
U.S. mathematics textbooks contain many errors and a large number of ambiguous and confusing statements and problems.*	1.000	1.000 (no difference)	3.60 2.510	3.25 2.754	3.25 2.754

* Indicates the same across grade spans.

Table I-10

Cronbach's Alpha for Supports of Increasing Student Achievement Portion

Question	Cronbach's alpha	Cronbach's alpha if item deleted
The best way to increase student achievement in mathematics is to....[V446-V471]	0.912	0.929

Table I-11

Corrected-Item Total Correlation, Cronbach's Alpha if Deleted with Accompanying Means and Standard Deviations for Increasing Student Achievement Portion

Sub-item	Corrected item-total correlation	Cronbach's alpha if deleted	Mean	*SD*
Provide teachers with workshop/conference types of professional development.*	-0.368	0.918	4.80	.837
Provide teachers with long-term professional development differentiated according to needs.	0.773	0.909	5.80	.447
Allow teachers to choose their own professional development opportunities.	-0.125	0.917	4.20	1.095
Send all teachers to the same professional development.	0.142	0.917	3.40	1.817
Pay for teachers to take more university mathematics courses. *	0.557	0.908	4.80	1.304
Pay for teachers to obtain a Utah mathematics endorsement.	0.215	0.915	4.40	1.817
Have teachers attend webinar mathematics professional development.*	0.697	0.906	4.20	1.095
Have teachers attend online mathematics professional development/university courses.*	0.697	0.906	4.20	1.095
Work with university researchers in a collaborative professional development.	0.811	0.904	4.20	1.304
Have teachers engage in Japanese lesson study.*	-0.409	0.918	2.20	.837
Improve professional learning communities (PLCs).	0.778	0.906	5.40	.894
Vertical teacher teaming/planning of mathematics curriculum and instructional strategies.	0.778	0.906	5.40	.894
Use a district/charter mathematics specialist/coach/mentor to work individually, or in groups, with teachers, as needed.	0.844	0.902	4.20	1.643
Have teachers attend national professional organizations' conferences such as the annual or regional NCTM.	0.725	0.904	3.00	1.581
Have teachers attend state professional organizations' conferences such as the annual UCTM (Utah Council of Teachers of Mathematics) or UAPCS (Utah Association of Public Charter Schools) conferences.	0.683	0.905	3.20	1.643
Conduct regular, comprehensive teacher evaluations.	0.791	0.903	4.00	1.581

(*table continues*)

Sub-item	Corrected item-total correlation	Cronbach's alpha if deleted	Mean	*SD*
Provide mathematics family nights for parents and students.	0.866	0.902	4.40	1.517
Provide peer tutoring for students.	0.866	0.902	4.40	1.517
Provide teacher/aide tutoring for students.	0.762	0.904	4.60	1.673
Provide appropriate Tier II and Tier III instruction for students.	0.471	0.910	5.20	.837
Provide individualized education plans for all students that need it.	0.731	0.904	3.80	1.789
Use some form of heterogeneous, ability, achievement, multigrade, accelerated or differentiated grouping for primary mathematics instruction.	0.262	0.914	4.20	1.789
Use homogenous (wholegroup) instruction for primary mathematics instruction.	-0.691	0.929	3.60	1.517
Provide webbased/computerbased/appbased tutoring for students.	0.601	0.910	4.40	.548
Educate parents on the curriculum and researchbased instructional strategies.	0.854	0.904	4.60	1.140
Educate board members on the curriculum and researchbased instructional strategies.	0.681	0.905	3.60	1.817
Educate members of the legislature on the curriculum and researchbased instructional strategies.	0.731	0.904	3.80	1.789
Provide specialized, intensive instruction for subpopulations of students such as SPED, ELL, low SES, migrant, homeless, etc.	0.726	0.904	4.00	1.871
Use common assessments and analyze student data on a regular basis.	Zero variance removed from scale	N/A	6.00	0.000

* In desired range.

Table I-12

Cronbach's Alpha for Revised 14 Items Across Grades Question for Mathematics Teaching and Learning Portion

Question	Cronbach's alpha	Cronbach's alpha if item deleted
To what extent do you agree with the following statements as they relate to mathematics teaching and learning (across all grade spans):	0.814	0.843

Table I-13

Cronbach's Alpha for Revised 25 Items K-9 Question for Mathematics Teaching and Learning Portion

Question	Cronbach's alpha	Cronbach's alpha if item deleted
To what extent do you agree with the following statements as they relate to mathematics teaching and learning (K-9):	0.832	0.844

Table I-14

Cronbach's Alpha for Revised 31 Items 10-12 Question for Mathematics Teaching and Learning Portion

Question	Cronbach's alpha	Cronbach's alpha if item deleted
To what extent do you agree with the following statements as they relate to mathematics teaching and learning (10-12):	0.996	0.996

Table I-15

Cronbach's Alpha for Revised 21 Items Supports of Increasing Student Achievement Portion

Question	Cronbach's alpha	Cronbach's alpha if item deleted
The best way to increase student achievement in mathematics is to....	0.941	0.950

Appendix J

Normality Tests for 30 Most Important Variables

Table J-1

ISAM18: Tests of Normality

		Shapiro-Wilk			Skewness	Std. Error	Kurtosis	Std. Error
Variable		Statistic	*df*	Sig.	s	*SE*	*k*	*SE*
ISAM18	1	.87	11	.078	-1.21	.66	1.14	1.28
	2	.98	25	.946	.04	.46	-.13	.90
	3	.98	43	.558	.10	.36	-.75	.71
	4	.98	51	.387	-.49	.33	.23	.66
	5	.89	13	.093	.68	.62	-.68	1.19

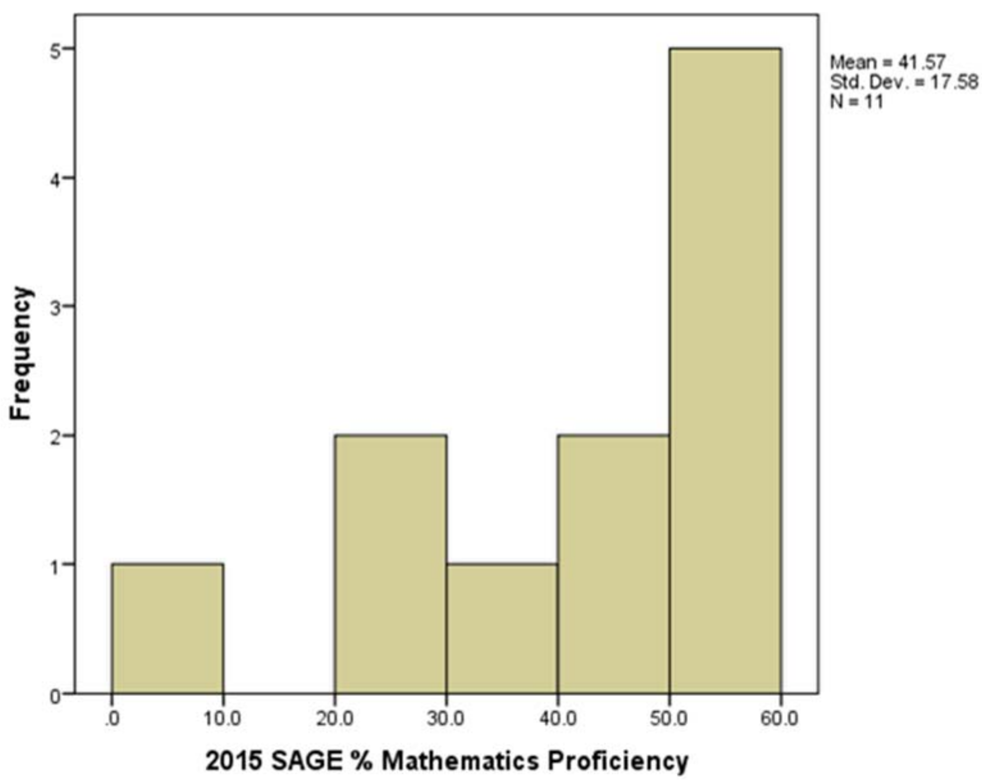

Figure J-1. Frequency by 2015 SAGE % Mathematics Proficiency for ISAM18 = 1. This figure illustrates the number of school leaders who rated ISAM18 at 1 based on their school's school-wide 2015 SAGE % mathematics proficiency.

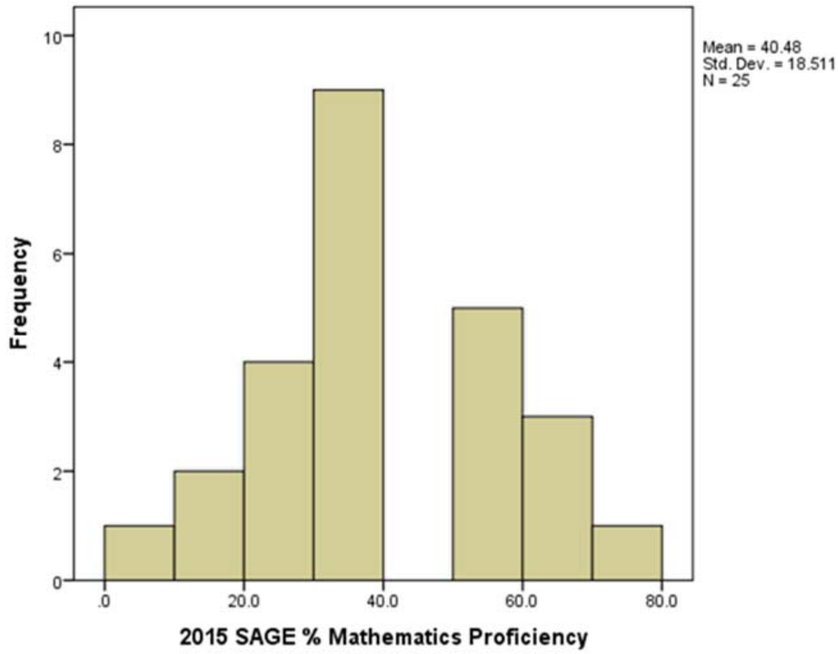

Figure J-2. Frequency by 2015 SAGE % Mathematics Proficiency for ISAM18 = 2. This figure illustrates the number of school leaders who rated ISAM18 at 2 based on their school's school-wide 2015 SAGE % mathematics proficiency.

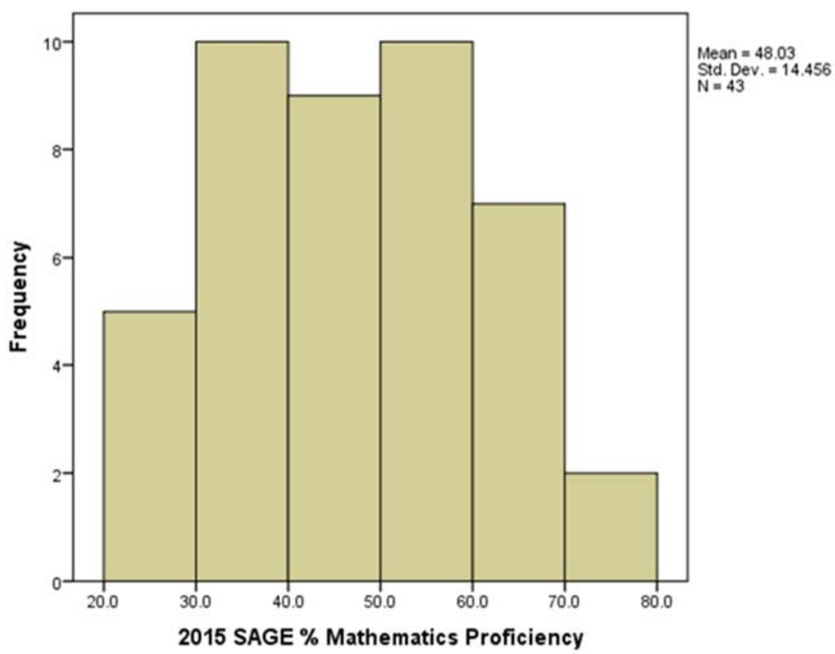

Figure J-3. Frequency by 2015 SAGE % Mathematics Proficiency for ISAM18 = 3. This figure illustrates the number of school leaders who rated ISAM18 at 3 based on their school's school-wide 2015 SAGE % mathematics proficiency.

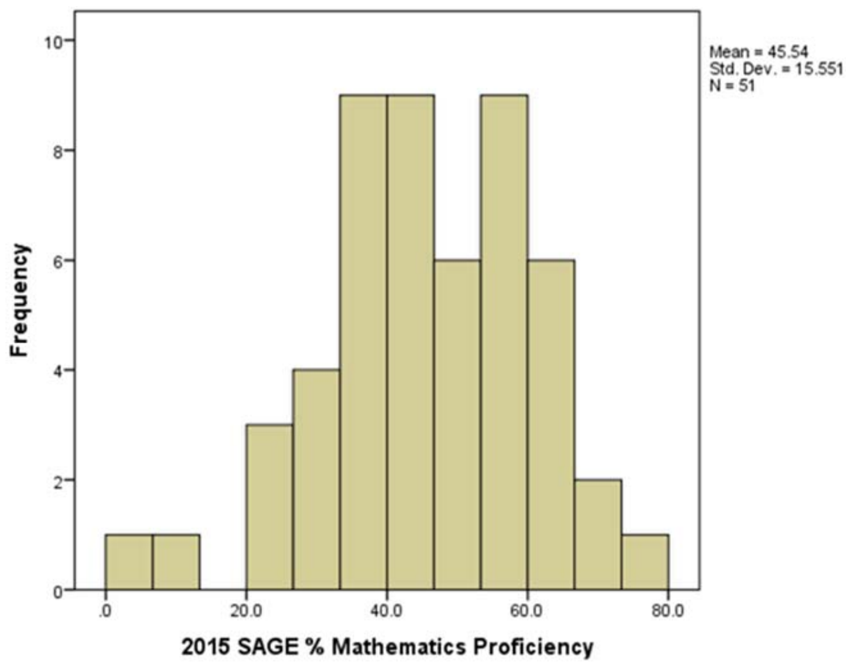

Figure J-4. Frequency by 2015 SAGE % Mathematics Proficiency for ISAM18 = 4. This figure illustrates the number of school leaders who rated ISAM18 at 4 based on their school's school-wide 2015 SAGE % mathematics proficiency.

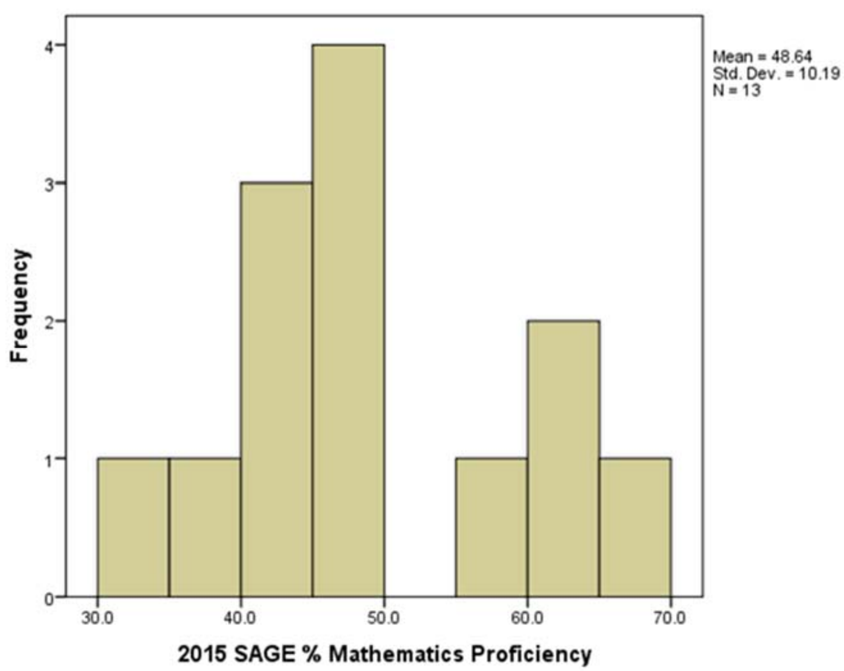

Figure J-5. Frequency by 2015 SAGE % Mathematics Proficiency for ISAM18 = 5. This figure illustrates the number of school leaders who rated ISAM18 at 5 based on their school's school-wide 2015 SAGE % mathematics proficiency.

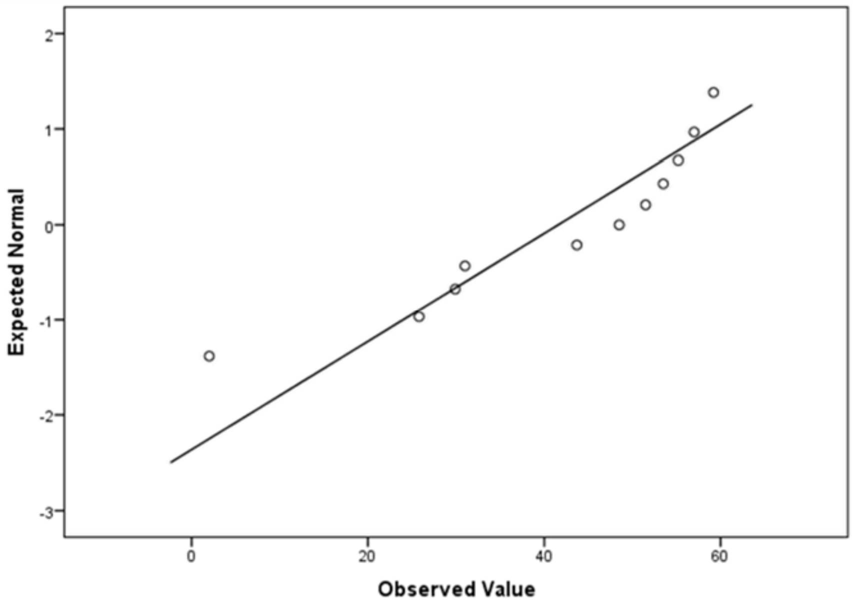

Figure J-6. Normal Q-Q Plot of 2015 SAGE % Mathematics Proficiency for ISAM18 = 1. This figure illustrates the observed value versus the expected normal for school leaders who rated ISAM18 at 1 based on their school's school-wide 2015 SAGE % mathematics proficiency.

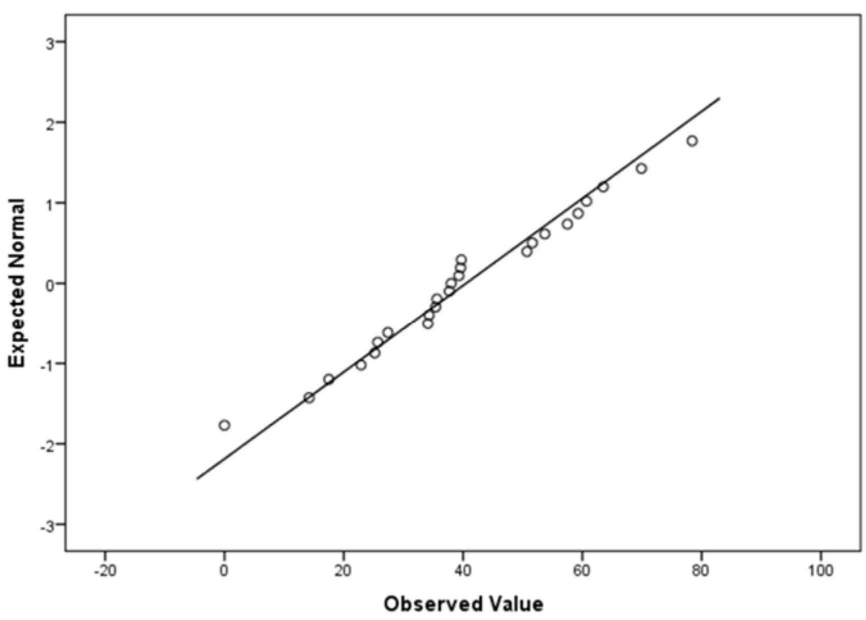

Figure J-7. Normal Q-Q Plot of 2015 SAGE % Mathematics Proficiency for ISAM18 = 2. This figure illustrates the observed value versus the expected normal for school leaders who rated ISAM18 at 2 based on their school's school-wide 2015 SAGE % mathematics proficiency.

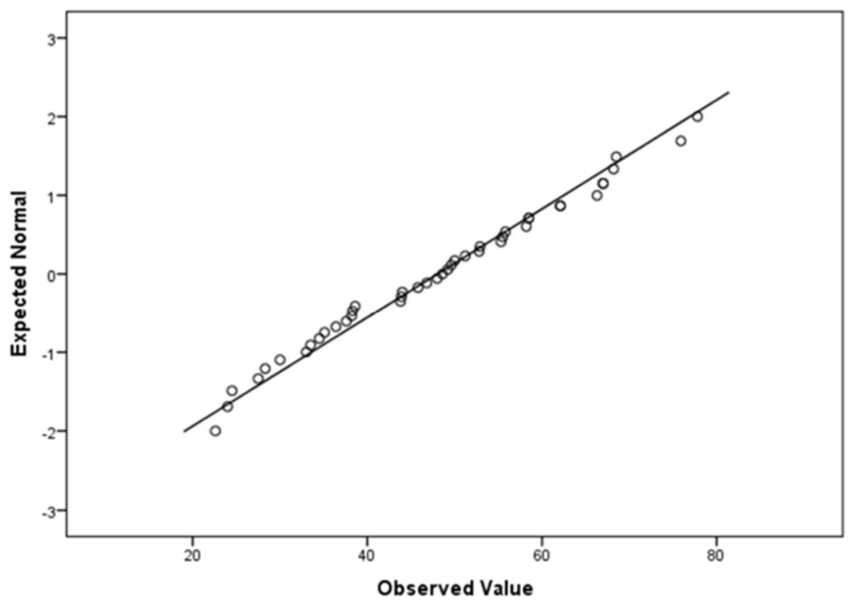

Figure J-8. Normal Q-Q Plot of 2015 SAGE % Mathematics Proficiency for ISAM18 = 3. This figure illustrates the observed value versus the expected normal for school leaders who rated ISAM18 at 3 based on their school's school-wide 2015 SAGE % mathematics proficiency.

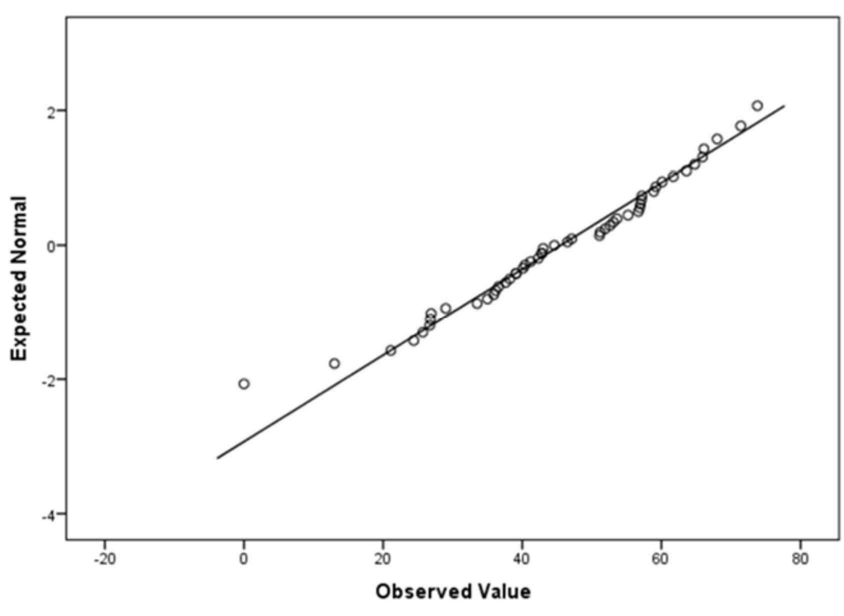

Figure J-9. Normal Q-Q Plot of 2015 SAGE % Mathematics Proficiency for ISAM18 = 4. This figure illustrates the observed value versus the expected normal for school leaders who rated ISAM18 at 4 based on their school's school-wide 2015 SAGE % mathematics proficiency.

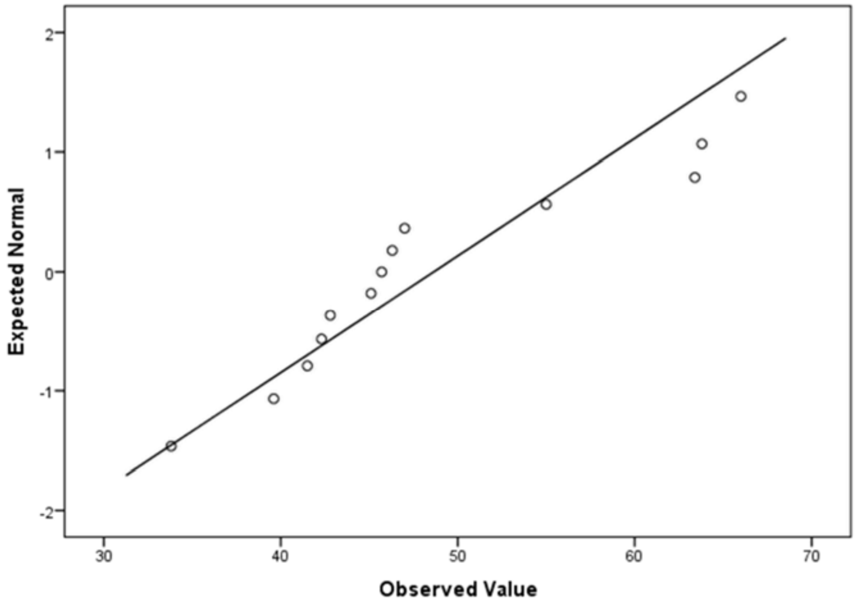

Figure J-10. Normal Q-Q Plot of 2015 SAGE % Mathematics Proficiency for ISAM18 = 5. This figure illustrates the observed value versus the expected normal for school leaders who rated ISAM18 at 5 based on their school's school-wide 2015 SAGE % mathematics proficiency.

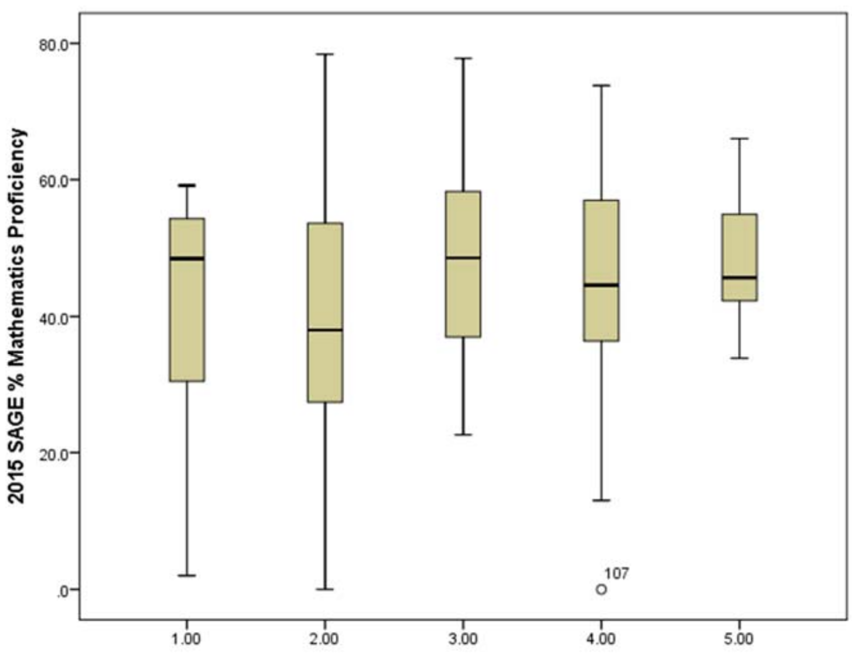

Figure J-11. Boxplot of 2015 SAGE % Mathematics Proficiency for ISAM18. This figure illustrates spread of school-wide 2015 SAGE % Mathematics Proficiency scores based on school leaders' ranking of ISAM18.

Table J-2

ISAM12: Tests of Normality

		Shapiro-Wilk						
Variable		Statistic	*df*	Sig.	Skewness	Std. Error	Kurtosis	Std. Error
ISAM12	1							
	2	.97	12	.888	-.56	.64	.84	1.23
	3	.96	29	.278	-.58	.43	.03	.85
	4	.98	83	.366	-.36	.26	-.15	.52
	5	.90	17	.065	1.11	.55	1.87	1.06

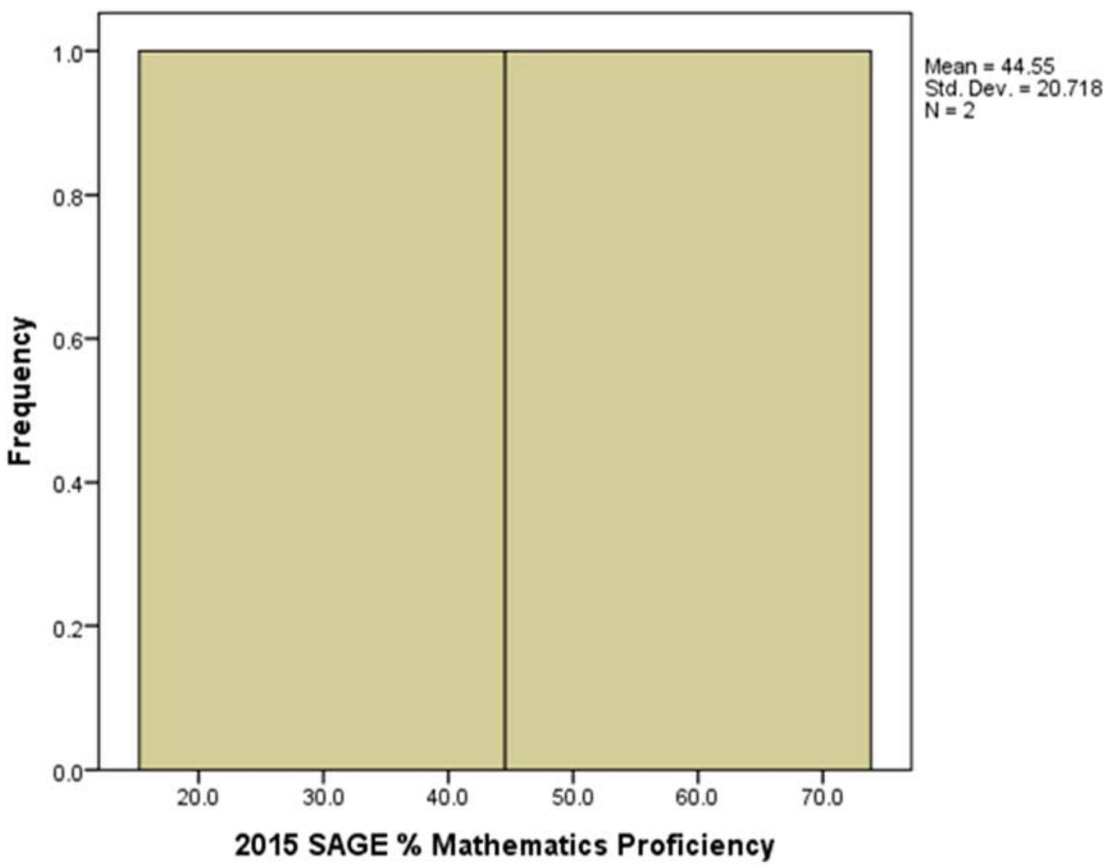

Figure J-12. Frequency by 2015 SAGE % Mathematics Proficiency for ISAM12 = 1. This figure illustrates the number of school leaders who rated ISAM12 at 1 based on their school's school-wide 2015 SAGE % mathematics proficiency.

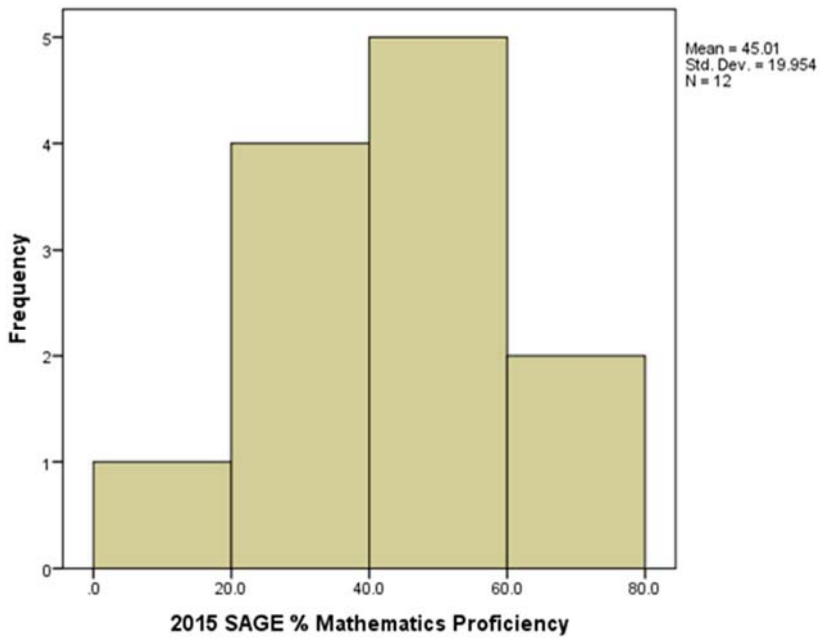

Figure J-13. Frequency by 2015 SAGE % Mathematics Proficiency for ISAM12 = 2. This figure illustrates the number of school leaders who rated ISAM12 at 2 based on their school's school-wide 2015 SAGE % mathematics proficiency.

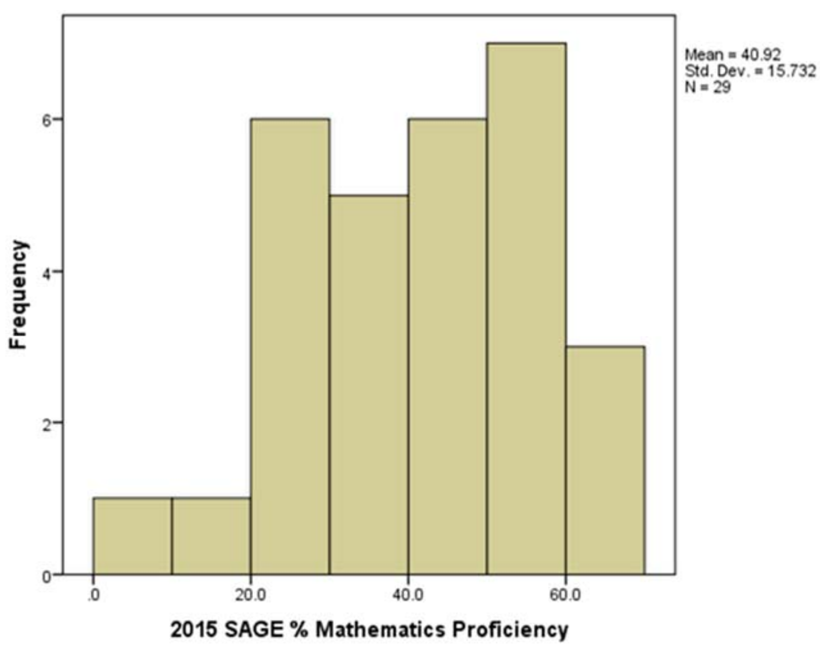

Figure J-14. Frequency by 2015 SAGE % Mathematics Proficiency for ISAM12 = 3. This figure illustrates the number of school leaders who rated ISAM12 at 3 based on their school's school-wide 2015 SAGE % mathematics proficiency.

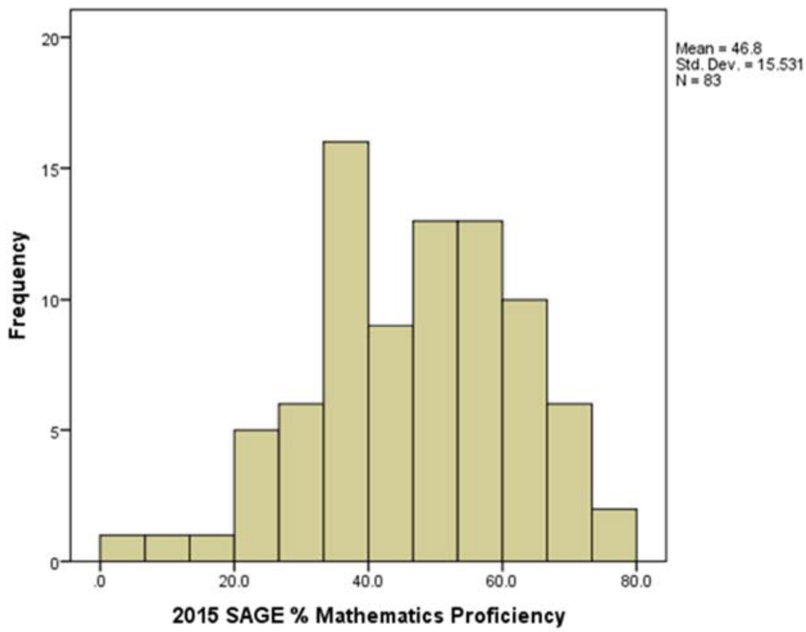

Figure J-15. Frequency by 2015 SAGE % Mathematics Proficiency for ISAM12 = 4. This figure illustrates the number of school leaders who rated ISAM12 at 4 based on their school's school-wide 2015 SAGE % mathematics proficiency.

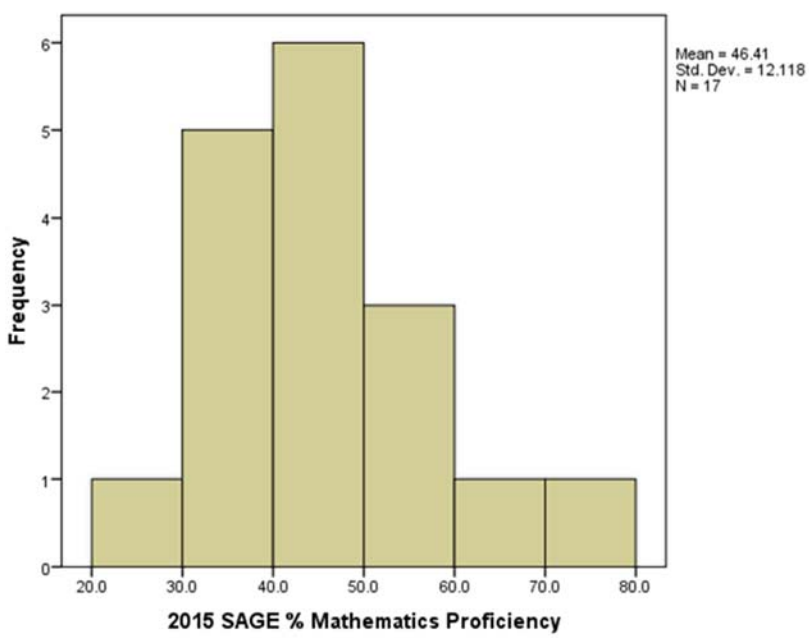

Figure J-16. Frequency by 2015 SAGE % Mathematics Proficiency for ISAM12 = 5. This figure illustrates the number of school leaders who rated ISAM12 at 5 based on their school's school-wide 2015 SAGE % mathematics proficiency.

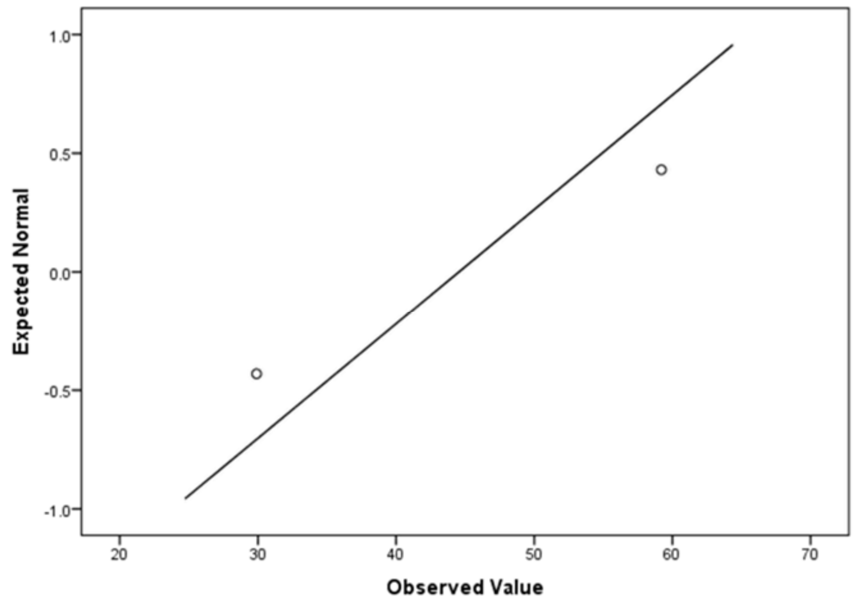

Figure J-17. Normal Q-Q Plot of 2015 SAGE % Mathematics Proficiency for ISAM12 = 1. This figure illustrates the observed value versus the expected normal for school leaders who rated ISAM12 at 1 based on their school's school-wide 2015 SAGE % mathematics proficiency.

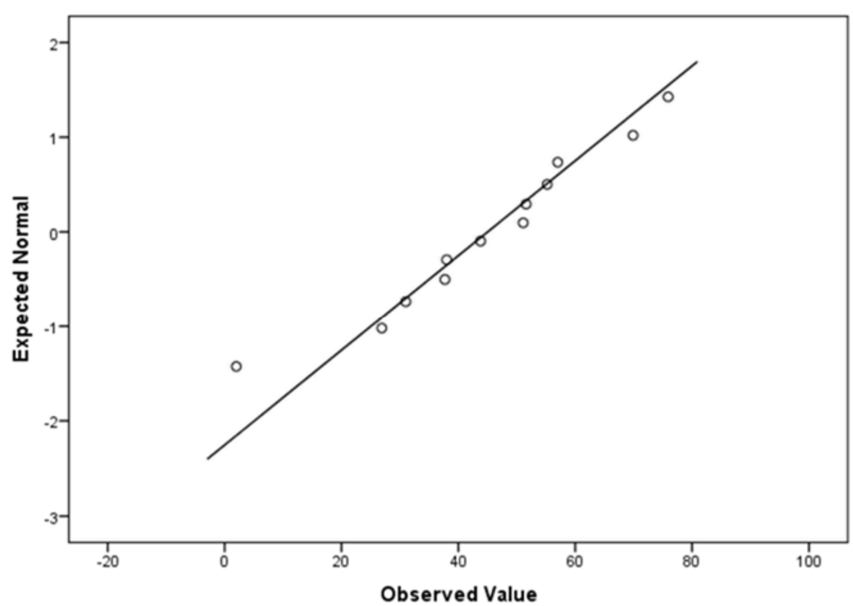

Figure J-18. Normal Q-Q Plot of 2015 SAGE % Mathematics Proficiency for ISAM12 = 2. This figure illustrates the observed value versus the expected normal for school leaders who rated ISAM12 at 2 based on their school's school-wide 2015 SAGE % mathematics proficiency.

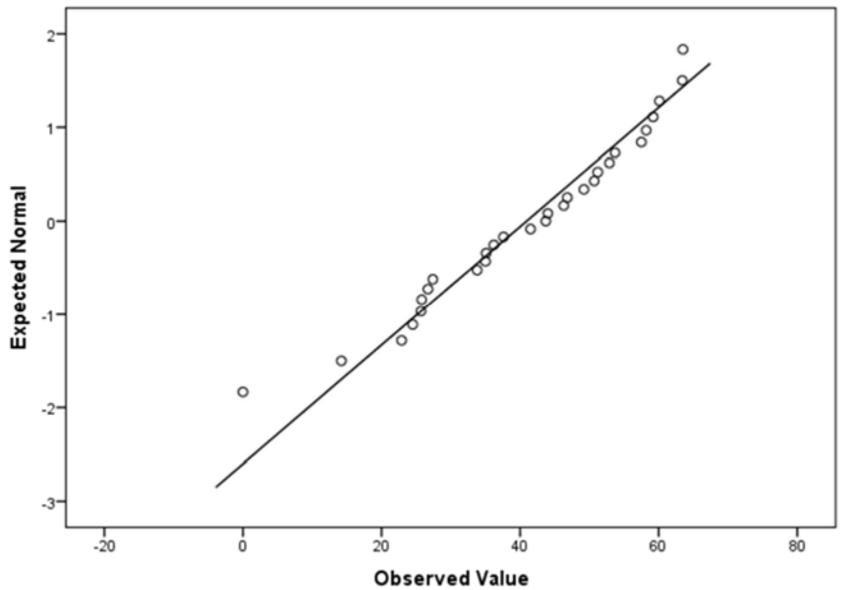

Figure J-19. Normal Q-Q Plot of 2015 SAGE % Mathematics Proficiency for ISAM12 = 3. This figure illustrates the observed value versus the expected normal for school leaders who rated ISAM12 at 3 based on their school's school-wide 2015 SAGE % mathematics proficiency.

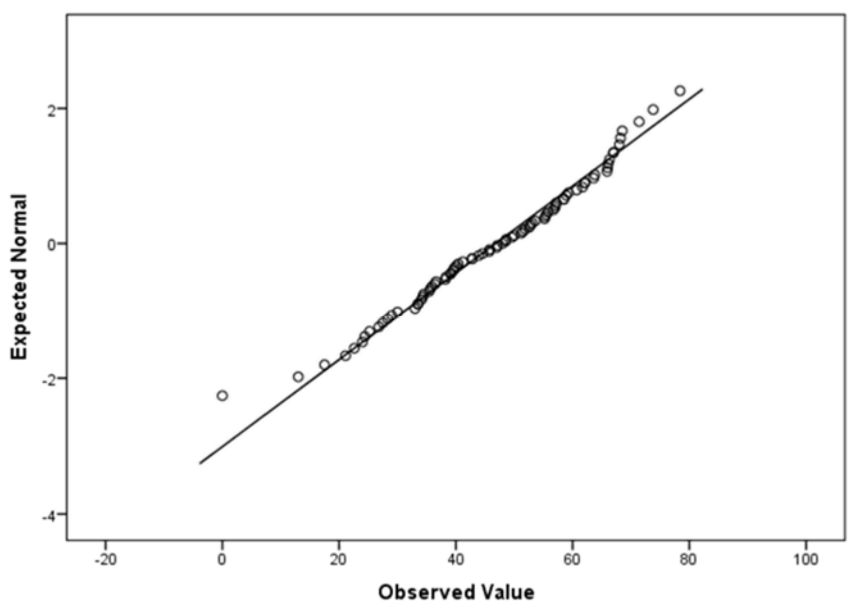

Figure J-20. Normal Q-Q Plot of 2015 SAGE % Mathematics Proficiency for ISAM12 = 4. This figure illustrates the observed value versus the expected normal for school leaders who rated ISAM12 at 4 based on their school's school-wide 2015 SAGE % mathematics proficiency.

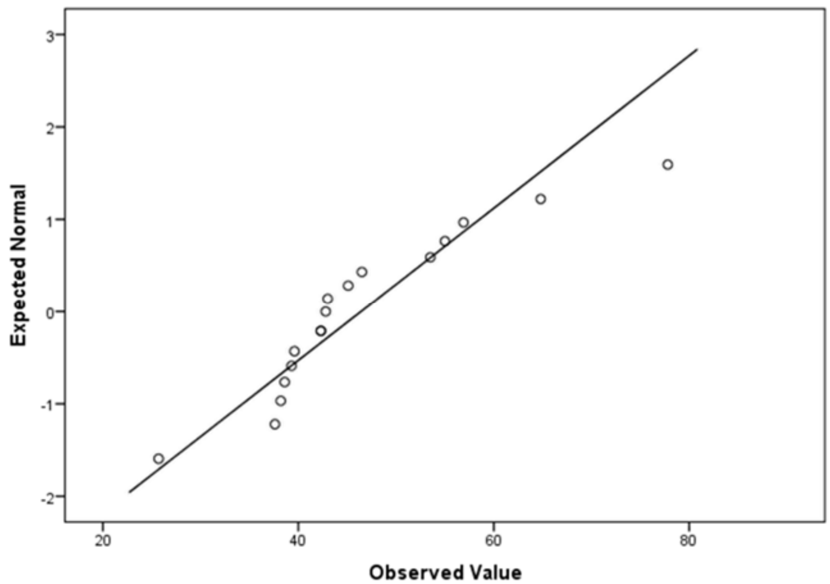

Figure J-21. Normal Q-Q Plot of 2015 SAGE % Mathematics Proficiency for ISAM12 = 5. This figure illustrates the observed value versus the expected normal for school leaders who rated ISAM12 at 5 based on their school's school-wide 2015 SAGE % mathematics proficiency.

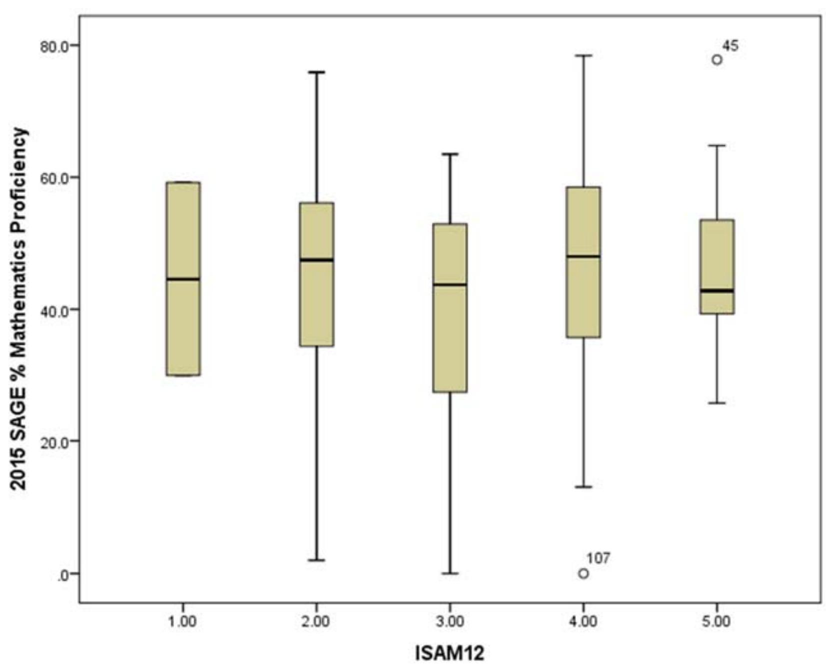

Figure J-22. Boxplot of 2015 SAGE % Mathematics Proficiency for ISAM12. This figure illustrates spread of school-wide 2015 SAGE % Mathematics Proficiency scores based on school leaders' ranking of ISAM12.

Table J-3

Yrs_Last_Teach_Pos: Tests of Normality

Variable		Shapiro-Wilk Statistic	*df*	Sig.	Skewness	Std. Error	Kurtosis	Std. Error
Yrs_Last_Teach_ Pos	0	.97	3	.683	-.83	1.23		
	1							
	2	.93	8	.537	-.76	.75	1.46	1.48
	3	.93	11	.435	.95	.66	.88	1.28
	4	.95	16	.480	-.61	.56	-.44	1.09
	5	.92	15	.217	-.31	.58	-1.27	1.12
	6	.91	18	.098	-1.13	.54	1.14	1.04
	7	.94	11	.480	.37	.66	-.96	1.28
	8	.84	12	.030	1.14	.64	.42	1.23
	9	.97	10	.891	.22	.69	-.46	1.33
	10	.97	12	.915	.03	.64	1.31	1.23
	11							
	12	.92	4	.557	.22	1.01	-3.74	2.62
	13	1.00	3	.900	-.27	1.23		
	14	.95	7	.726				
	15	1.00	3	.884	.42	.79	-.66	1.59
	16							
	17				.31	1.23		
	18							
	19							
	20							
	21							
	22							
	23							
	24							

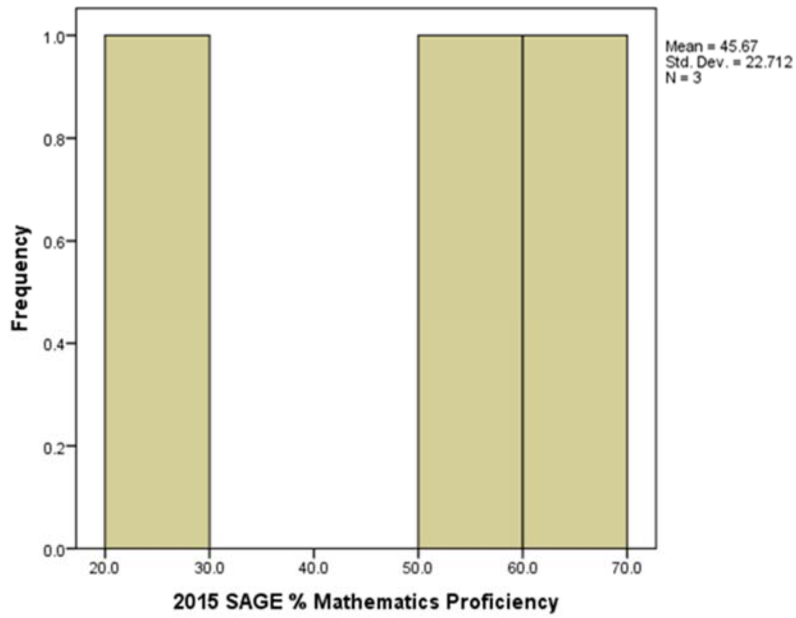

Figure J-23. Frequency by 2015 SAGE % Mathematics Proficiency for Yrs_Last_Teach_Pos = 0. This figure illustrates the number of school leaders who spent 0 years in their last teaching position based on their school's school-wide 2015 SAGE % mathematics proficiency.

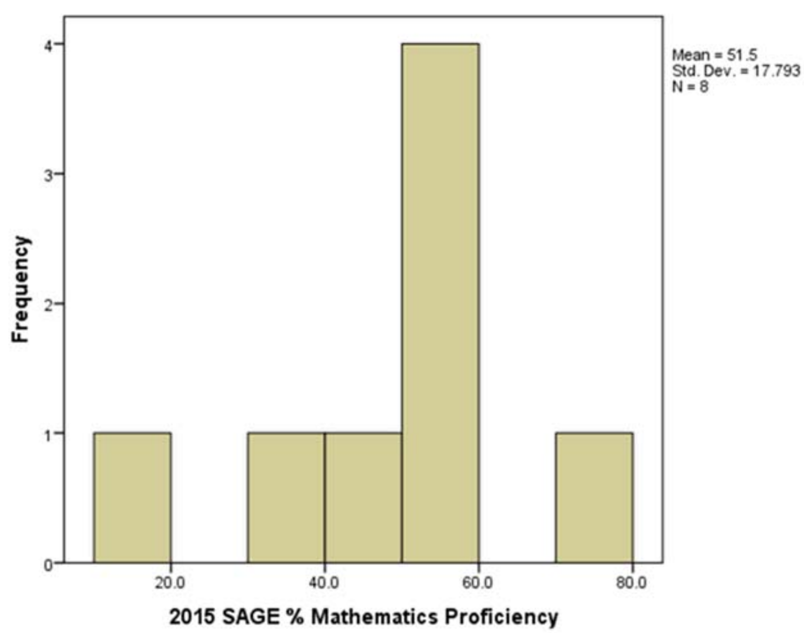

Figure J-24. Frequency by 2015 SAGE % Mathematics Proficiency for Yrs_Last_Teach_Pos = 2. This figure illustrates the number of school leaders who spent 2 years in their last teaching position based on their school's school-wide 2015 SAGE % mathematics proficiency.

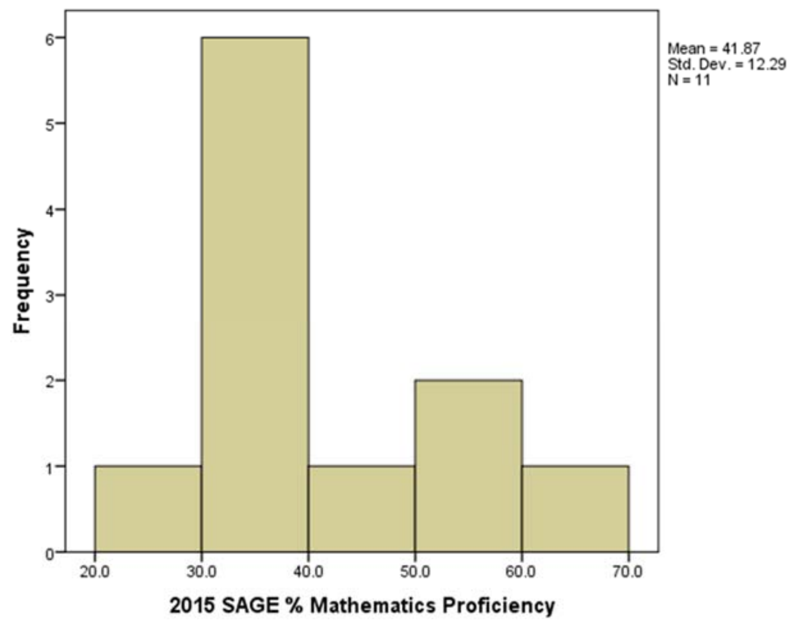

Figure J-25. Frequency by 2015 SAGE % Mathematics Proficiency for Yrs_Last_Teach_Pos = 3. This figure illustrates the number of school leaders who spent 3 years in their last teaching position based on their school's school-wide 2015 SAGE % mathematics proficiency.

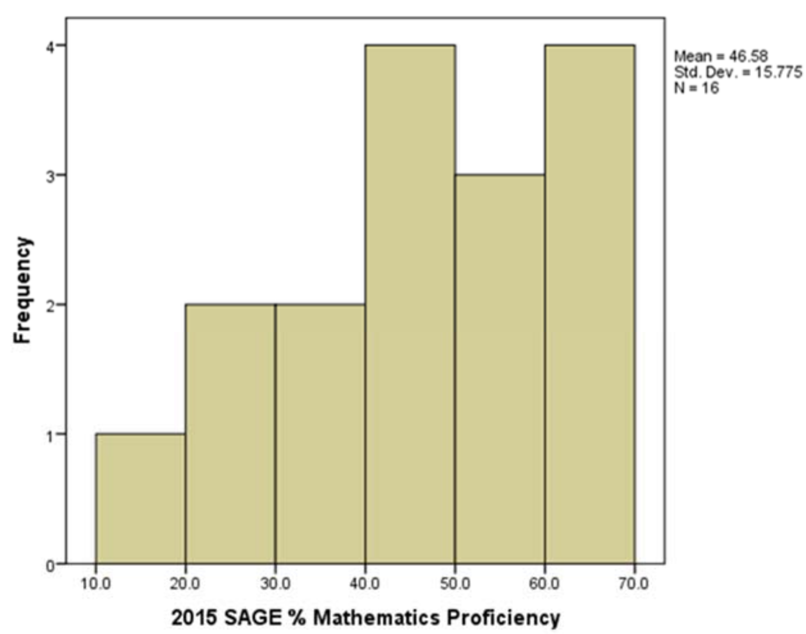

Figure J-26. Frequency by 2015 SAGE % Mathematics Proficiency for Yrs_Last_Teach_Pos = 4. This figure illustrates the number of school leaders who spent 4 years in their last teaching position based on their school's school-wide 2015 SAGE % mathematics proficiency.

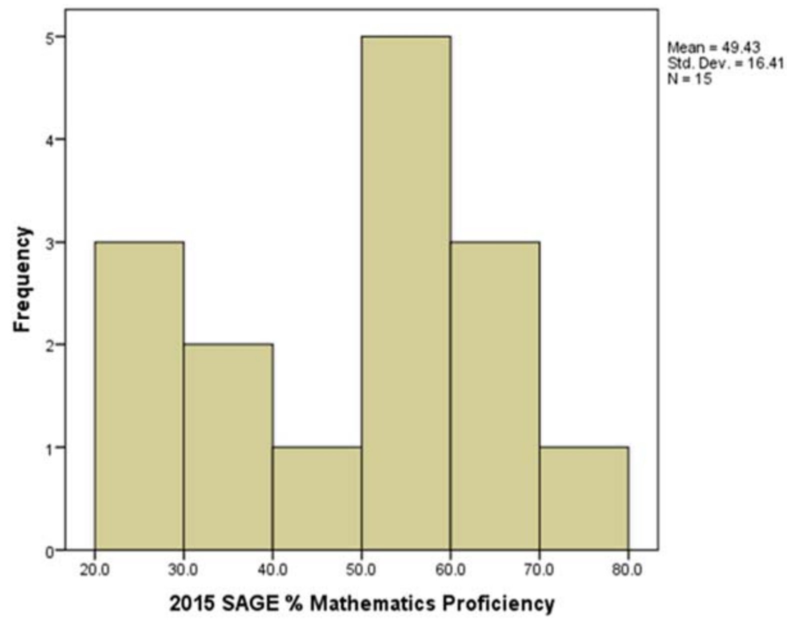

Figure J-27. Frequency by 2015 SAGE % Mathematics Proficiency for Yrs_Last_Teach_Pos = 5. This figure illustrates the number of school leaders who spent 5 years in their last teaching position based on their school's school-wide 2015 SAGE % mathematics proficiency.

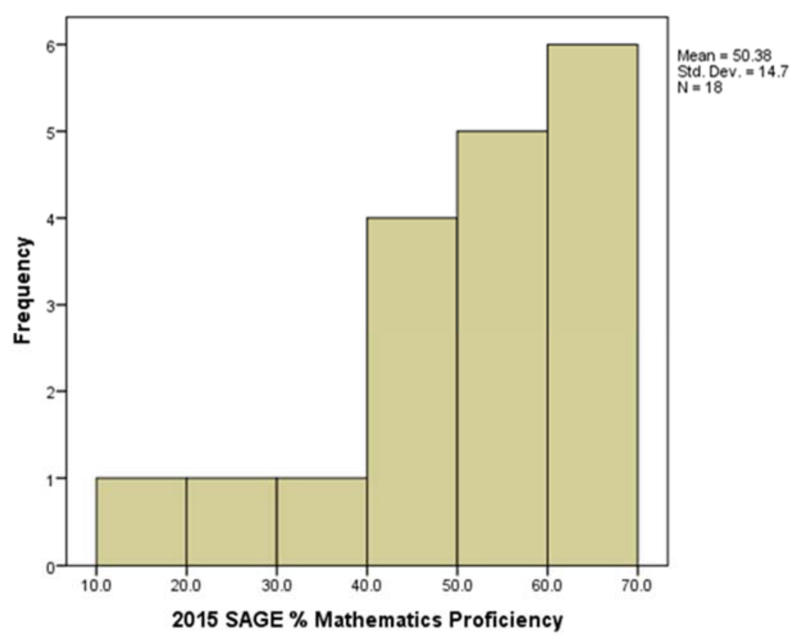

Figure J-28. Frequency by 2015 SAGE % Mathematics Proficiency for Yrs_Last_Teach_Pos = 6. This figure illustrates the number of school leaders who spent 6 years in their last teaching position based on their school's school-wide 2015 SAGE % mathematics proficiency.

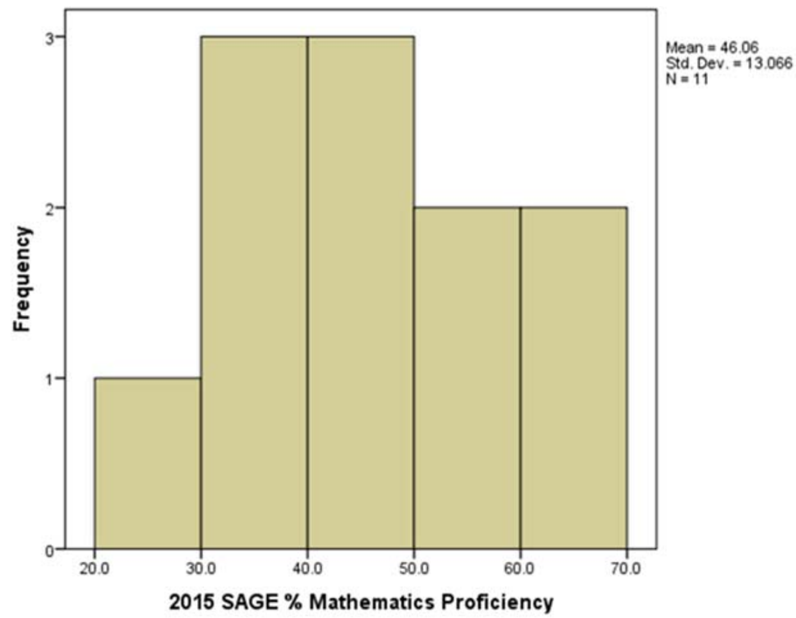

Figure J-29. Frequency by 2015 SAGE % Mathematics Proficiency for Yrs_Last_Teach_Pos = 7. This figure illustrates the number of school leaders who spent 7 years in their last teaching position based on their school's school-wide 2015 SAGE % mathematics proficiency.

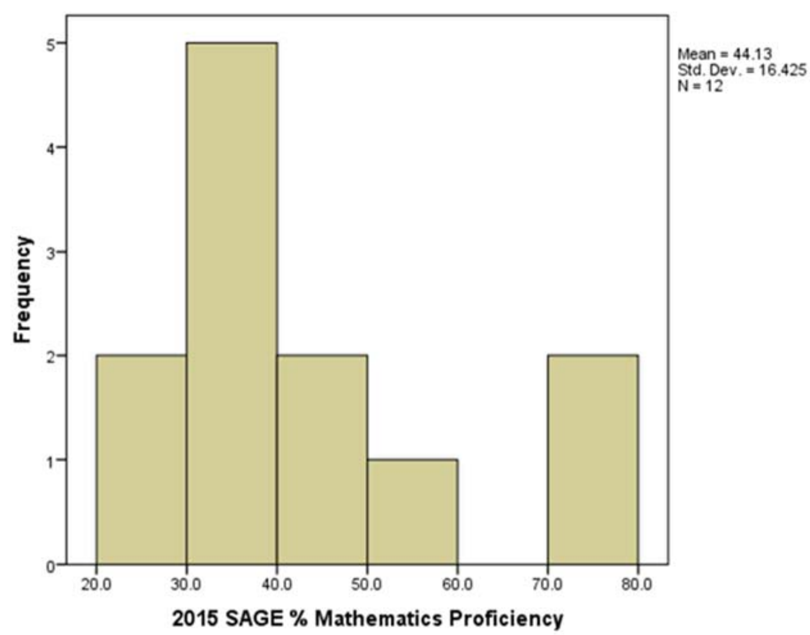

Figure J-30. Frequency by 2015 SAGE % Mathematics Proficiency for Yrs_Last_Teach_Pos = 8. This figure illustrates the number of school leaders who spent 8 years in their last teaching position based on their school's school-wide 2015 SAGE % mathematics proficiency.

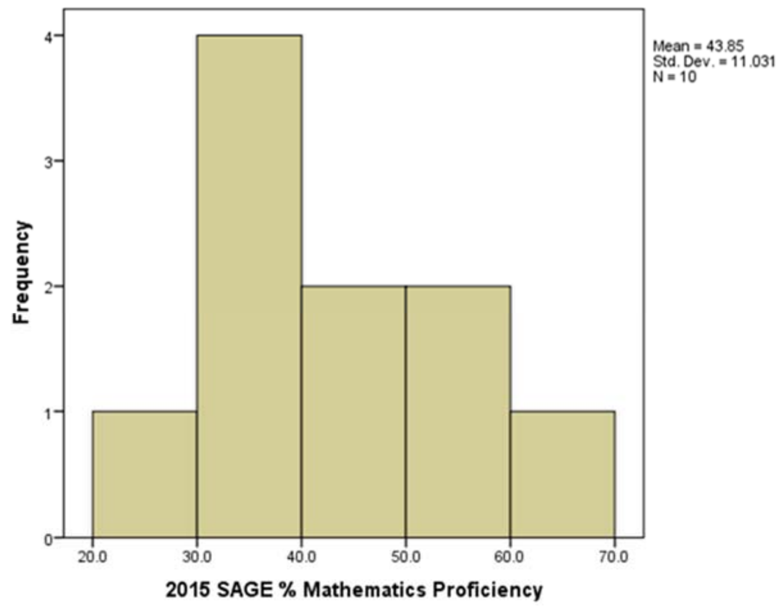

Figure J-31. Frequency by 2015 SAGE % Mathematics Proficiency for Yrs_Last_Teach_Pos = 9. This figure illustrates the number of school leaders who spent 9 years in their last teaching position based on their school's school-wide 2015 SAGE % mathematics proficiency.

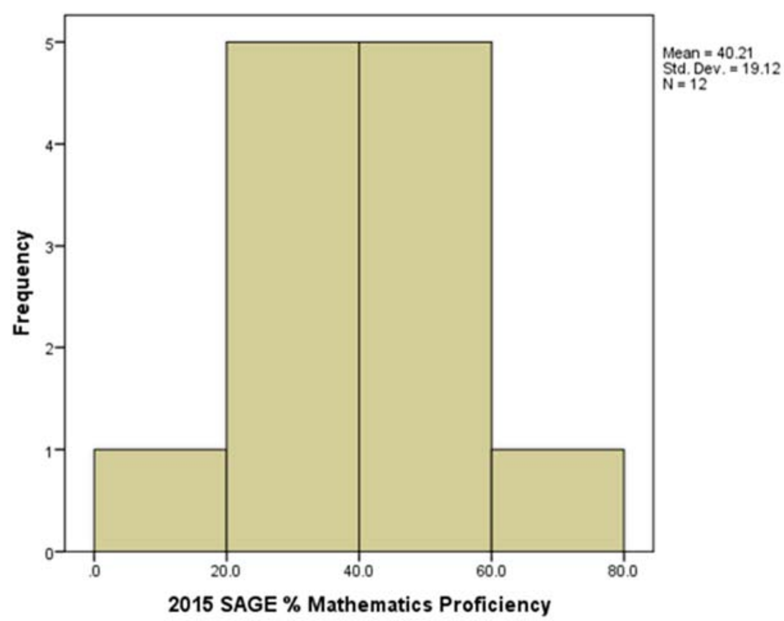

Figure J-32. Frequency by 2015 SAGE % Mathematics Proficiency for Yrs_Last_Teach_Pos = 10. This figure illustrates the number of school leaders who spent 10 years in their last teaching position based on their school's school-wide 2015 SAGE % mathematics proficiency.

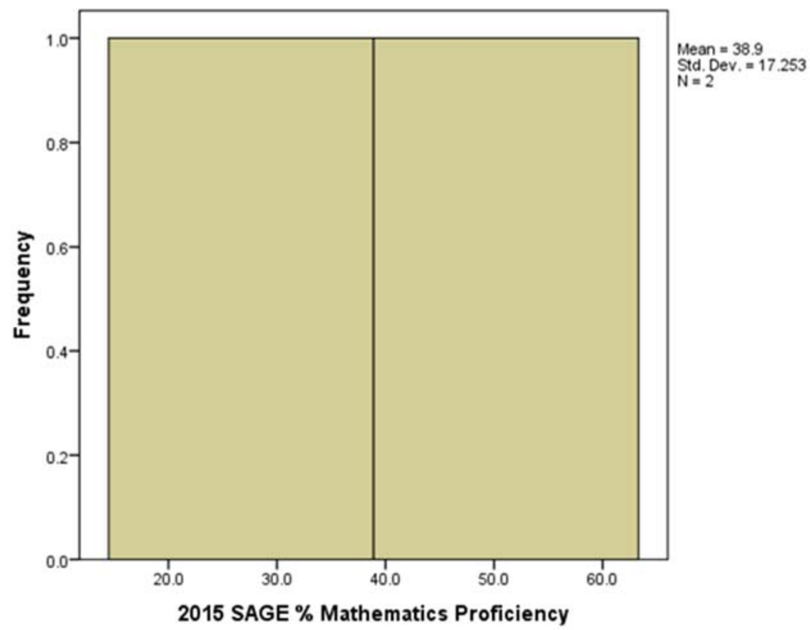

Figure J-33. Frequency by 2015 SAGE % Mathematics Proficiency for Yrs_Last_Teach_Pos = 11. This figure illustrates the number of school leaders who spent 11 years in their last teaching position based on their school's school-wide 2015 SAGE % mathematics proficiency.

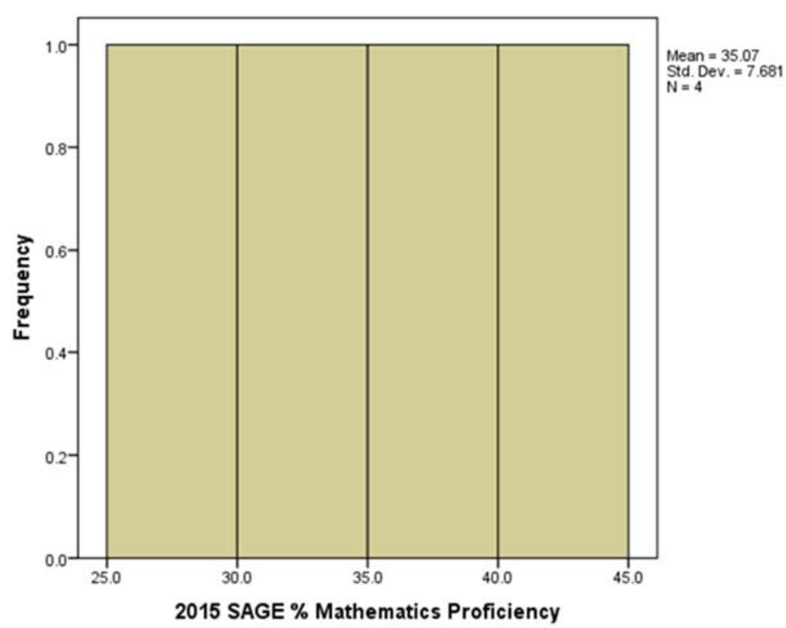

Figure J-34. Frequency by 2015 SAGE % Mathematics Proficiency for Yrs_Last_Teach_Pos = 12. This figure illustrates the number of school leaders who spent 12 years in their last teaching position based on their school's school-wide 2015 SAGE % mathematics proficiency.

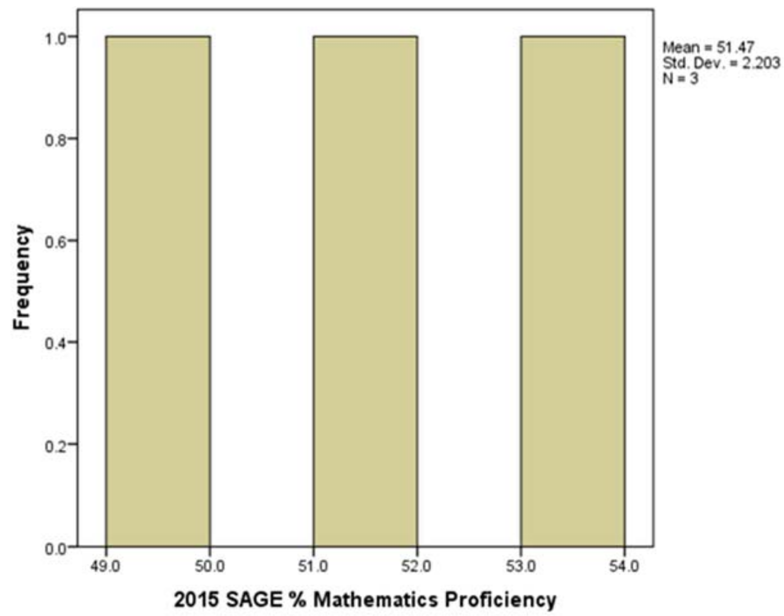

Figure J-35. Frequency by 2015 SAGE % Mathematics Proficiency for Yrs_Last_Teach_Pos = 13. This figure illustrates the number of school leaders who spent 13 years in their last teaching position based on their school's school-wide 2015 SAGE % mathematics proficiency.

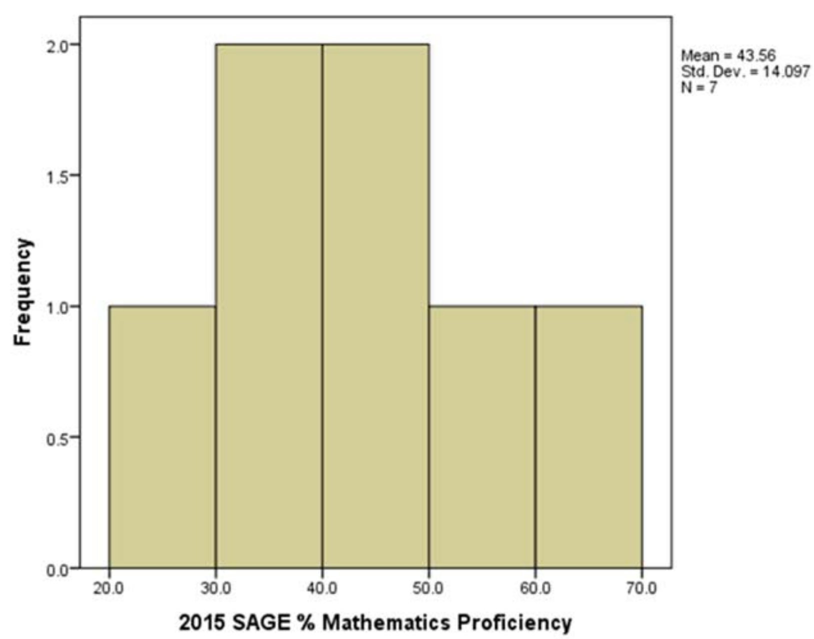

Figure J-36. Frequency by 2015 SAGE % Mathematics Proficiency for Yrs_Last_Teach_Pos = 15. This figure illustrates the number of school leaders who spent 15 years in their last teaching position based on their school's school-wide 2015 SAGE % mathematics proficiency.

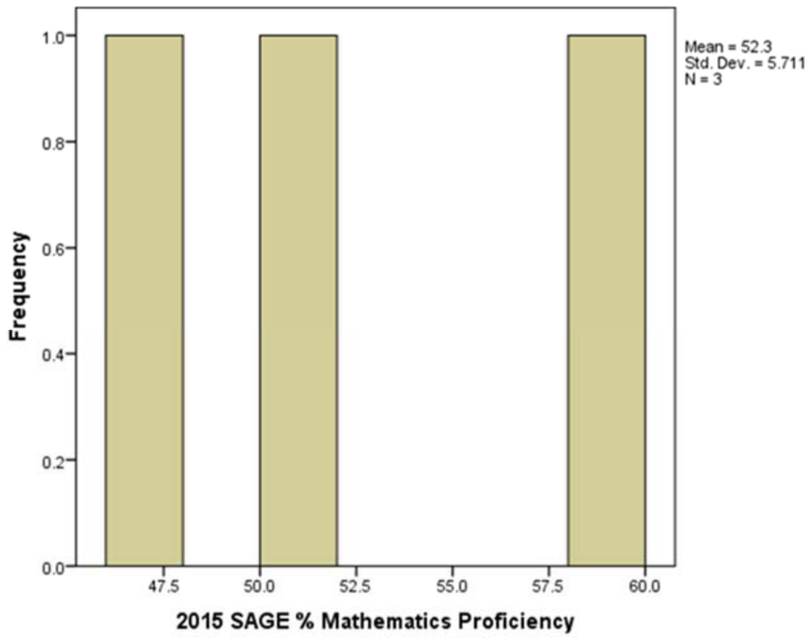

Figure J-37. Frequency by 2015 SAGE % Mathematics Proficiency for Yrs_Last_Teach_Pos = 17. This figure illustrates the number of school leaders who spent 17 years in their last teaching position based on their school's school-wide 2015 SAGE % mathematics proficiency.

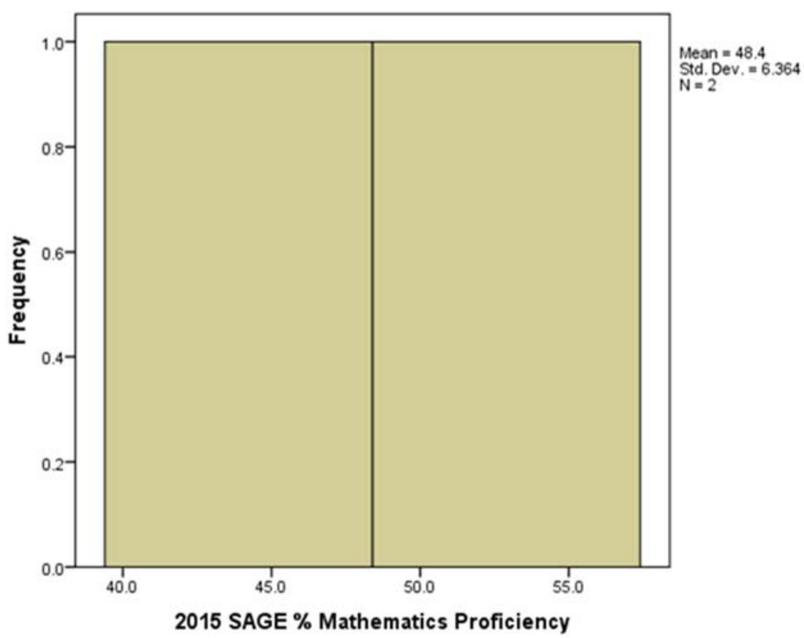

Figure J-38. Frequency by 2015 SAGE % Mathematics Proficiency for Yrs_Last_Teach_Pos = 18. This figure illustrates the number of school leaders who spent 18 years in their last teaching position based on their school's school-wide 2015 SAGE % mathematics proficiency.

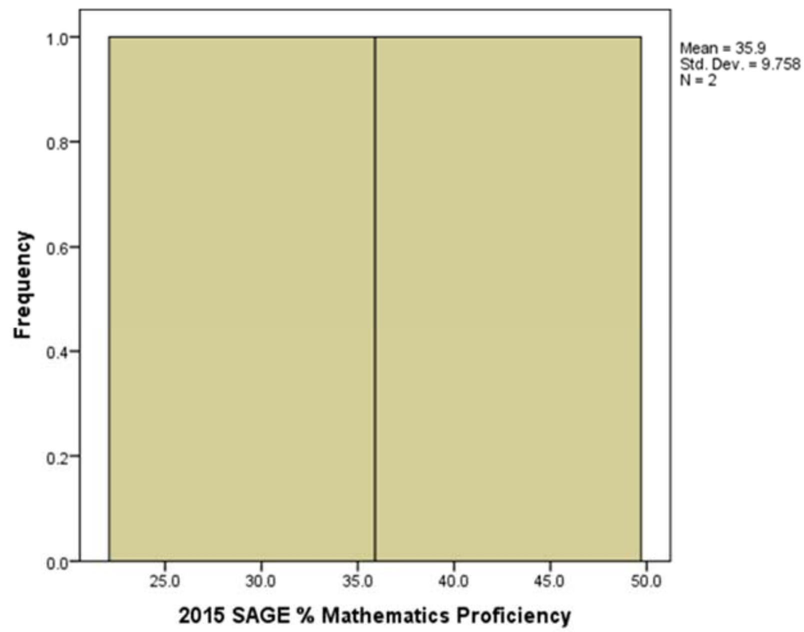

Figure J-39. Frequency by 2015 SAGE % Mathematics Proficiency for Yrs_Last_Teach_Pos = 19. This figure illustrates the number of school leaders who spent 19 years in their last teaching position based on their school's school-wide 2015 SAGE % mathematics proficiency.

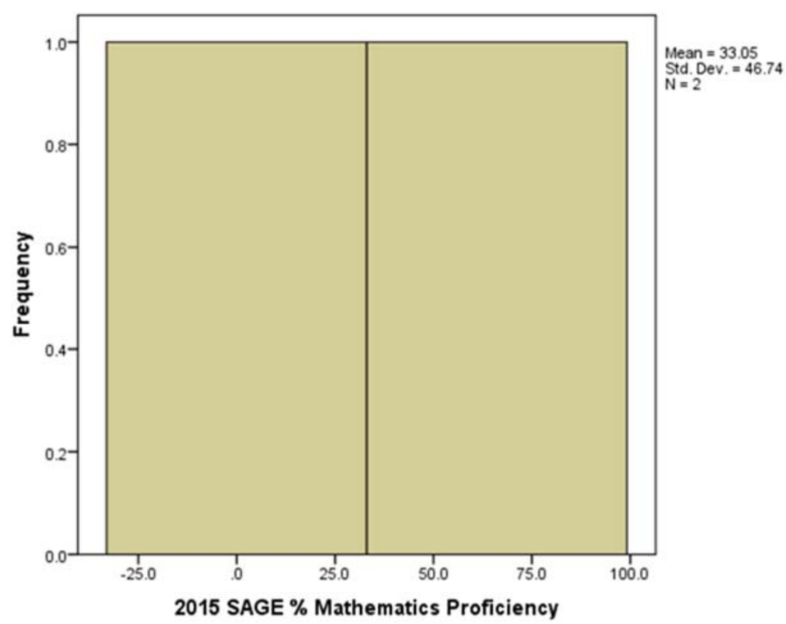

Figure J-40. Frequency by 2015 SAGE % Mathematics Proficiency for Yrs_Last_Teach_Pos = 20. This figure illustrates the number of school leaders who spent 20 years in their last teaching position based on their school's school-wide 2015 SAGE % mathematics proficiency.

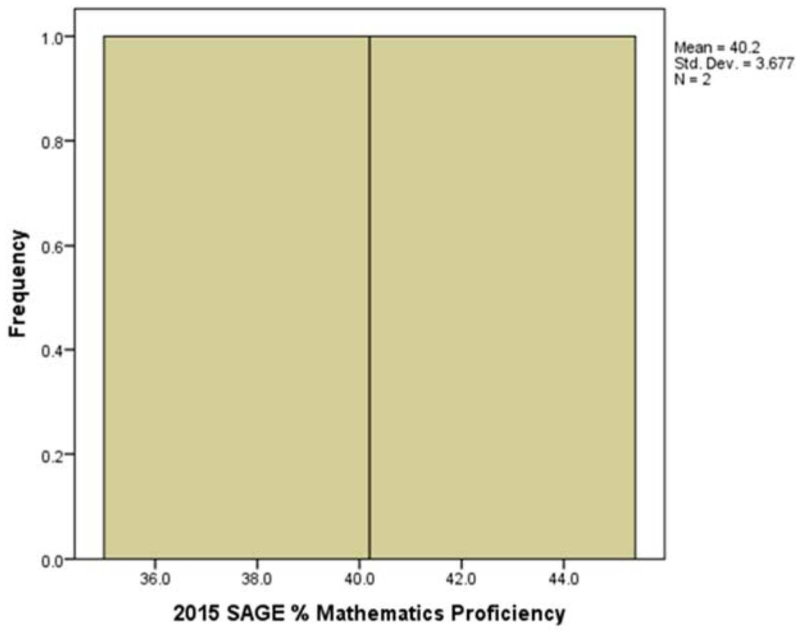

Figure J-41. Frequency by 2015 SAGE % Mathematics Proficiency for Yrs_Last_Teach_Pos = 21. This figure illustrates the number of school leaders who spent 21 years in their last teaching position based on their school's school-wide 2015 SAGE % mathematics proficiency.

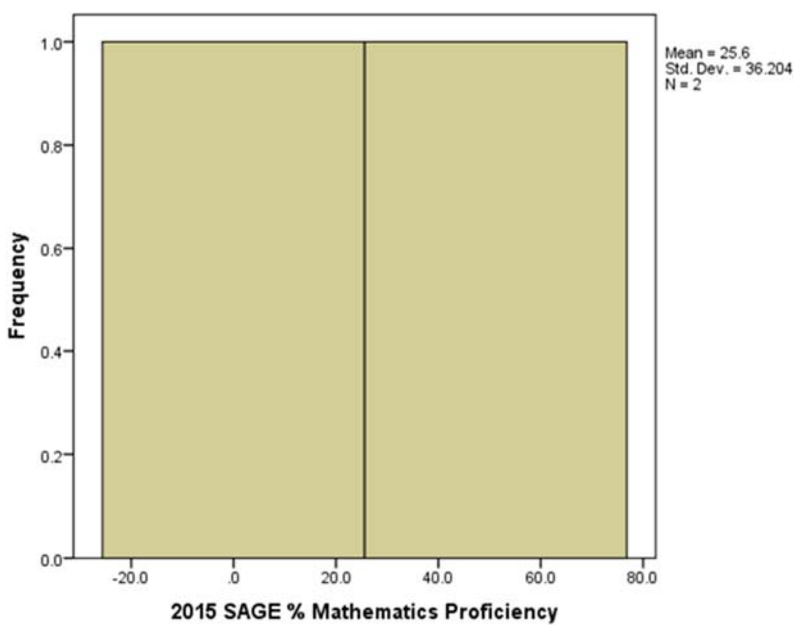

Figure J-42. Frequency by 2015 SAGE % Mathematics Proficiency for Yrs_Last_Teach_Pos = 22. This figure illustrates the number of school leaders who spent 22 years in their last teaching position based on their school's school-wide 2015 SAGE % mathematics proficiency.

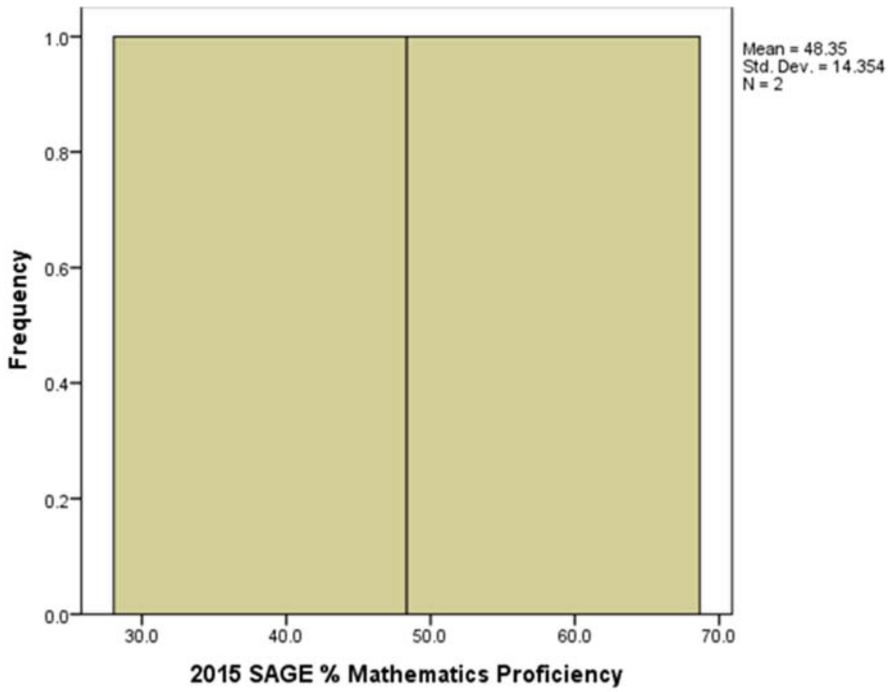

Figure J-43. Frequency by 2015 SAGE % Mathematics Proficiency for Yrs_Last_Teach_Pos = 24. This figure illustrates the number of school leaders who spent 24 years in their last teaching position based on their school's school-wide 2015 SAGE % mathematics proficiency.

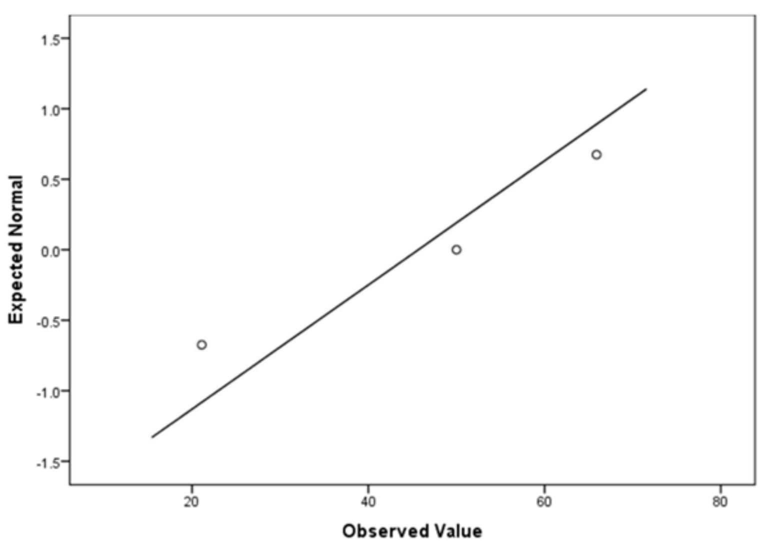

Figure J-44. Normal Q-Q Plot of 2015 SAGE % Mathematics Proficiency for Yrs_Last_Teach_Pos = 0. This figure illustrates the observed value versus the expected normal for school leaders who spent 0 years in their last teaching position based on their school's school-wide 2015 SAGE % mathematics proficiency.

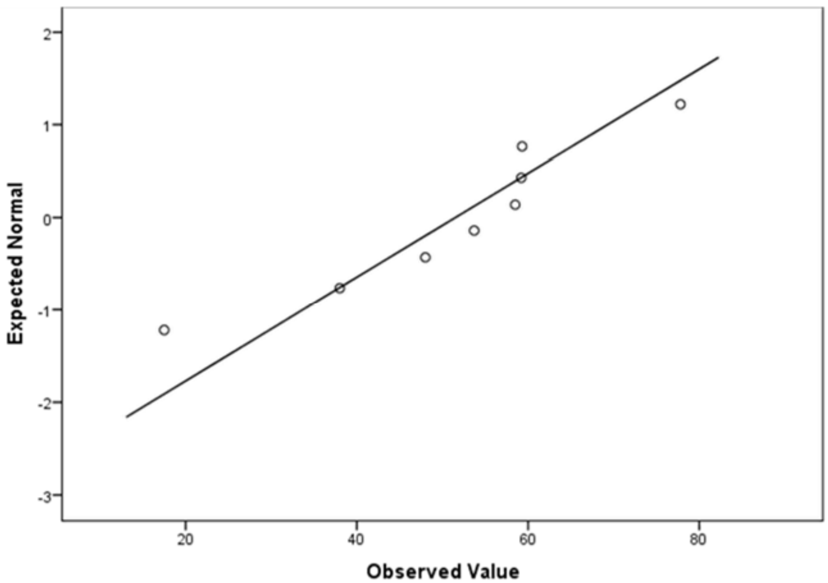

Figure J-45. Normal Q-Q Plot of 2015 SAGE % Mathematics Proficiency for Yrs_Last_Teach_Pos = 2. This figure illustrates the observed value versus the expected normal for school leaders who spent 2 years in their last teaching position based on their school's school-wide 2015 SAGE % mathematics proficiency.

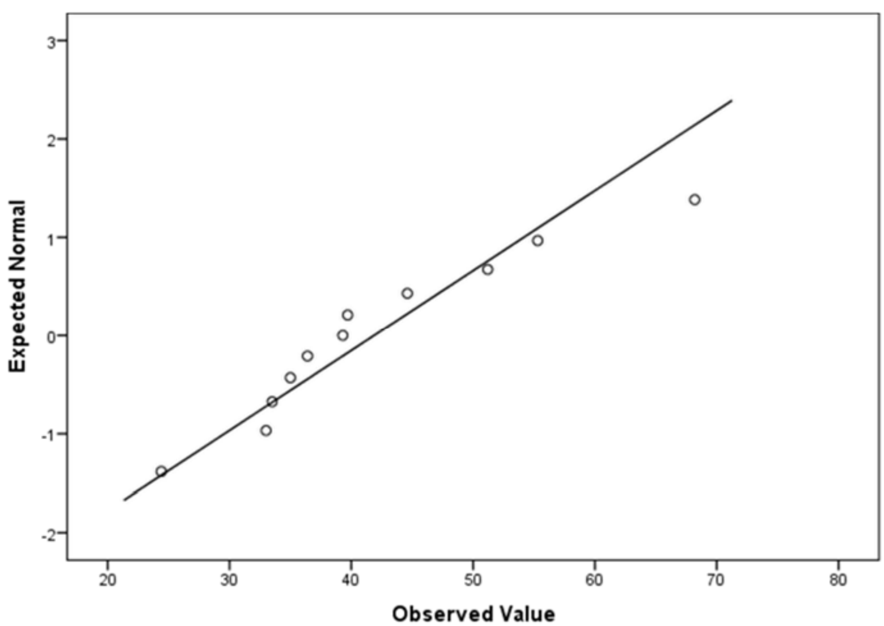

Figure J-46. Normal Q-Q Plot of 2015 SAGE % Mathematics Proficiency for Yrs_Last_Teach_Pos = 3. This figure illustrates the observed value versus the expected normal for school leaders who spent 3 years in their last teaching position based on their school's school-wide 2015 SAGE % mathematics proficiency.

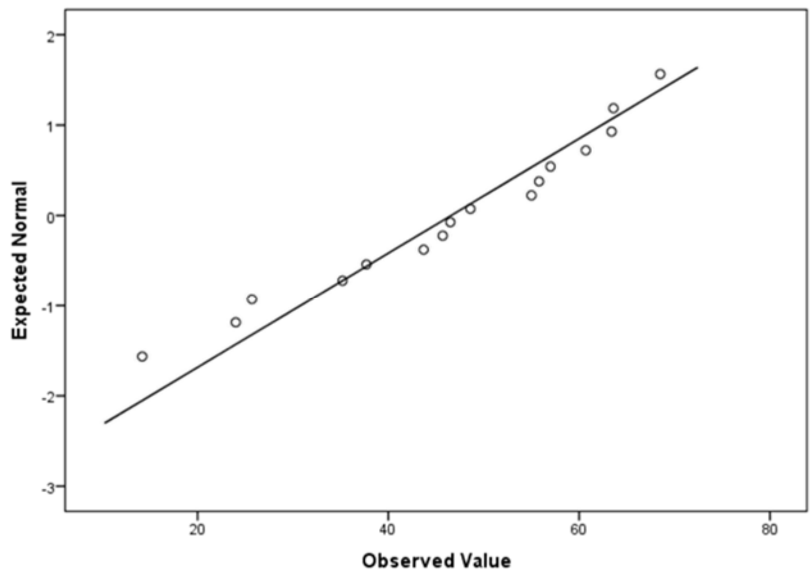

Figure J-47. Normal Q-Q Plot of 2015 SAGE % Mathematics Proficiency for Yrs_Last_Teach_Pos = 4. This figure illustrates the observed value versus the expected normal for school leaders who spent 4 years in their last teaching position based on their school's school-wide 2015 SAGE % mathematics proficiency.

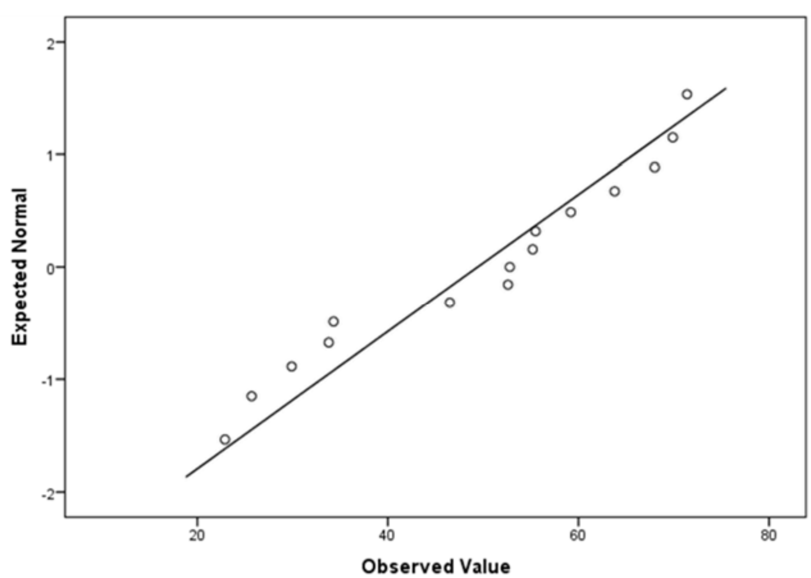

Figure J-48. Normal Q-Q Plot of 2015 SAGE % Mathematics Proficiency for Yrs_Last_Teach_Pos = 5. This figure illustrates the observed value versus the expected normal for school leaders who spent 5 years in their last teaching position based on their school's school-wide 2015 SAGE % mathematics proficiency.

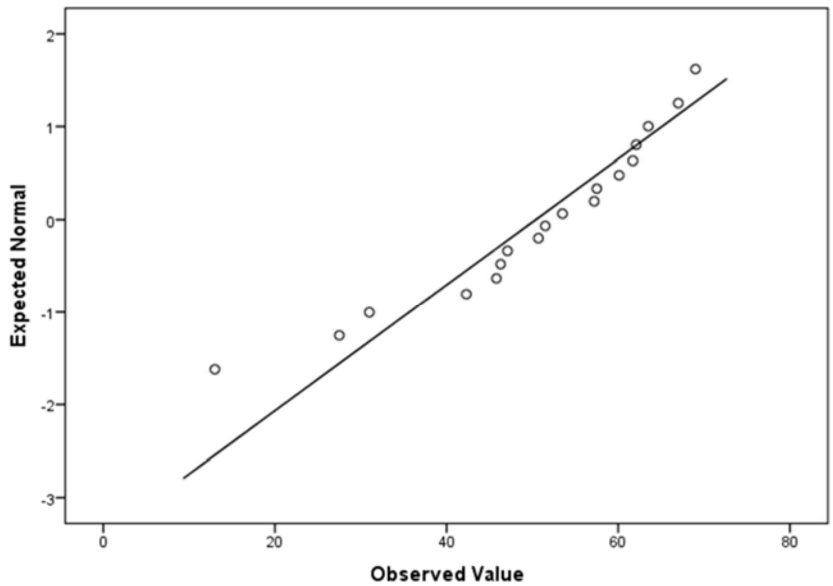

Figure J-49. Normal Q-Q Plot of 2015 SAGE % Mathematics Proficiency for Yrs_Last_Teach_Pos = 6. This figure illustrates the observed value versus the expected normal for school leaders who spent 6 years in their last teaching position based on their school's school-wide 2015 SAGE % mathematics proficiency.

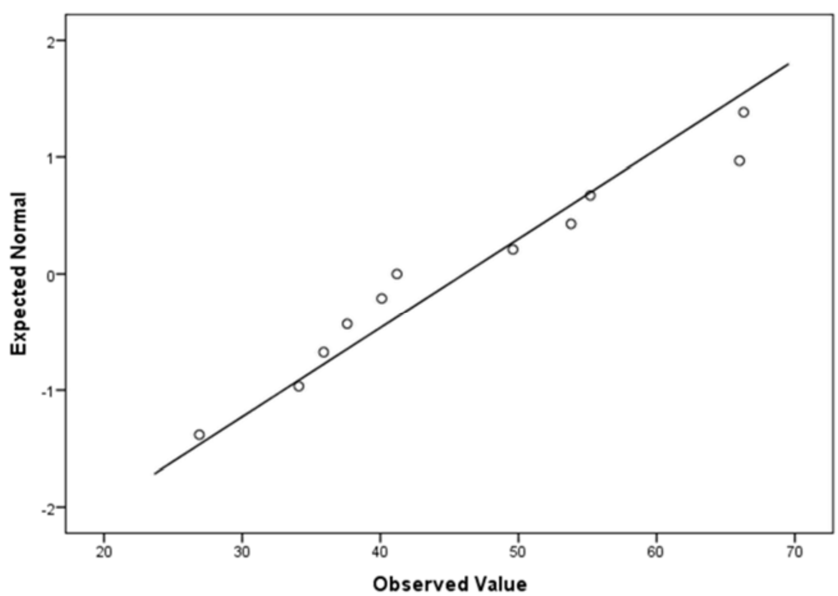

Figure J-50. Normal Q-Q Plot of 2015 SAGE % Mathematics Proficiency for Yrs_Last_Teach_Pos = 7. This figure illustrates the observed value versus the expected normal for school leaders who spent 7 years in their last teaching position based on their school's school-wide 2015 SAGE % mathematics proficiency.

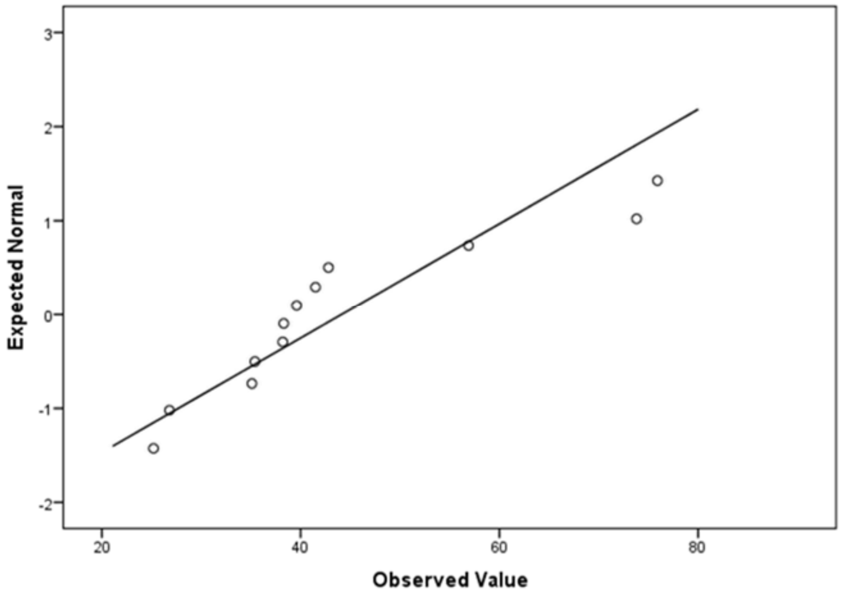

Figure J-51. Normal Q-Q Plot of 2015 SAGE % Mathematics Proficiency for Yrs_Last_Teach_Pos = 8. This figure illustrates the observed value versus the expected normal for school leaders who spent 8 years in their last teaching position based on their school's school-wide 2015 SAGE % mathematics proficiency.

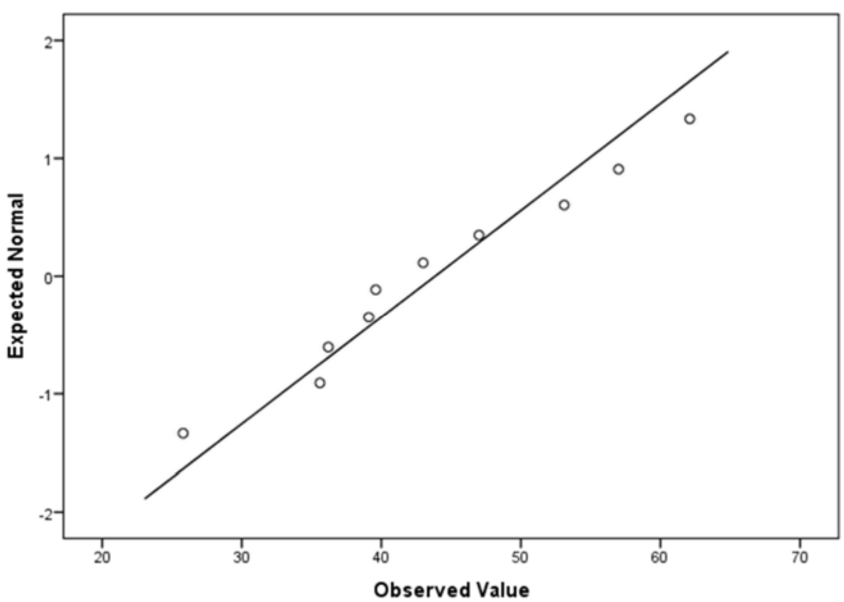

Figure J-52. Normal Q-Q Plot of 2015 SAGE % Mathematics Proficiency for Yrs_Last_Teach_Pos = 9. This figure illustrates the observed value versus the expected normal for school leaders who spent 9 years in their last teaching position based on their school's school-wide 2015 SAGE % mathematics proficiency.

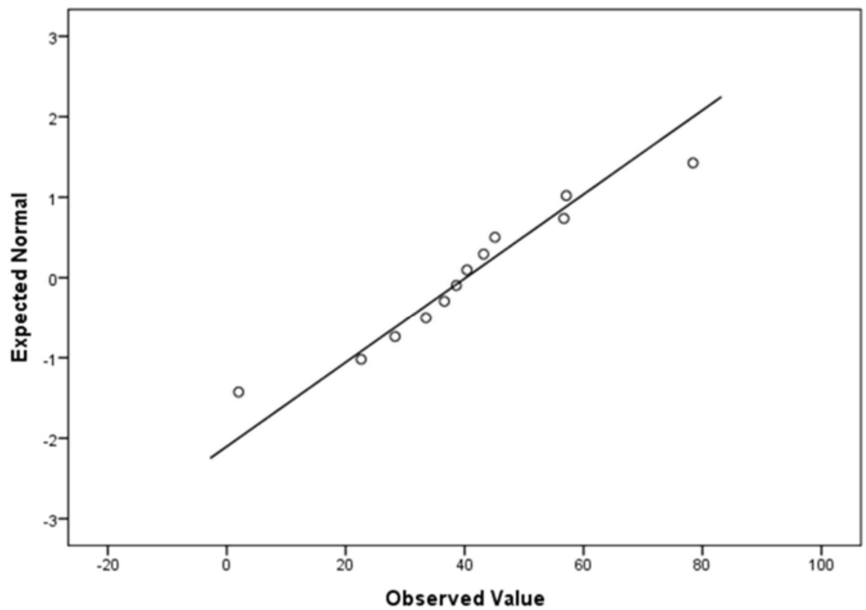

Figure J-53. Normal Q-Q Plot of 2015 SAGE % Mathematics Proficiency for Yrs_Last_Teach_Pos = 10. This figure illustrates the observed value versus the expected normal for school leaders who spent 10 years in their last teaching position based on their school's school-wide 2015 SAGE % mathematics proficiency.

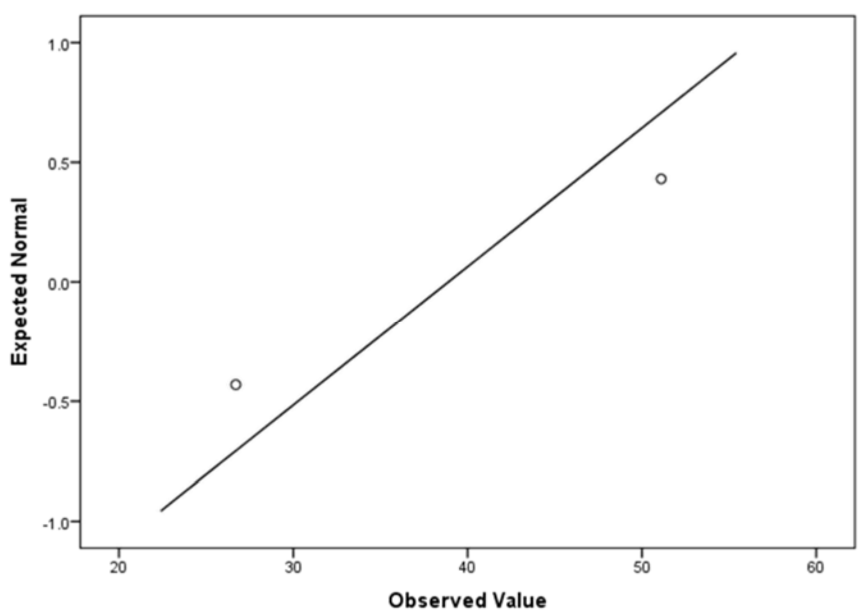

Figure J-54. Normal Q-Q Plot of 2015 SAGE % Mathematics Proficiency for Yrs_Last_Teach_Pos = 11. This figure illustrates the observed value versus the expected normal for school leaders who spent 11 years in their last teaching position based on their school's school-wide 2015 SAGE % mathematics proficiency.

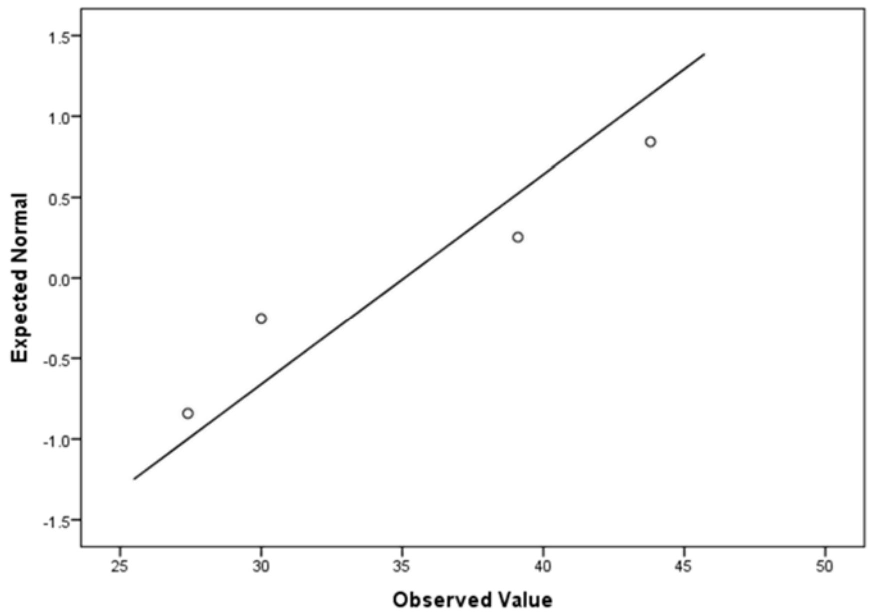

Figure J-55. Normal Q-Q Plot of 2015 SAGE % Mathematics Proficiency for Yrs_Last_Teach_Pos = 12. This figure illustrates the observed value versus the expected normal for school leaders who spent 12 years in their last teaching position based on their school's school-wide 2015 SAGE % mathematics proficiency.

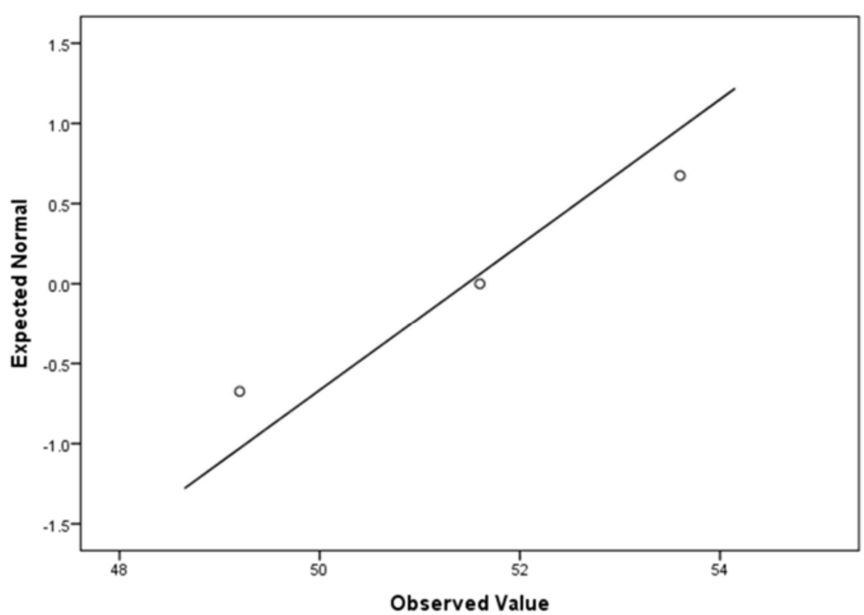

Figure J-56. Normal Q-Q Plot of 2015 SAGE % Mathematics Proficiency for Yrs_Last_Teach_Pos = 13. This figure illustrates the observed value versus the expected normal for school leaders who spent 13 years in their last teaching position based on their school's school-wide 2015 SAGE % mathematics proficiency.

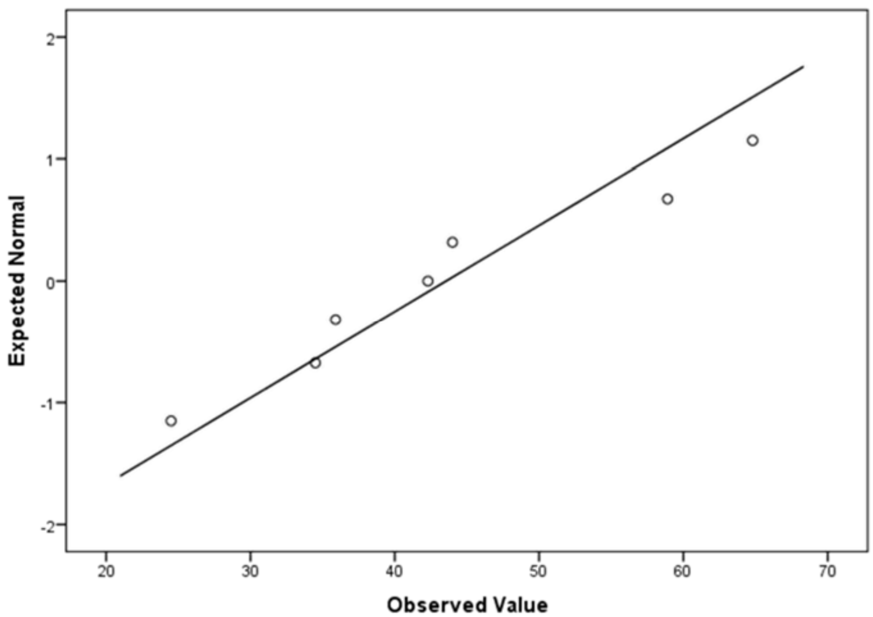

Figure J-57. Normal Q-Q Plot of 2015 SAGE % Mathematics Proficiency for Yrs_Last_Teach_Pos = 15. This figure illustrates the observed value versus the expected normal for school leaders who spent 15 years in their last teaching position based on their school's school-wide 2015 SAGE % mathematics proficiency.

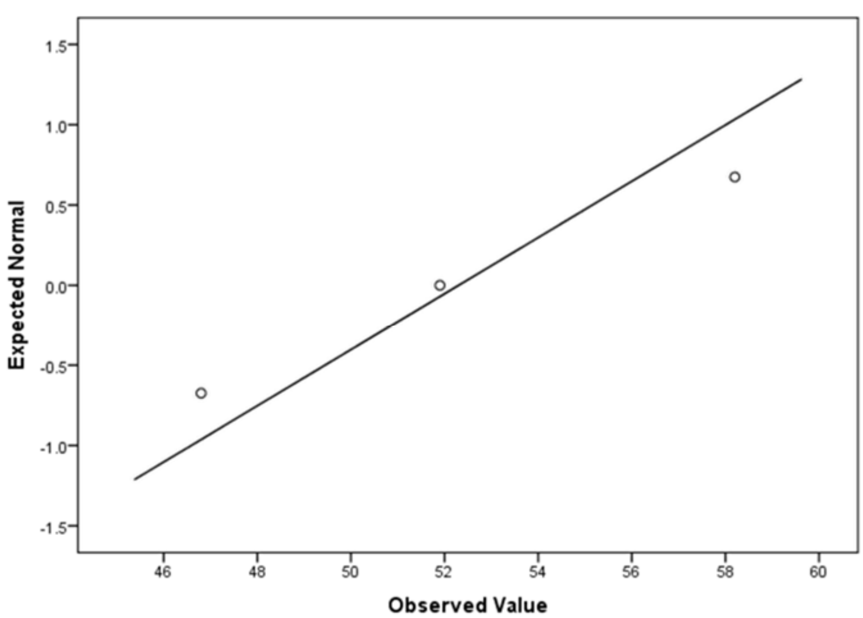

Figure J-58. Normal Q-Q Plot of 2015 SAGE % Mathematics Proficiency for Yrs_Last_Teach_Pos = 17. This figure illustrates the observed value versus the expected normal for school leaders who spent 17 years in their last teaching position based on their school's school-wide 2015 SAGE % mathematics proficiency.

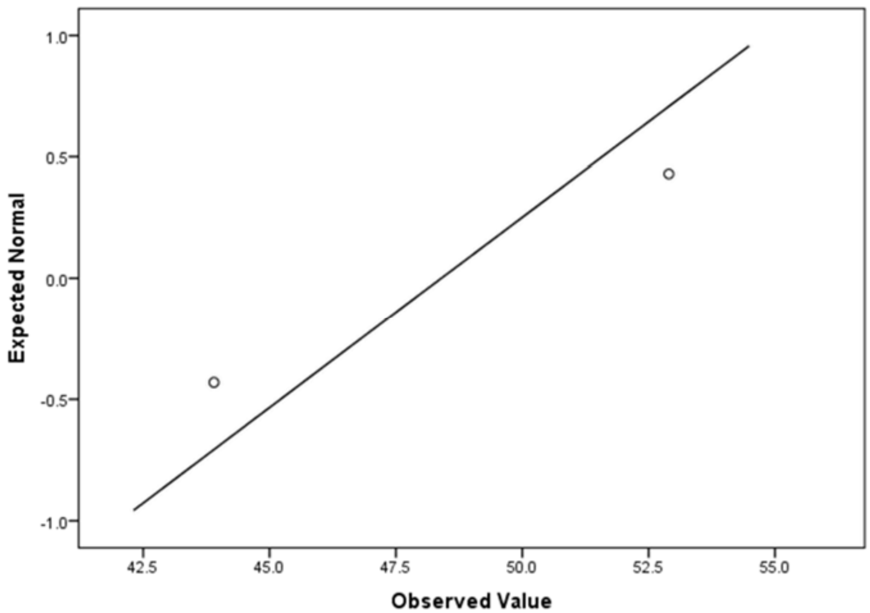

Figure J-59. Normal Q-Q Plot of 2015 SAGE % Mathematics Proficiency for Yrs_Last_Teach_Pos = 18. This figure illustrates the observed value versus the expected normal for school leaders who spent 18 years in their last teaching position based on their school's school-wide 2015 SAGE % mathematics proficiency.

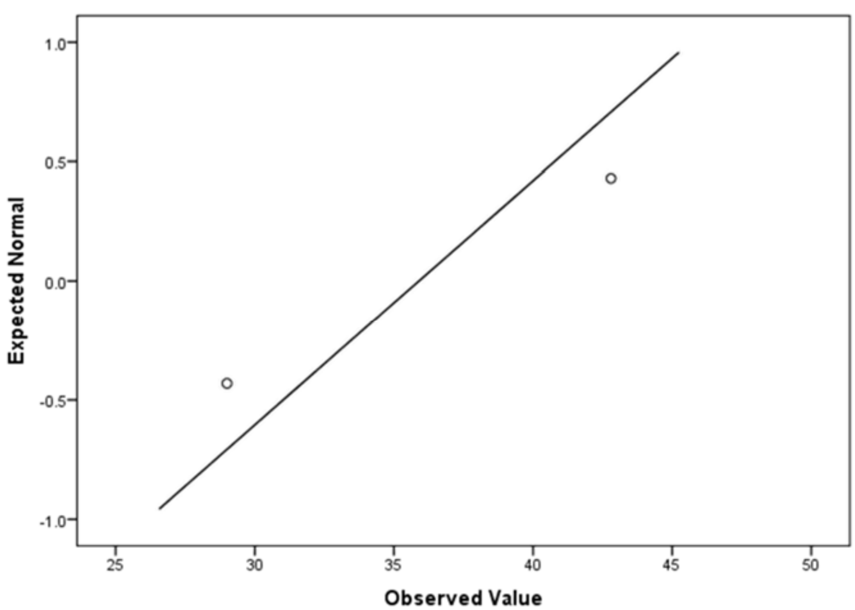

Figure J-60. Normal Q-Q Plot of 2015 SAGE % Mathematics Proficiency for Yrs_Last_Teach_Pos = 19. This figure illustrates the observed value versus the expected normal for school leaders who spent 19 years in their last teaching position based on their school's school-wide 2015 SAGE % mathematics proficiency.

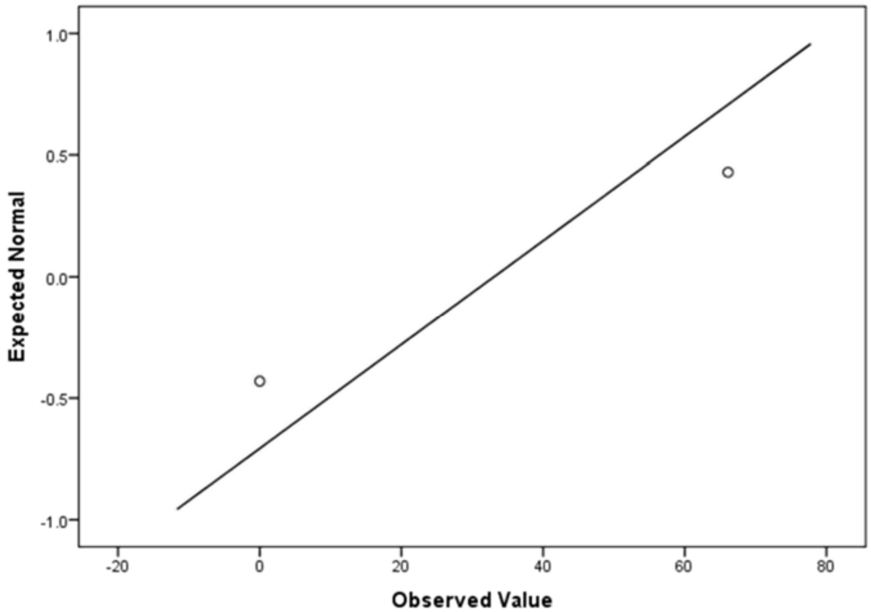

Figure J-61. Normal Q-Q Plot of 2015 SAGE % Mathematics Proficiency for Yrs_Last_Teach_Pos = 20. This figure illustrates the observed value versus the expected normal for school leaders who spent 20 years in their last teaching position based on their school's school-wide 2015 SAGE % mathematics proficiency.

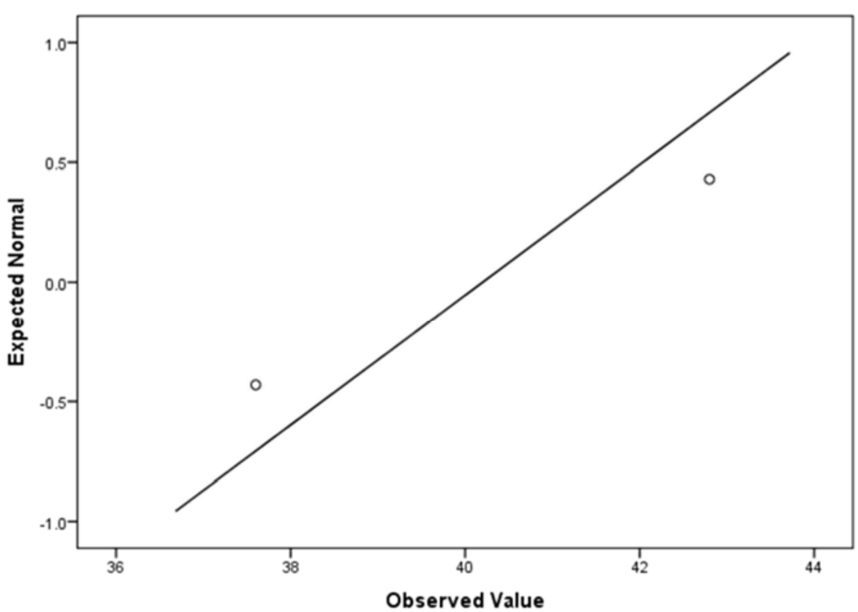

Figure J-62. Normal Q-Q Plot of 2015 SAGE % Mathematics Proficiency for Yrs_Last_Teach_Pos = 21. This figure illustrates the observed value versus the expected normal for school leaders who spent 21 years in their last teaching position based on their school's school-wide 2015 SAGE % mathematics proficiency.

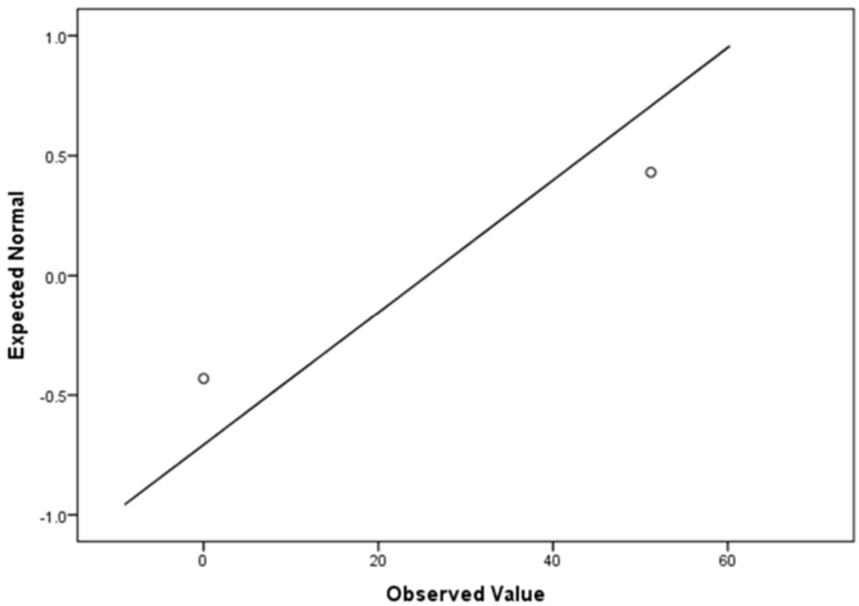

Figure J-63. Normal Q-Q Plot of 2015 SAGE % Mathematics Proficiency for Yrs_Last_Teach_Pos = 22. This figure illustrates the observed value versus the expected normal for school leaders who spent 22 years in their last teaching position based on their school's school-wide 2015 SAGE % mathematics proficiency.

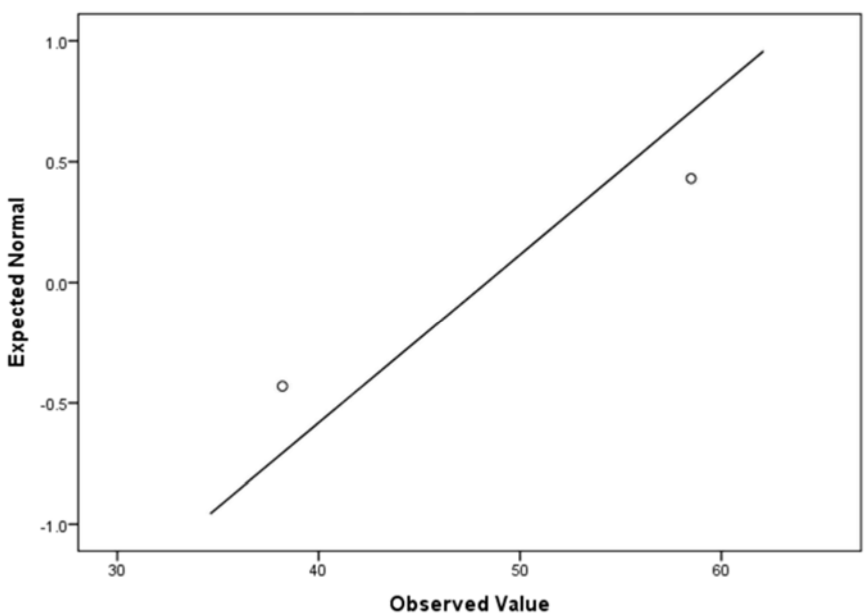

Figure J-64. Normal Q-Q Plot of 2015 SAGE % Mathematics Proficiency for Yrs_Last_Teach_Pos = 24. This figure illustrates the observed value versus the expected normal for school leaders who spent 24 years in their last teaching position based on their school's school-wide 2015 SAGE % mathematics proficiency.

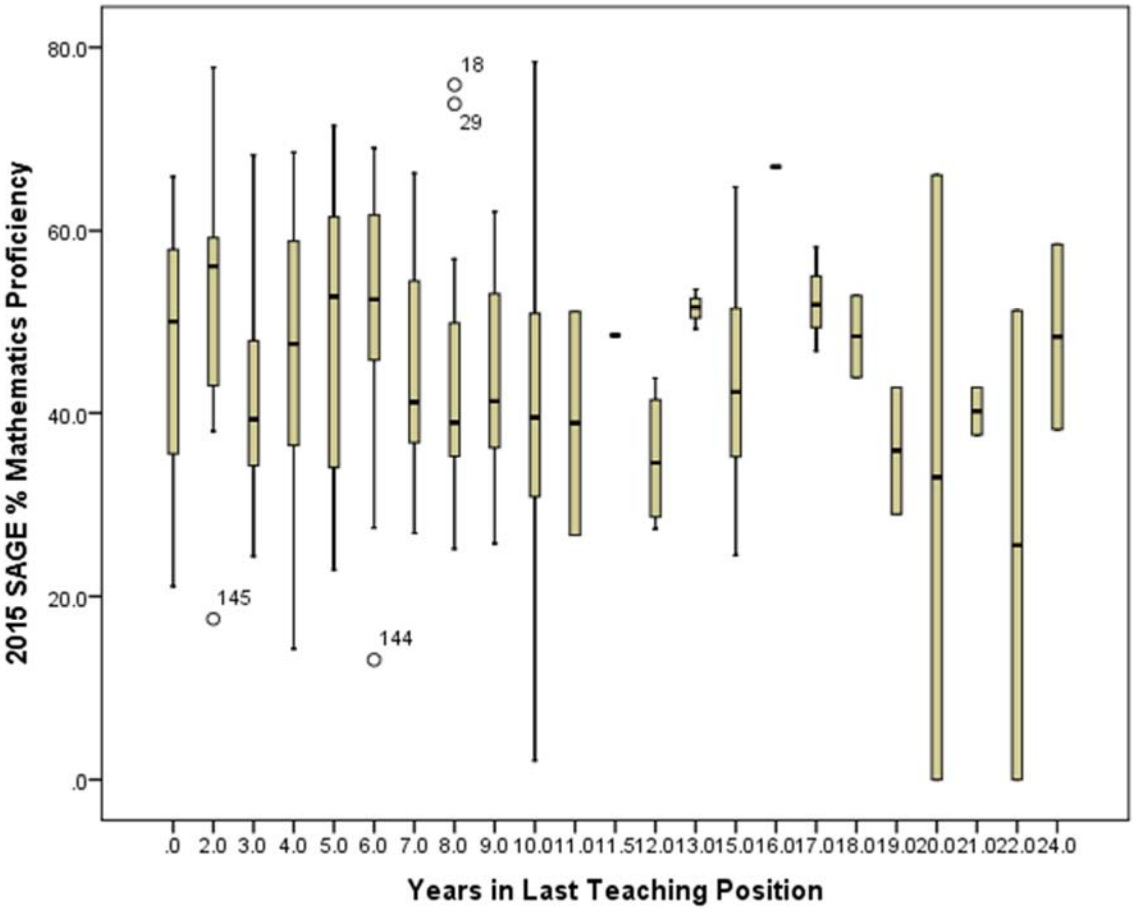

Figure J-65. Boxplot of 2015 SAGE % Mathematics Proficiency for Yrs_Last_Teach_Pos. This figure illustrates spread of school-wide 2015 SAGE % Mathematics Proficiency scores based on school leaders' number of years in their last teaching position.

Table J-4

MTL64: Tests of Normality

Variable		Shapiro-Wilk Statistic	df	Sig.	Skewness	Std. Error	Kurtosis	Std. Error
MTL64	1							
	2	.89	8	.209	-1.38	.75	1.89	1.48
	3	.97	37	.378	.43	.39	-.05	.76
	4	.96	35	.172	-.14	.40	-.03	.78
	5	.83	6	.10	-1.39	.85	2.54	1.74

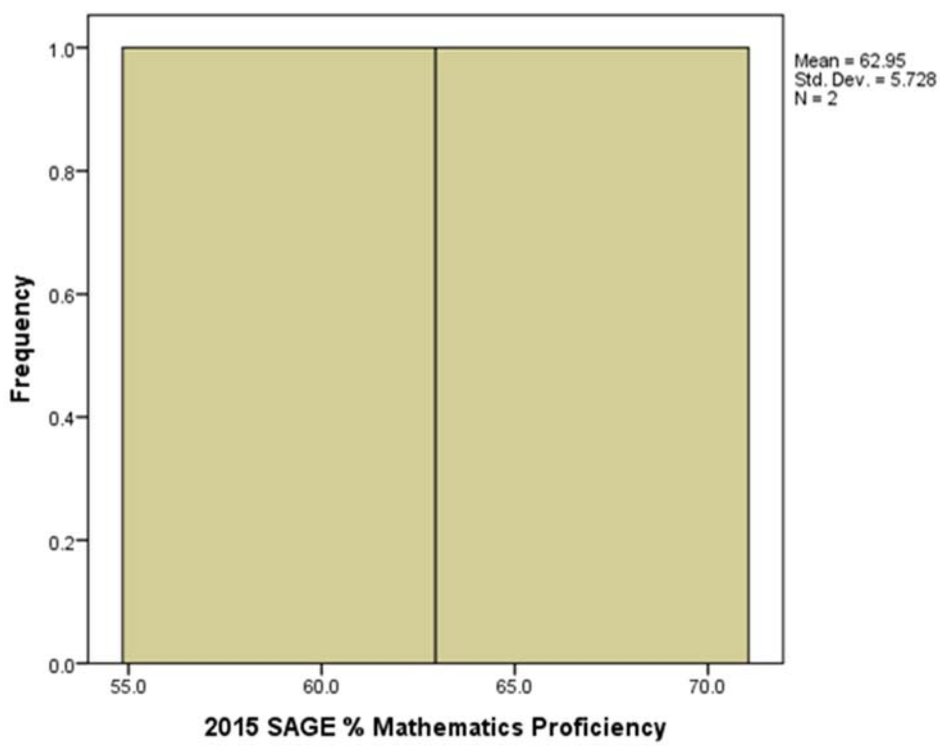

Figure J-66. Frequency by 2015 SAGE % Mathematics Proficiency for MTL64 = 1. This figure illustrates the number of school leaders who rated MTL64 at 1 based on their school's school-wide 2015 SAGE % mathematics proficiency.

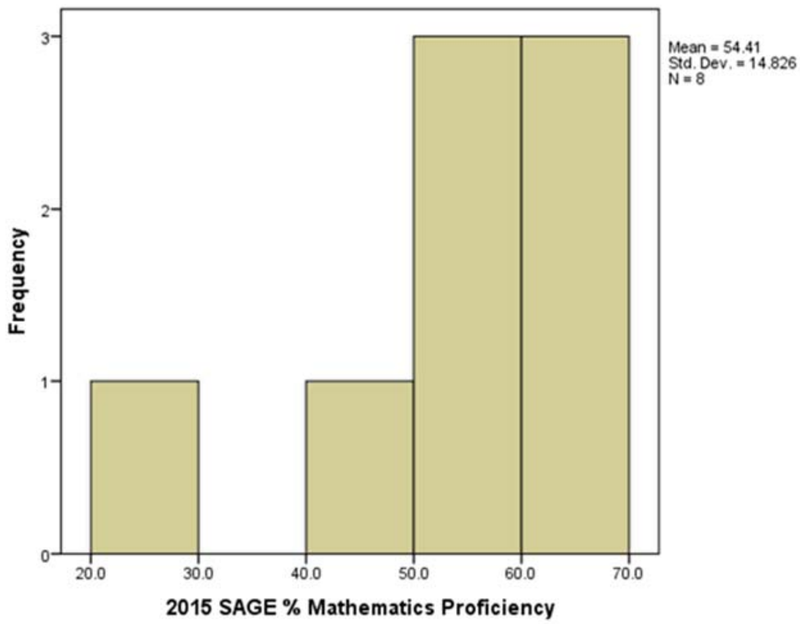

Figure J-67. Frequency by 2015 SAGE % Mathematics Proficiency for MTL64 = 2. This figure illustrates the number of school leaders who rated MTL64 at 2 based on their school's school-wide 2015 SAGE % mathematics proficiency.

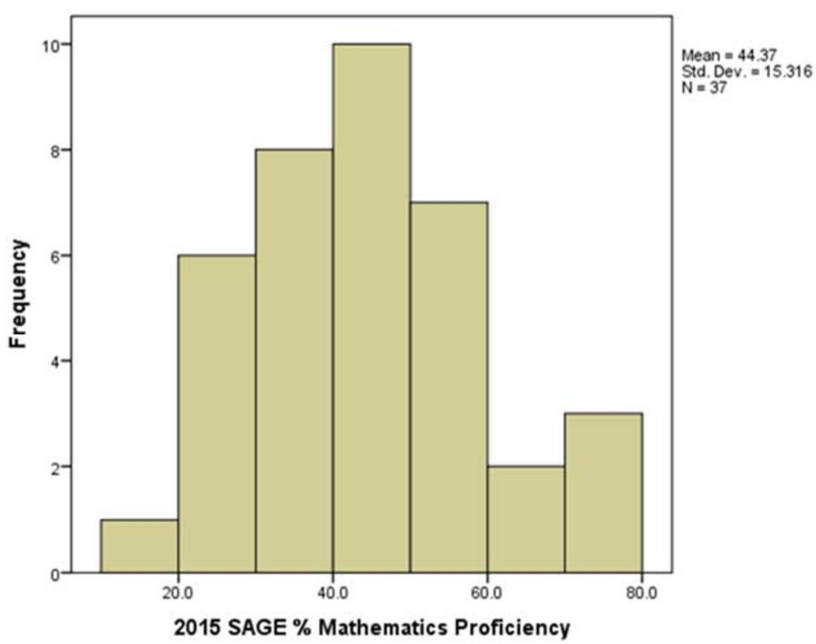

Figure J-68. Frequency by 2015 SAGE % Mathematics Proficiency for MTL64 = 3. This figure illustrates the number of school leaders who rated MTL64 at 3 based on their school's school-wide 2015 SAGE % mathematics proficiency.

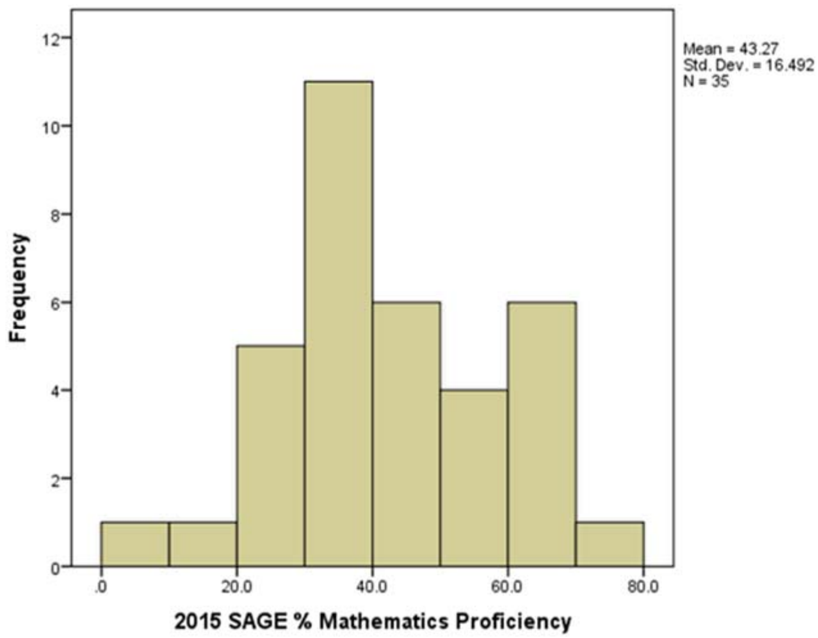

Figure J-69. Frequency by 2015 SAGE % Mathematics Proficiency for MTL64 = 4. This figure illustrates the number of school leaders who rated MTL64 at 4 based on their school's school-wide 2015 SAGE % mathematics proficiency.

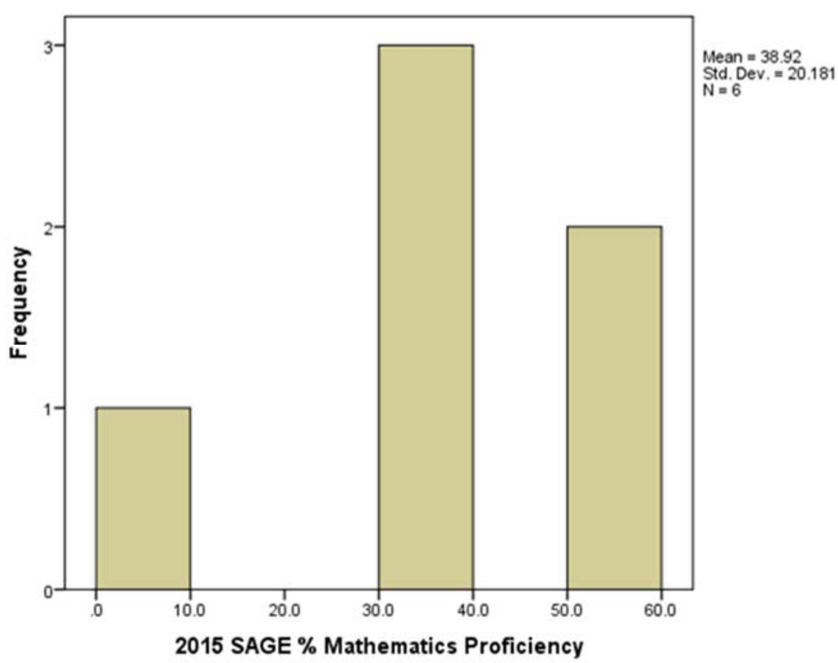

Figure J-70. Frequency by 2015 SAGE % Mathematics Proficiency for MTL64 = 5. This figure illustrates the number of school leaders who rated MTL64 at 5 based on their school's school-wide 2015 SAGE % mathematics proficiency.

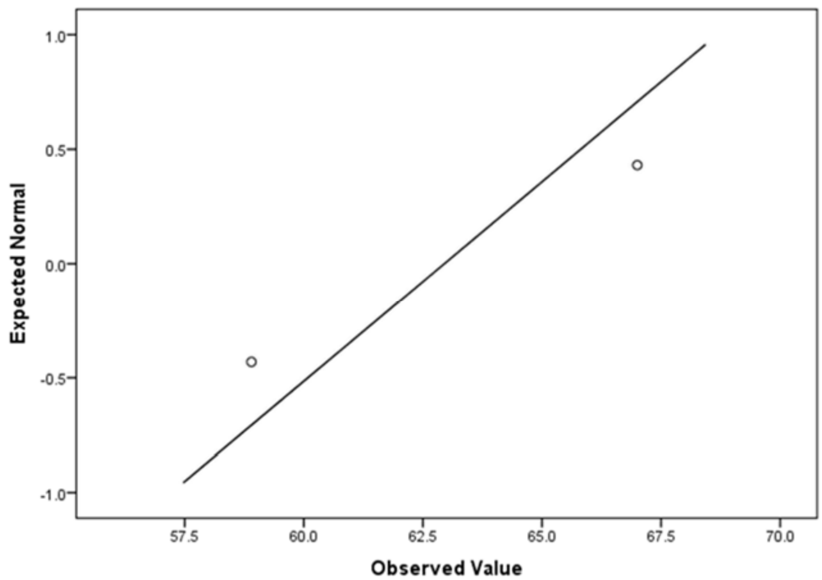

Figure J-71. Normal Q-Q Plot of 2015 SAGE % Mathematics Proficiency for MTL64 = 1. This figure illustrates the observed value versus the expected normal for school leaders who ranked MTL64 as 1 based on their school's school-wide 2015 SAGE % mathematics proficiency.

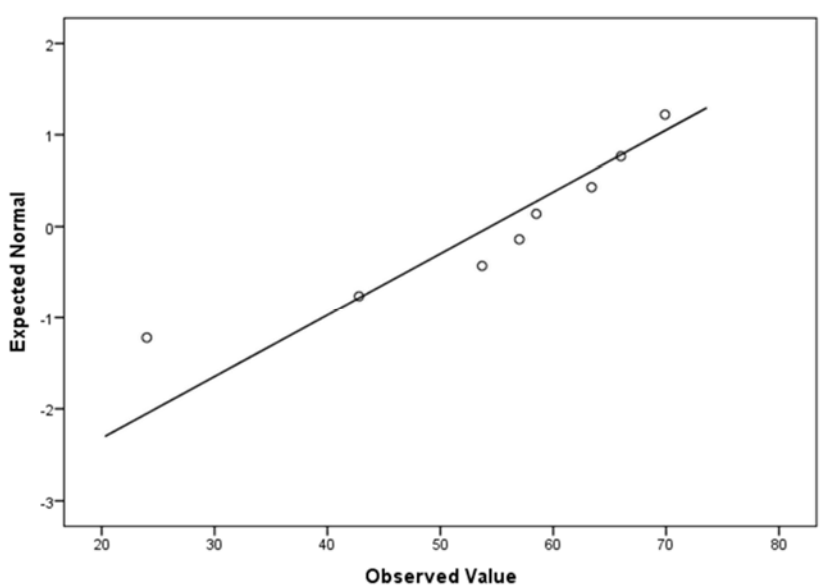

Figure J-72. Normal Q-Q Plot of 2015 SAGE % Mathematics Proficiency for MTL64 = 2. This figure illustrates the observed value versus the expected normal for school leaders who ranked MTL64 as 2 based on their school's school-wide 2015 SAGE % mathematics proficiency.

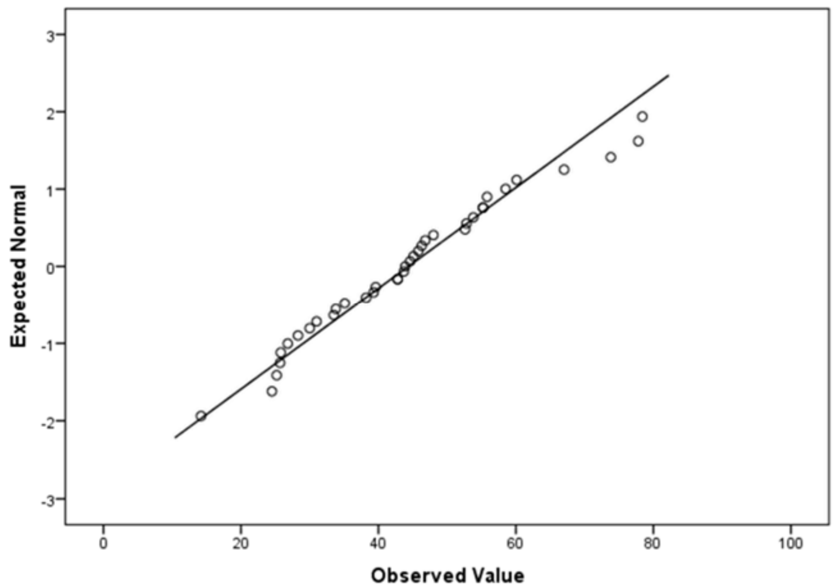

Figure J-73. Normal Q-Q Plot of 2015 SAGE % Mathematics Proficiency for MTL64 = 3. This figure illustrates the observed value versus the expected normal for school leaders who ranked MTL64 as 3 based on their school's school-wide 2015 SAGE % mathematics proficiency.

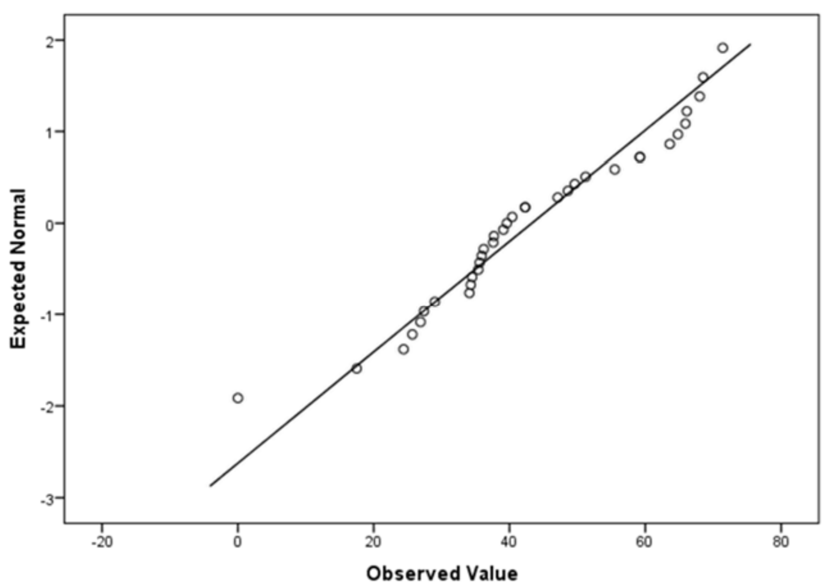

Figure J-74. Normal Q-Q Plot of 2015 SAGE % Mathematics Proficiency for MTL64 = 4. This figure illustrates the observed value versus the expected normal for school leaders who ranked MTL64 as 4 based on their school's school-wide 2015 SAGE % mathematics proficiency.

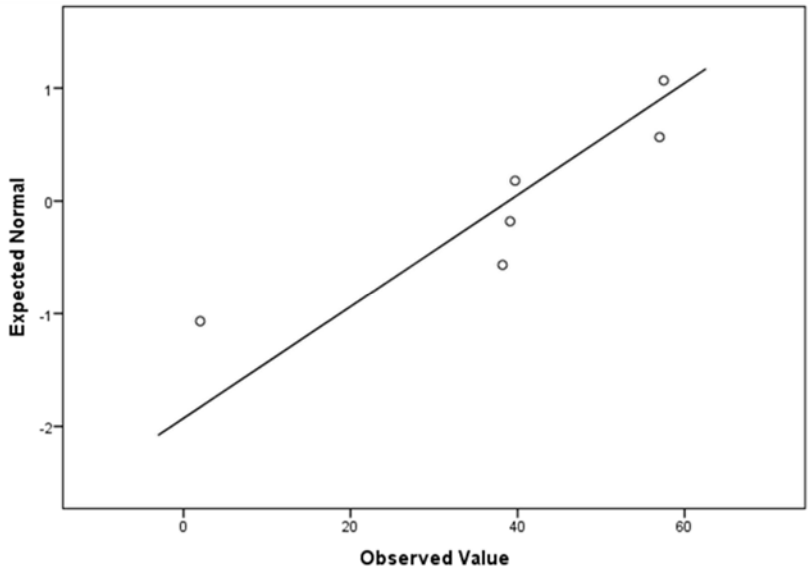

Figure J-75. Normal Q-Q Plot of 2015 SAGE % Mathematics Proficiency for MTL64 = 5. This figure illustrates the observed value versus the expected normal for school leaders who ranked MTL64 as 5 based on their school's school-wide 2015 SAGE % mathematics proficiency.

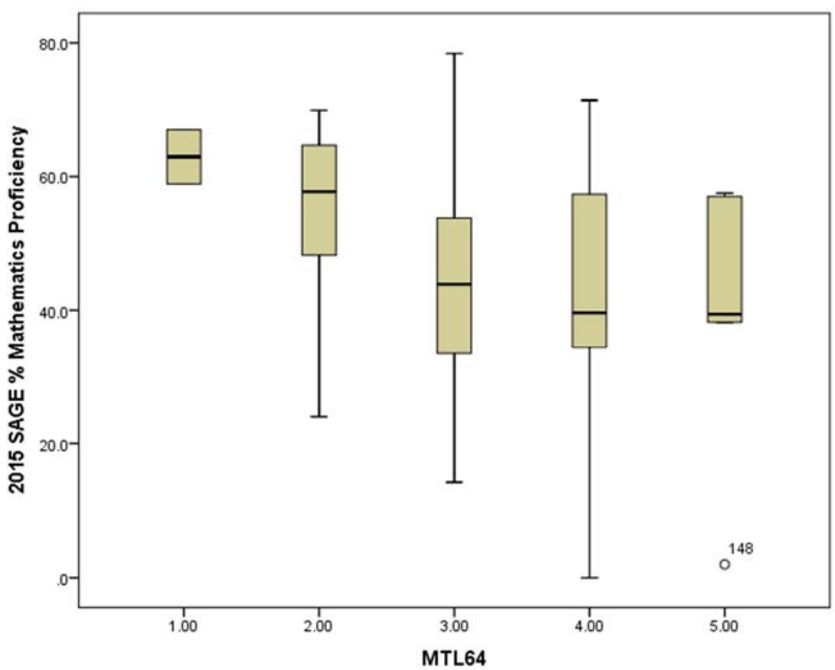

Figure J-76. Boxplot of 2015 SAGE % Mathematics Proficiency for MTL64. This figure illustrates spread of school-wide 2015 SAGE % Mathematics Proficiency scores based on school leaders' ranking of MTL64.

Table J-5

Tot_Yrs_Teach: Tests of Normality

		Shapiro-Wilk						
Variable		Statistic	df	Sig.	Skewness	Std. Error	Kurtosis	Std. Error
Tot_Yrs_ Teach	0	.97	3	.683	-.83	1.23		
	1							
	2							
	3	.99	3	.844	-.42	1.23		
	4	.97	10	.899	-.25	.69	-.65	1.33
	5	.96	13	.68	-.16	.62	-1.03	1.19
	6	.96	8	.77	-.85	.75	1.18	1.48
	7	.95	15	.552	-.44	.58	-.59	1.12
	8	.96	11	.737	.53	.66	-.35	1.28
	9	.93	8	.545	-.29	.75	-1.29	1.48
	10	.94	8	.567	.81	.75	.09	1.48
	11	.99	4	.952	-.12	1.01	-1.42	2.62
	12	.94	6	.677	-.18	.85	-1.2	1.74
	13	.93	4	.591	1.16	1.01	1.83	2.62
	14	.85	5	.189	-1.57	.91	2.43	2.00
	15	.95	12	.624	-.27	.64	1.33	1.23
	16	.93	6	.606				
	17							
	18	.96	3	.616	.98	1.23		
	19	.85	3	.243	1.61	1.23		
	20	.78	5	.056	-1.82	.91	3.40	2.00
	21							
	22							
	23							
	24	.98	4	.903	.55	1.01	-.46	2.62
	25							
	26							
	27							
	28							
	29							

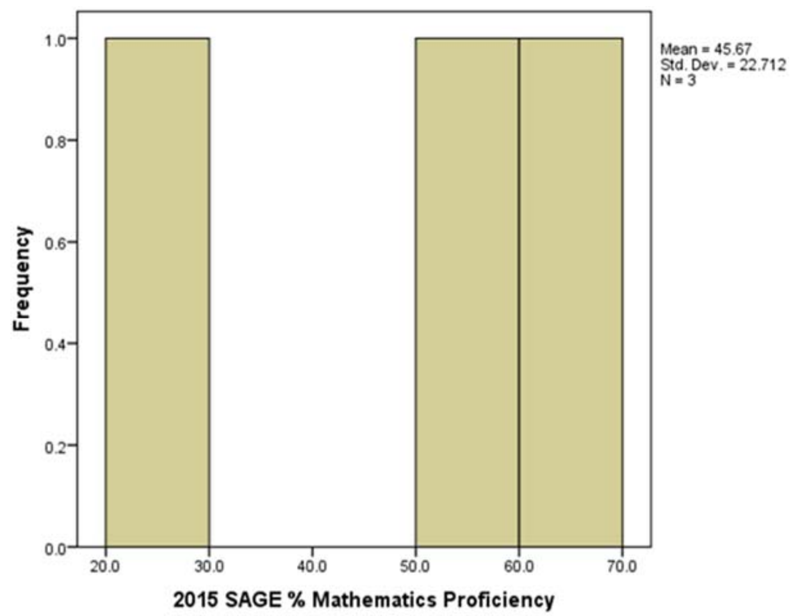

Figure J-77. Frequency by 2015 SAGE % Mathematics Proficiency for Tot_Yrs_Teach = 0. This figure illustrates the number of school leaders who spent 0 years in total teaching based on their school's school-wide 2015 SAGE % mathematics proficiency.

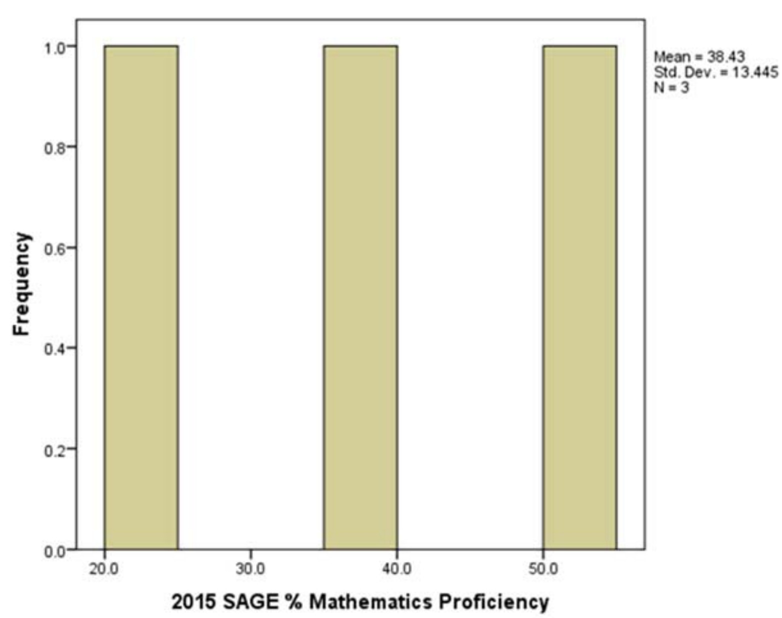

Figure J-78. Frequency by 2015 SAGE % Mathematics Proficiency for Tot_Yrs_Teach = 3. This figure illustrates the number of school leaders who spent 3 years in total teaching based on their school's school-wide 2015 SAGE % mathematics proficiency.

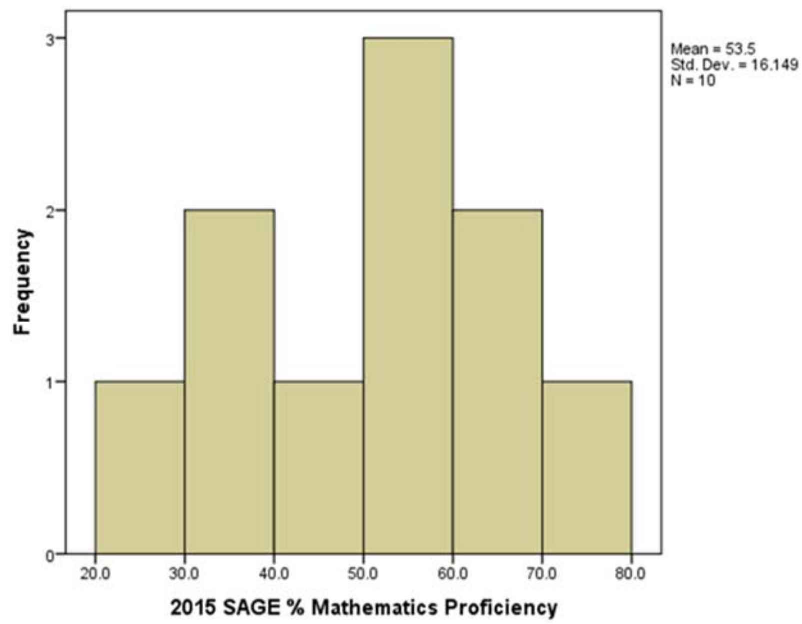

Figure J-79. Frequency by 2015 SAGE % Mathematics Proficiency for Tot_Yrs_Teach = 4. This figure illustrates the number of school leaders who spent 4 years in total teaching based on their school's school-wide 2015 SAGE % mathematics proficiency.

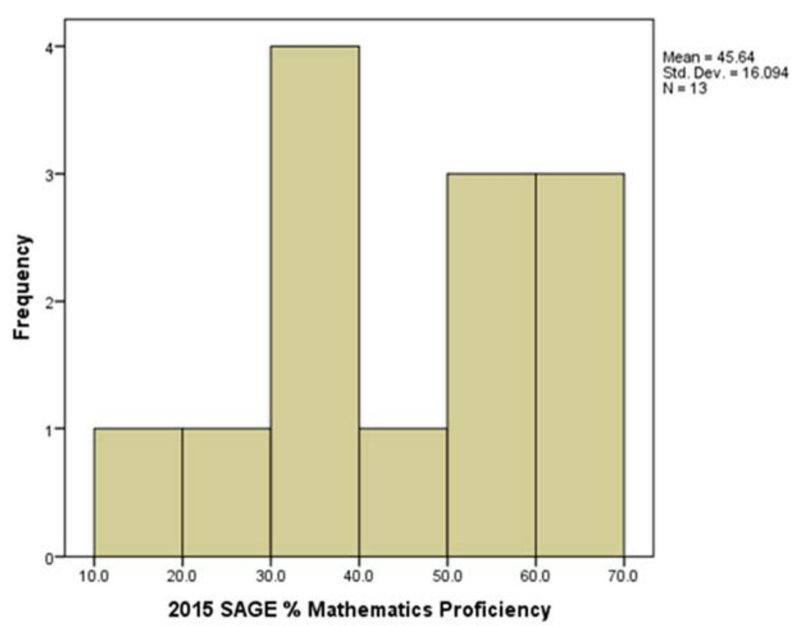

Figure J-80. Frequency by 2015 SAGE % Mathematics Proficiency for Tot_Yrs_Teach = 5. This figure illustrates the number of school leaders who spent 5 years in total teaching based on their school's school-wide 2015 SAGE % mathematics proficiency.

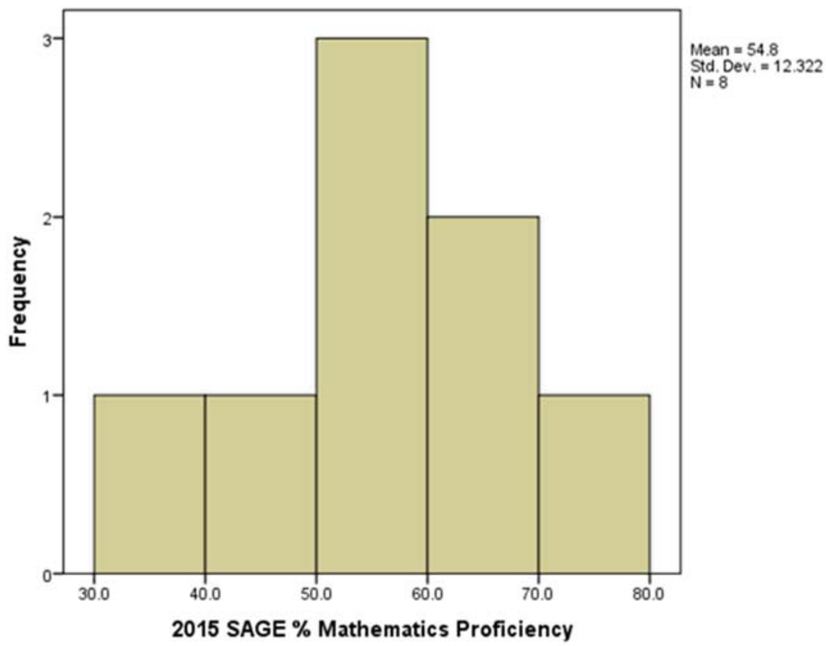

Figure J-81. Frequency by 2015 SAGE % Mathematics Proficiency for Tot_Yrs_Teach = 6. This figure illustrates the number of school leaders who spent 6 years in total teaching based on their school's school-wide 2015 SAGE % mathematics proficiency.

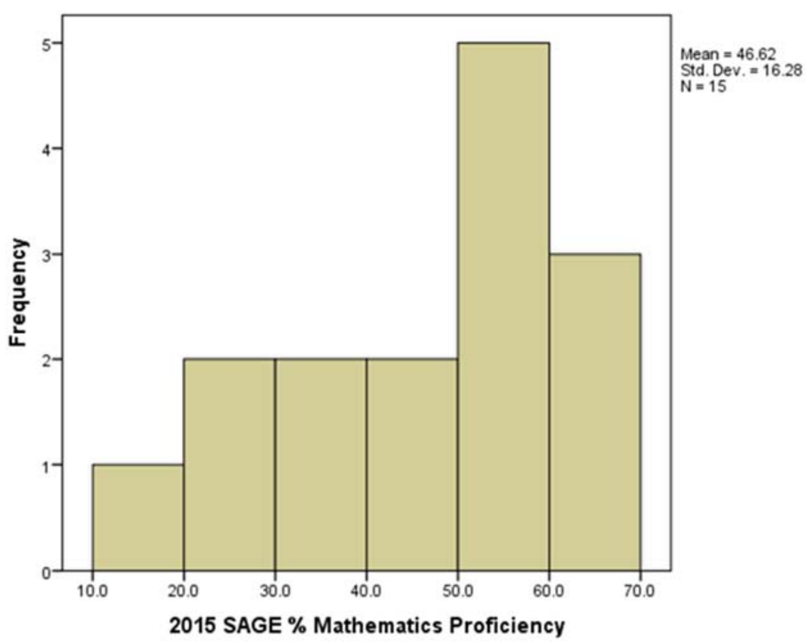

Figure J-82. Frequency by 2015 SAGE % Mathematics Proficiency for Tot_Yrs_Teach = 7. This figure illustrates the number of school leaders who spent 7 years in total teaching based on their school's school-wide 2015 SAGE % mathematics proficiency.

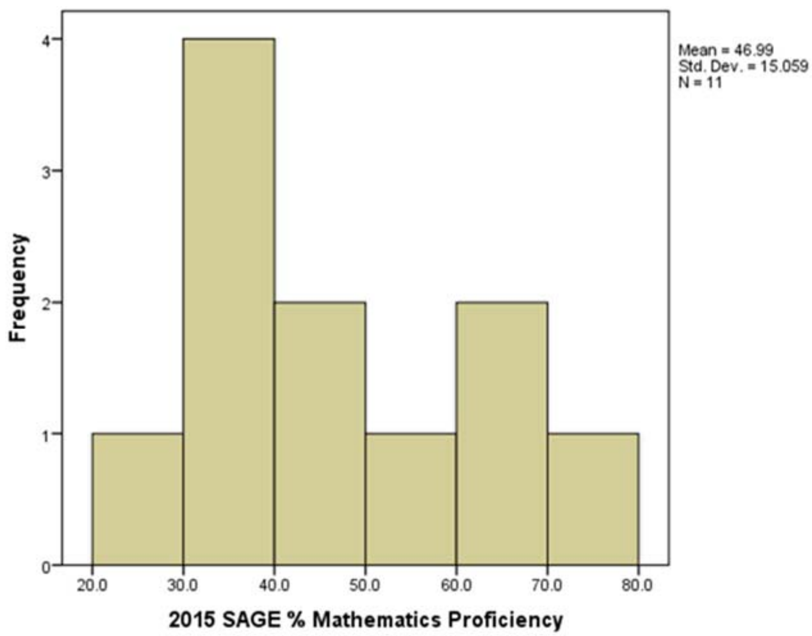

Figure J-83. Frequency by 2015 SAGE % Mathematics Proficiency for Tot_Yrs_Teach = 8. This figure illustrates the number of school leaders who spent 8 years in total teaching based on their school's school-wide 2015 SAGE % mathematics proficiency.

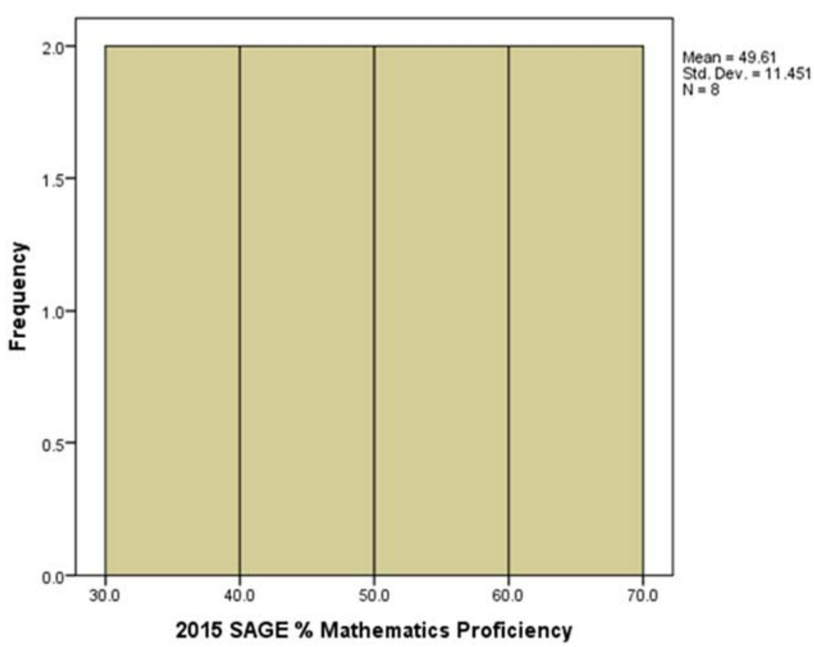

Figure J-84. Frequency by 2015 SAGE % Mathematics Proficiency for Tot_Yrs_Teach = 9. This figure illustrates the number of school leaders who spent 9 years in total teaching based on their school's school-wide 2015 SAGE % mathematics proficiency.

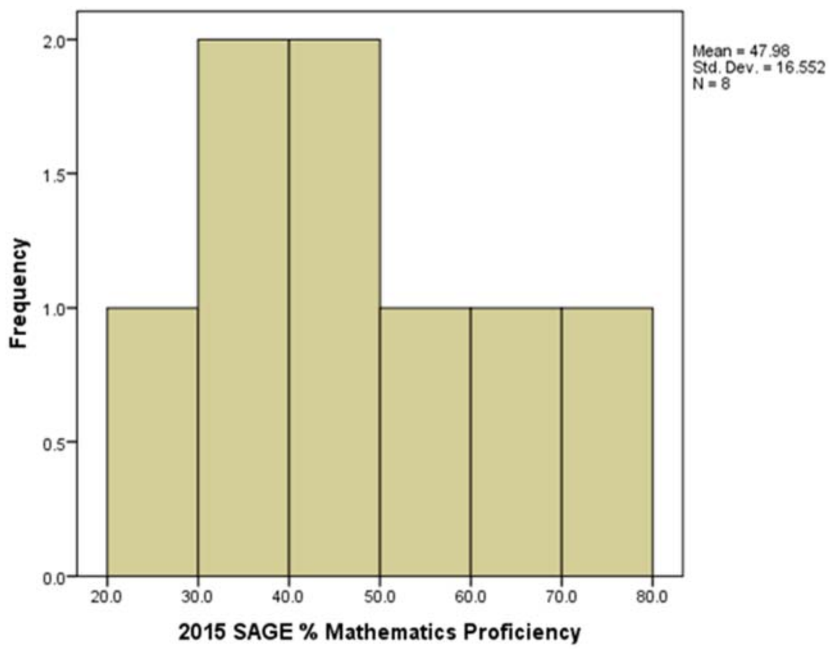

Figure J-85. Frequency by 2015 SAGE % Mathematics Proficiency for Tot_Yrs_Teach = 10. This figure illustrates the number of school leaders who spent 10 years in total teaching based on their school's school-wide 2015 SAGE % mathematics proficiency.

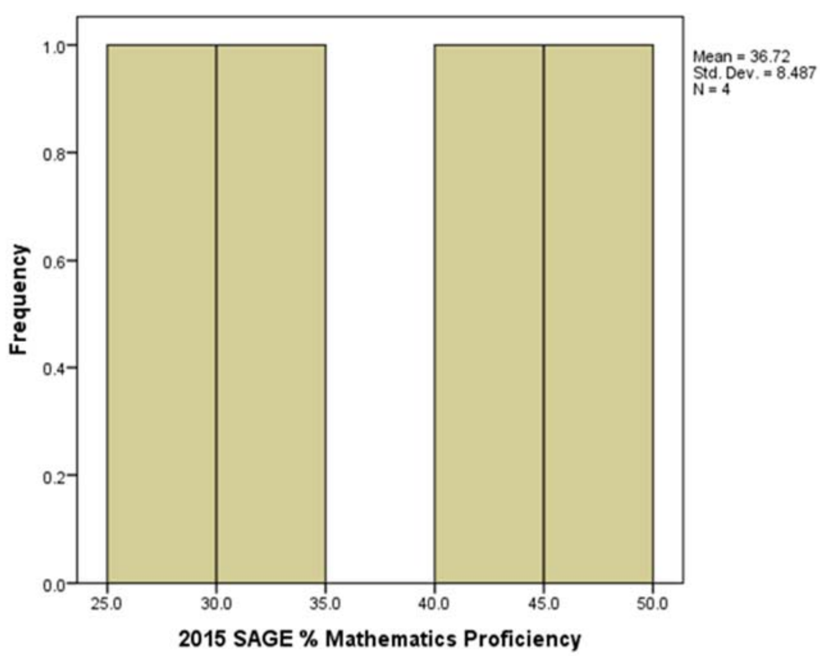

Figure J-86. Frequency by 2015 SAGE % Mathematics Proficiency for Tot_Yrs_Teach = 11. This figure illustrates the number of school leaders who spent 11 years in total teaching based on their school's school-wide 2015 SAGE % mathematics proficiency.

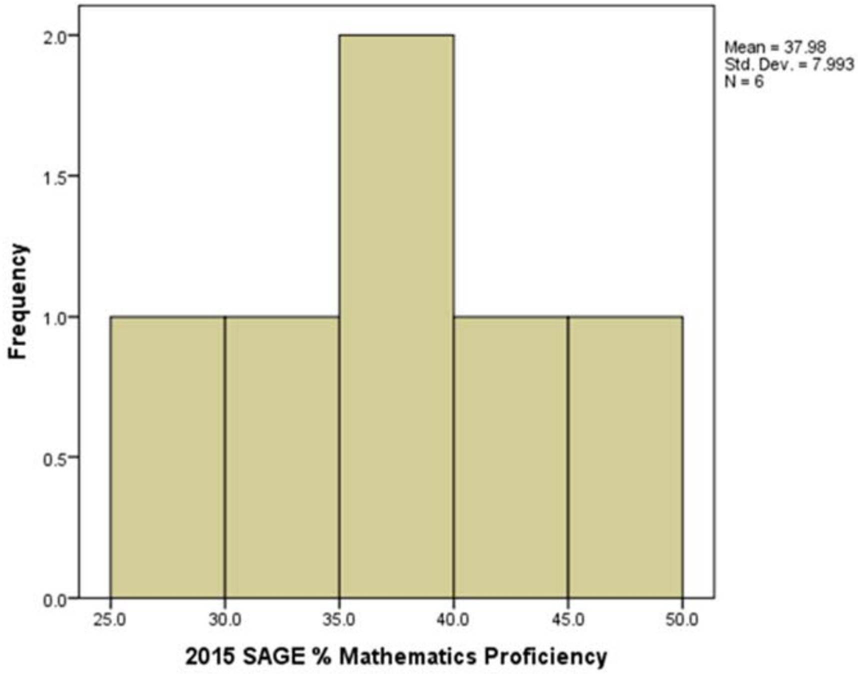

Figure J-87. Frequency by 2015 SAGE % Mathematics Proficiency for Tot_Yrs_Teach = 12. This figure illustrates the number of school leaders who spent 12 years in total teaching based on their school's school-wide 2015 SAGE % mathematics proficiency.

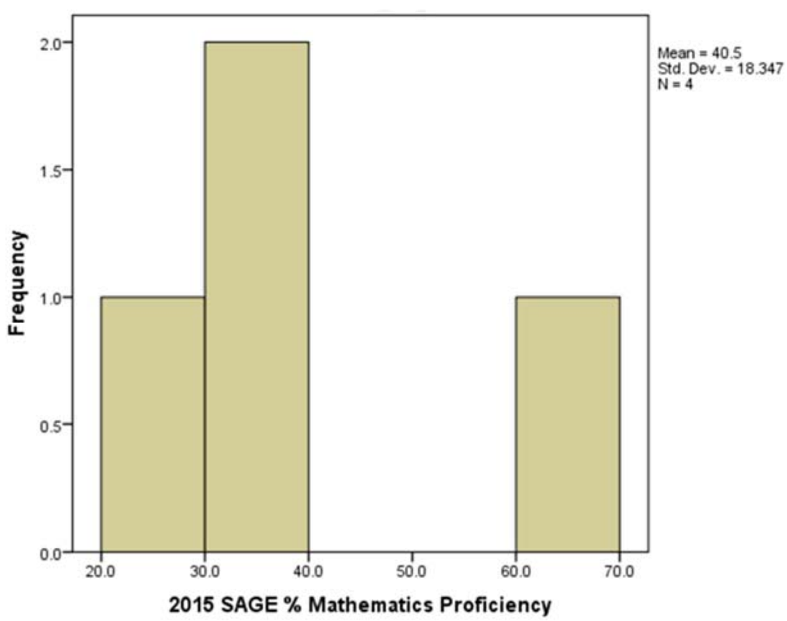

Figure J-88. Frequency by 2015 SAGE % Mathematics Proficiency for Tot_Yrs_Teach = 13. This figure illustrates the number of school leaders who spent 13 years in total teaching based on their school's school-wide 2015 SAGE % mathematics proficiency.

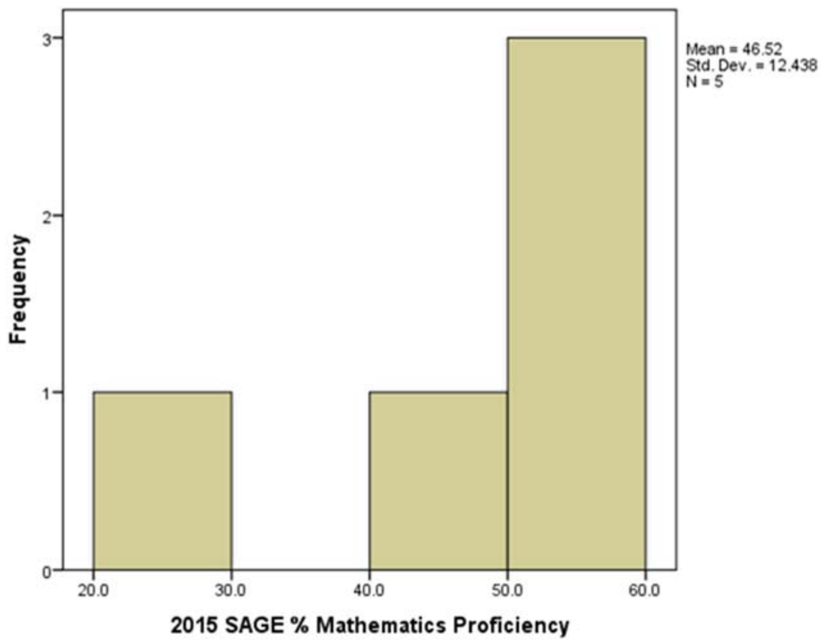

Figure J-89. Frequency by 2015 SAGE % Mathematics Proficiency for Tot_Yrs_Teach = 14. This figure illustrates the number of school leaders who spent 14 years in total teaching based on their school's school-wide 2015 SAGE % mathematics proficiency.

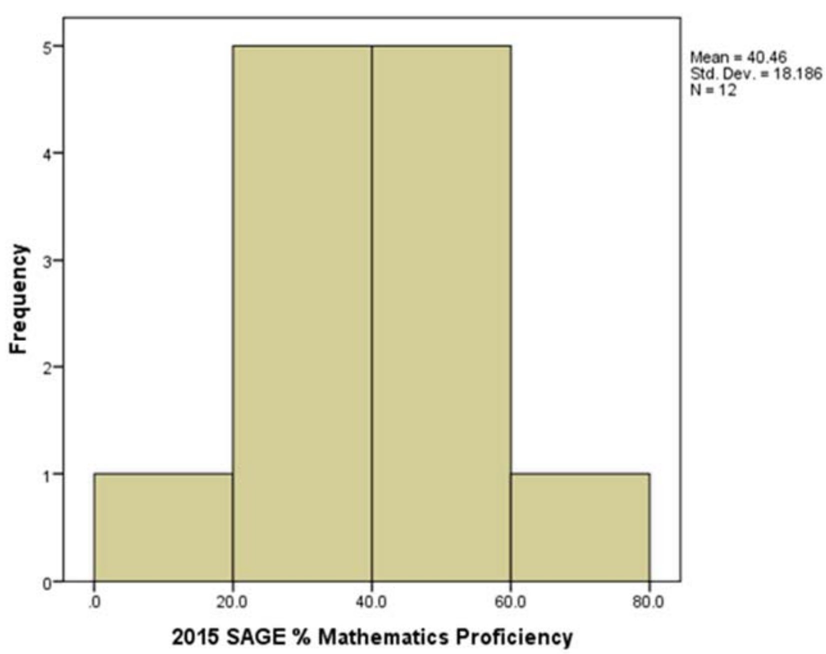

Figure J-90. Frequency by 2015 SAGE % Mathematics Proficiency for Tot_Yrs_Teach = 15. This figure illustrates the number of school leaders who spent 15 years in total teaching based on their school's school-wide 2015 SAGE % mathematics proficiency.

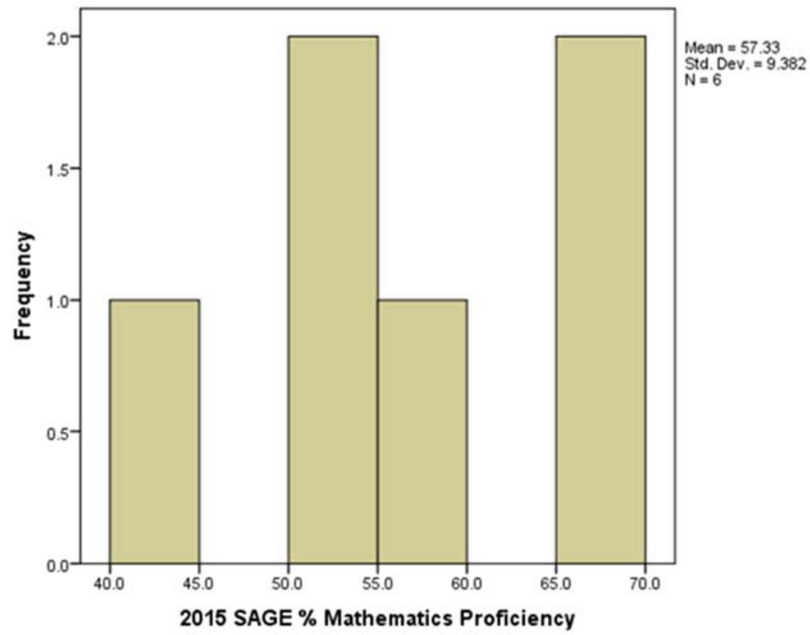

Figure J-91. Frequency by 2015 SAGE % Mathematics Proficiency for Tot_Yrs_Teach = 16. This figure illustrates the number of school leaders who spent 16 years in total teaching based on their school's school-wide 2015 SAGE % mathematics proficiency.

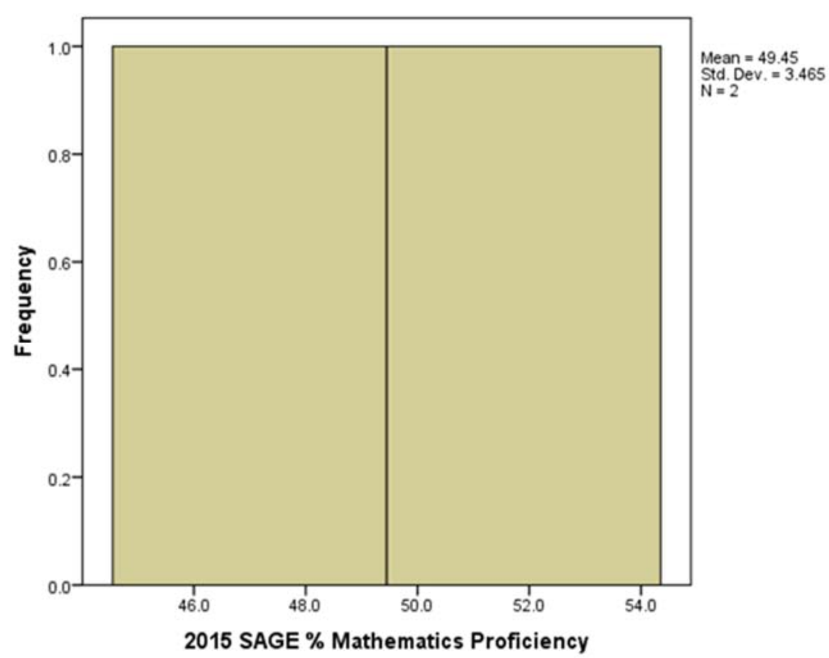

Figure J-92. Frequency by 2015 SAGE % Mathematics Proficiency for Tot_Yrs_Teach = 17. This figure illustrates the number of school leaders who spent 17 years in total teaching based on their school's school-wide 2015 SAGE % mathematics proficiency.

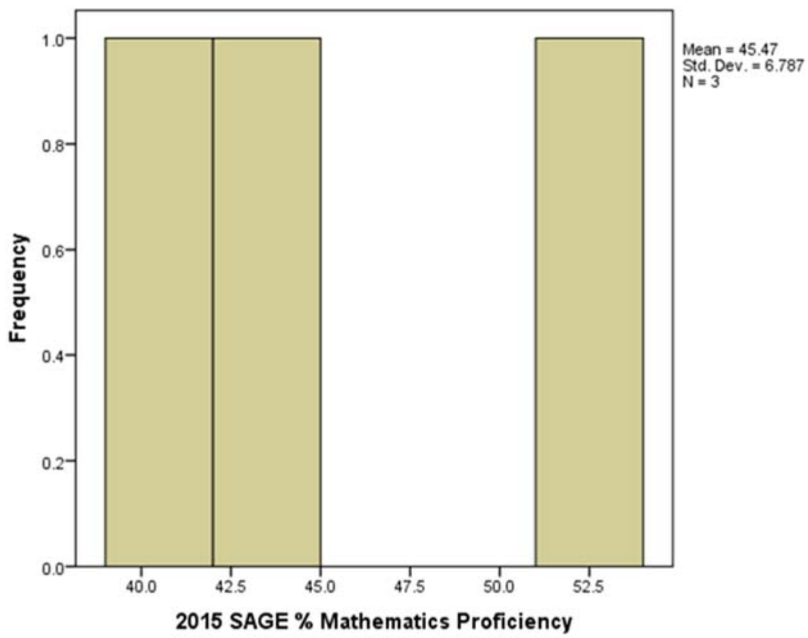

Figure J-93. Frequency by 2015 SAGE % Mathematics Proficiency for Tot_Yrs_Teach = 18. This figure illustrates the number of school leaders who spent 18 years in total teaching based on their school's school-wide 2015 SAGE % mathematics proficiency.

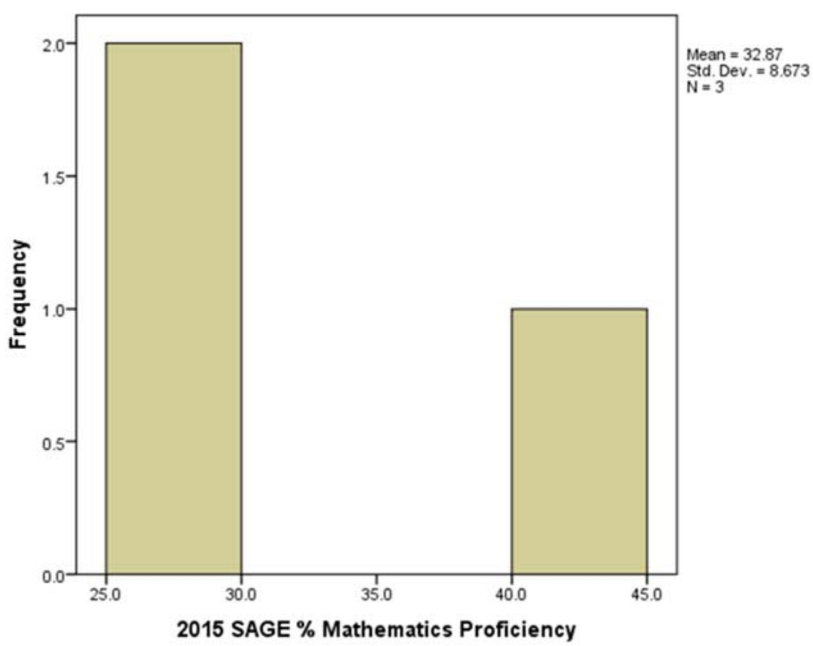

Figure J-94. Frequency by 2015 SAGE % Mathematics Proficiency for Tot_Yrs_Teach = 19. This figure illustrates the number of school leaders who spent 19 years in total teaching based on their school's school-wide 2015 SAGE % mathematics proficiency.

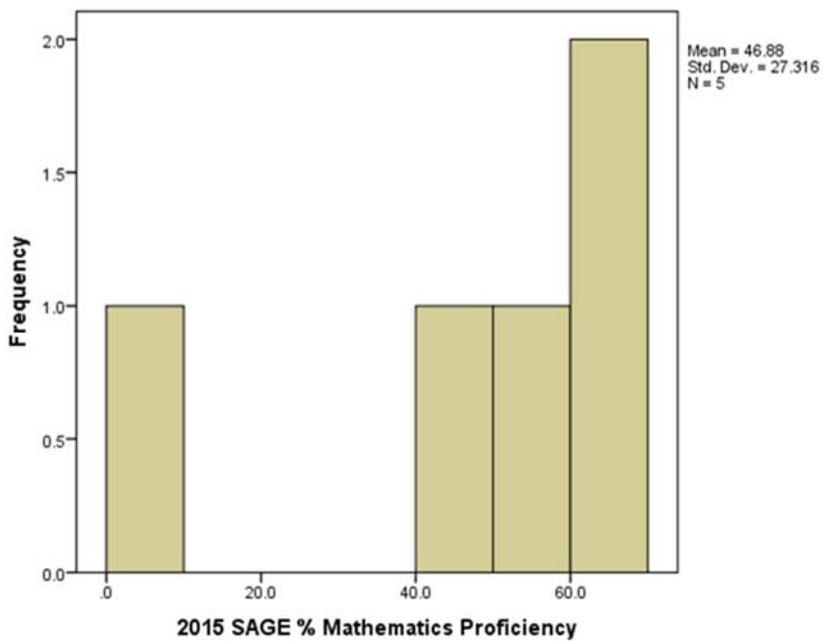

Figure J-95. Frequency by 2015 SAGE % Mathematics Proficiency for Tot_Yrs_Teach = 20. This figure illustrates the number of school leaders who spent 20 years in total teaching based on their school's school-wide 2015 SAGE % mathematics proficiency.

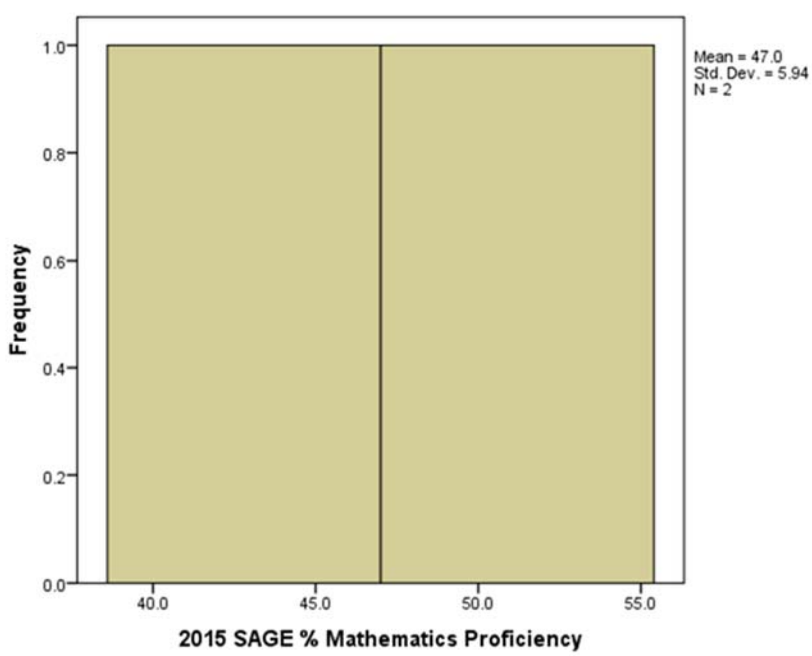

Figure J-96. Frequency by 2015 SAGE % Mathematics Proficiency for Tot_Yrs_Teach = 22. This figure illustrates the number of school leaders who spent 22 years in total teaching based on their school's school-wide 2015 SAGE % mathematics proficiency.

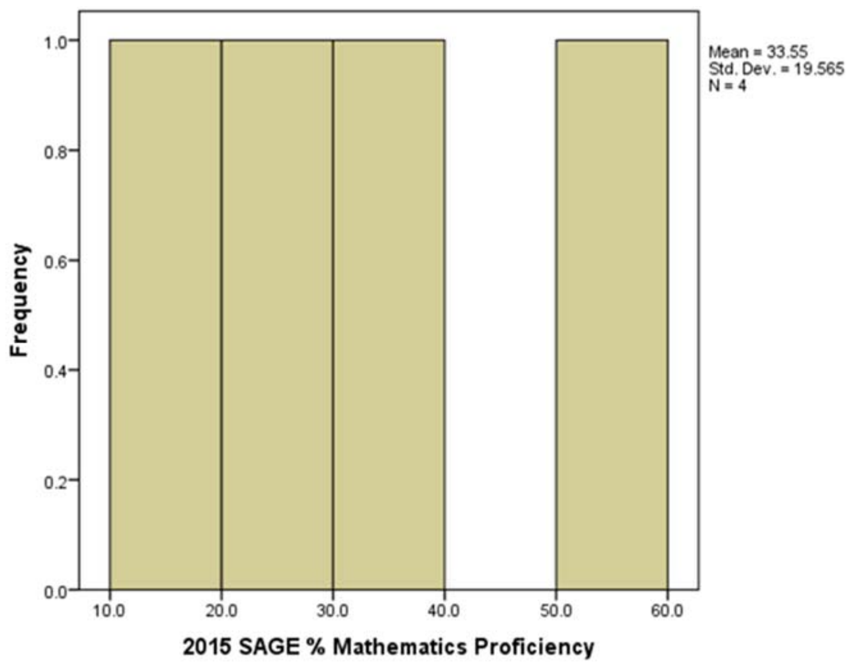

Figure J-97. Frequency by 2015 SAGE % Mathematics Proficiency for Tot_Yrs_Teach = 24. This figure illustrates the number of school leaders who spent 24 years in total teaching based on their school's school-wide 2015 SAGE % mathematics proficiency.

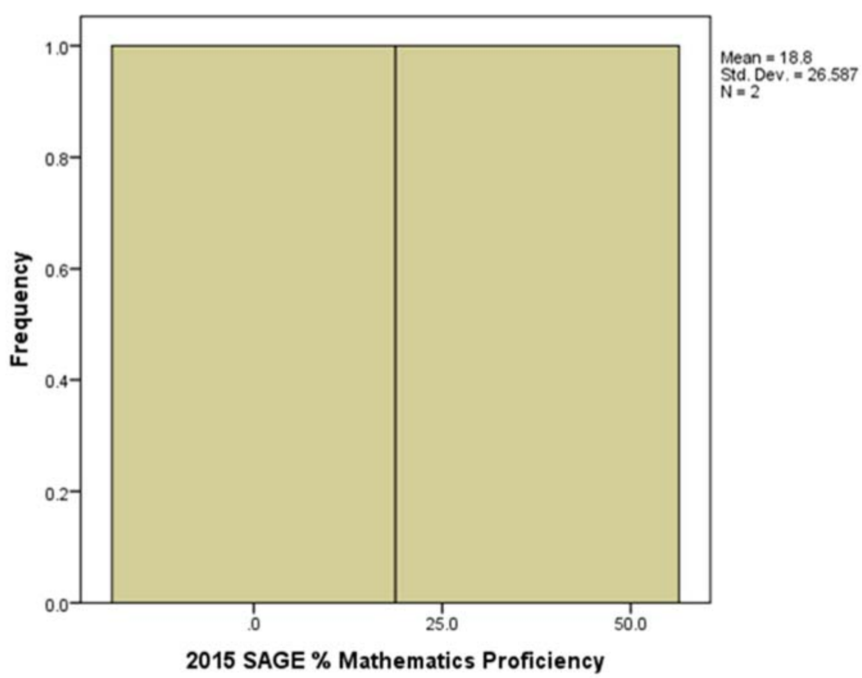

Figure J-98. Frequency by 2015 SAGE % Mathematics Proficiency for Tot_Yrs_Teach = 29. This figure illustrates the number of school leaders who spent 29 years in total teaching based on their school's school-wide 2015 SAGE % mathematics proficiency.

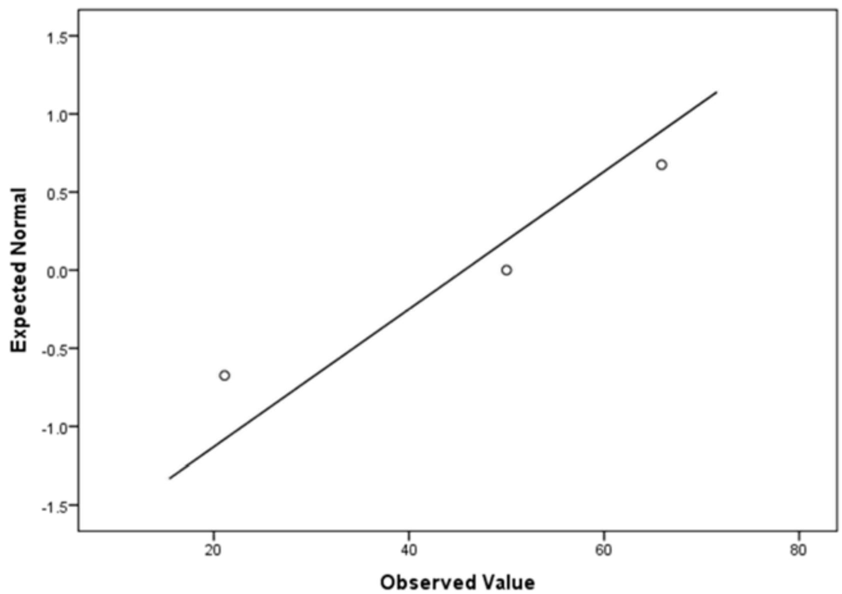

Figure J-99. Normal Q-Q Plot of 2015 SAGE % Mathematics Proficiency for Tot_Yrs_Teach = 0. This figure illustrates the observed value versus the expected normal for school leaders who spent 0 years total teaching based on their school's school-wide 2015 SAGE % mathematics proficiency.

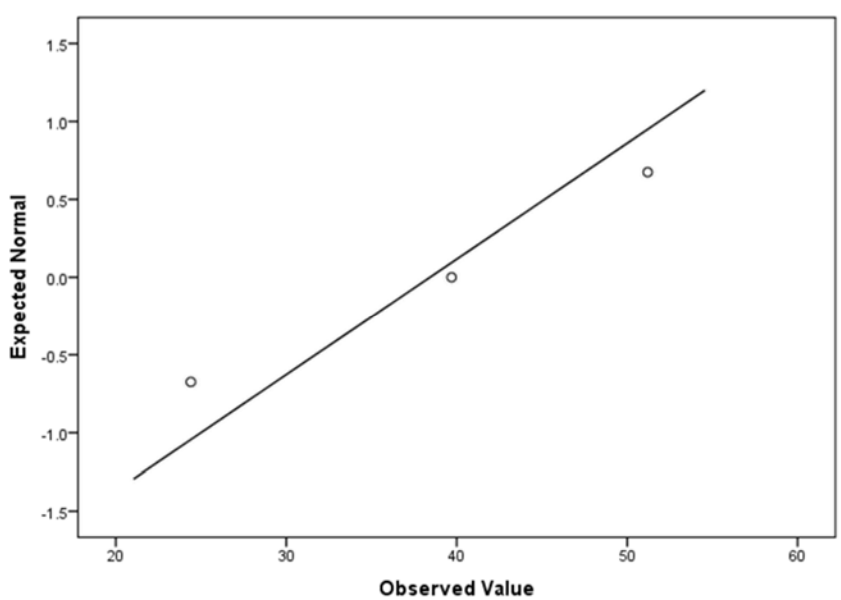

Figure J-100. Normal Q-Q Plot of 2015 SAGE % Mathematics Proficiency for Tot_Yrs_Teach = 3. This figure illustrates the observed value versus the expected normal for school leaders who spent 3 years total teaching based on their school's school-wide 2015 SAGE % mathematics proficiency.

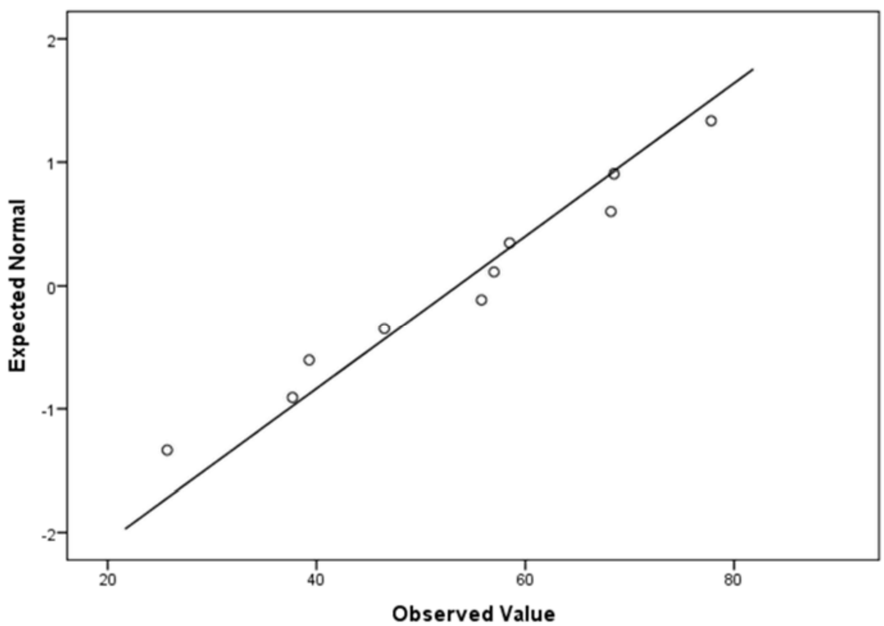

Figure J-101. Normal Q-Q Plot of 2015 SAGE % Mathematics Proficiency for Tot_Yrs_Teach = 4. This figure illustrates the observed value versus the expected normal for school leaders who spent 4 years total teaching based on their school's school-wide 2015 SAGE % mathematics proficiency.

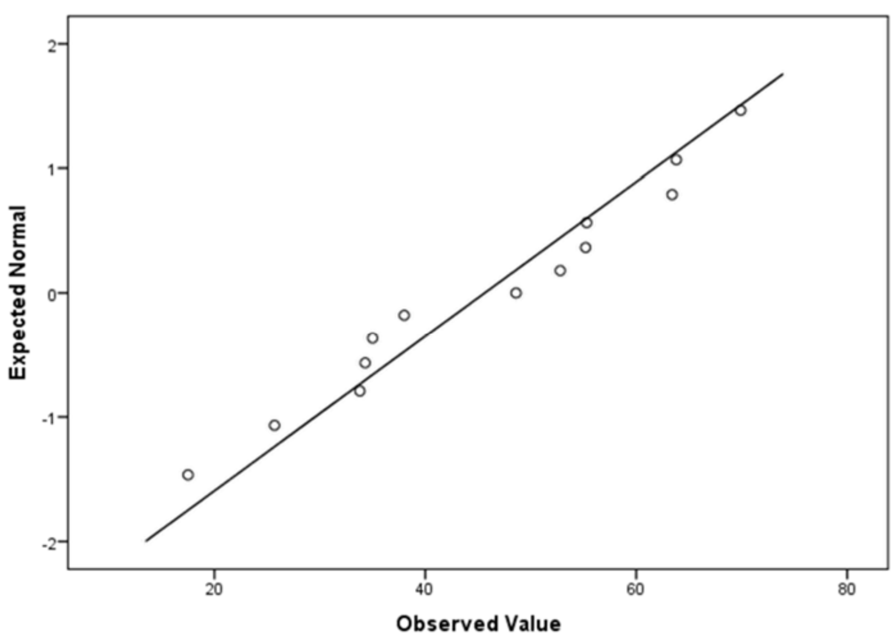

Figure J-102. Normal Q-Q Plot of 2015 SAGE % Mathematics Proficiency for Tot_Yrs_Teach = 5. This figure illustrates the observed value versus the expected normal for school leaders who spent 5 years total teaching based on their school's school-wide 2015 SAGE % mathematics proficiency.

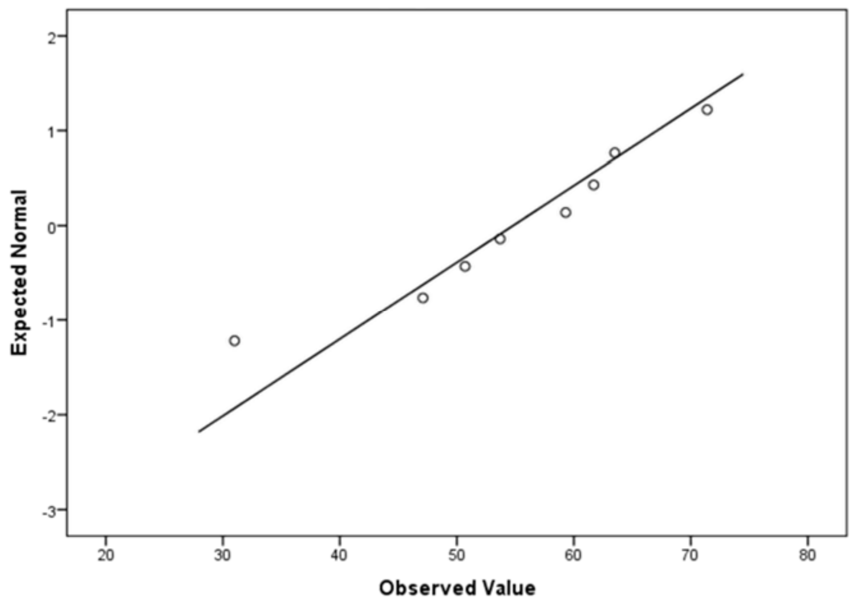

Figure J-103. Normal Q-Q Plot of 2015 SAGE % Mathematics Proficiency for Tot_Yrs_Teach = 6. This figure illustrates the observed value versus the expected normal for school leaders who spent 6 years total teaching based on their school's school-wide 2015 SAGE % mathematics proficiency.

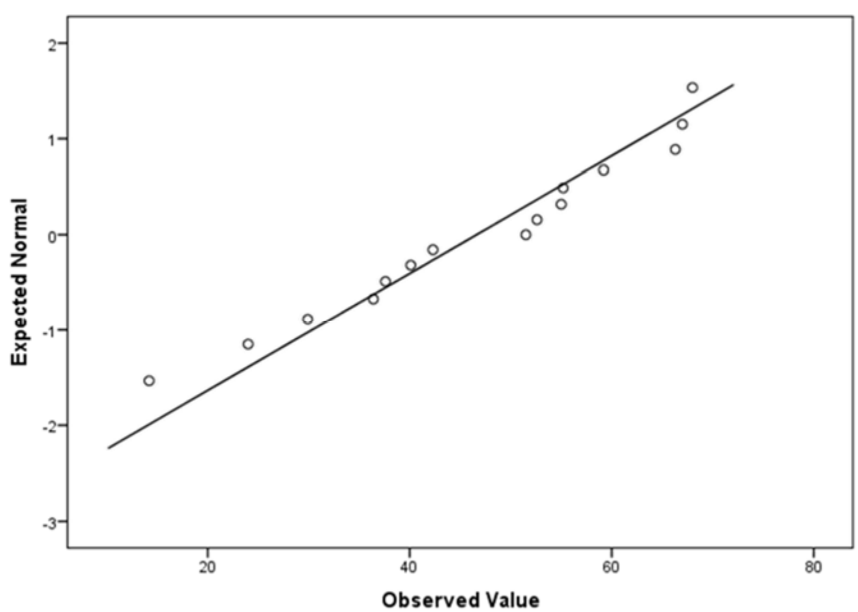

Figure J-104. Normal Q-Q Plot of 2015 SAGE % Mathematics Proficiency for Tot_Yrs_Teach = 7. This figure illustrates the observed value versus the expected normal for school leaders who spent 7 years total teaching based on their school's school-wide 2015 SAGE % mathematics proficiency.

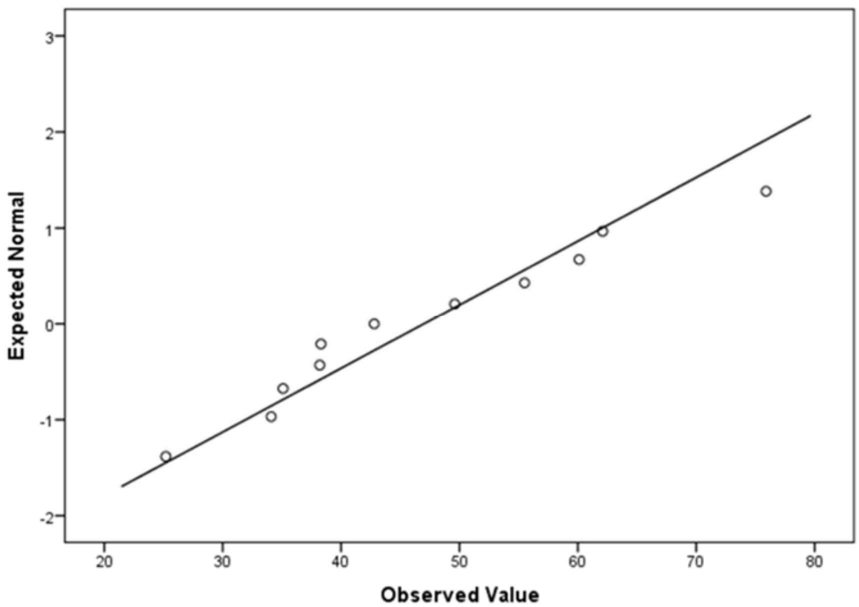

Figure J-105. Normal Q-Q Plot of 2015 SAGE % Mathematics Proficiency for Tot_Yrs_Teach = 8. This figure illustrates the observed value versus the expected normal for school leaders who spent 8 years total teaching based on their school's school-wide 2015 SAGE % mathematics proficiency.

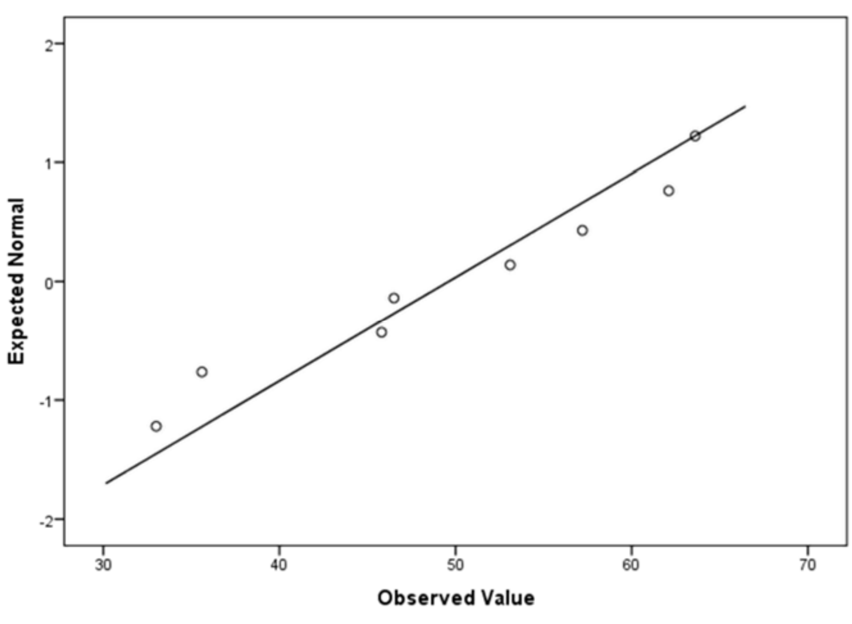

Figure J-106. Normal Q-Q Plot of 2015 SAGE % Mathematics Proficiency for Tot_Yrs_Teach = 9. This figure illustrates the observed value versus the expected normal for school leaders who spent 9 years total teaching based on their school's school-wide 2015 SAGE % mathematics proficiency.

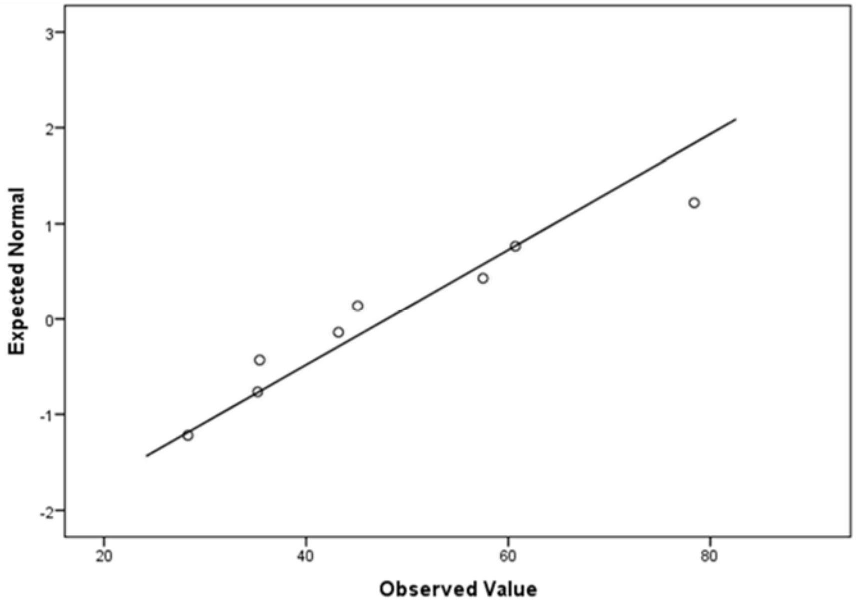

Figure J-107. Normal Q-Q Plot of 2015 SAGE % Mathematics Proficiency for Tot_Yrs_Teach = 10. This figure illustrates the observed value versus the expected normal for school leaders who spent 10 years total teaching based on their school's school-wide 2015 SAGE % mathematics proficiency.

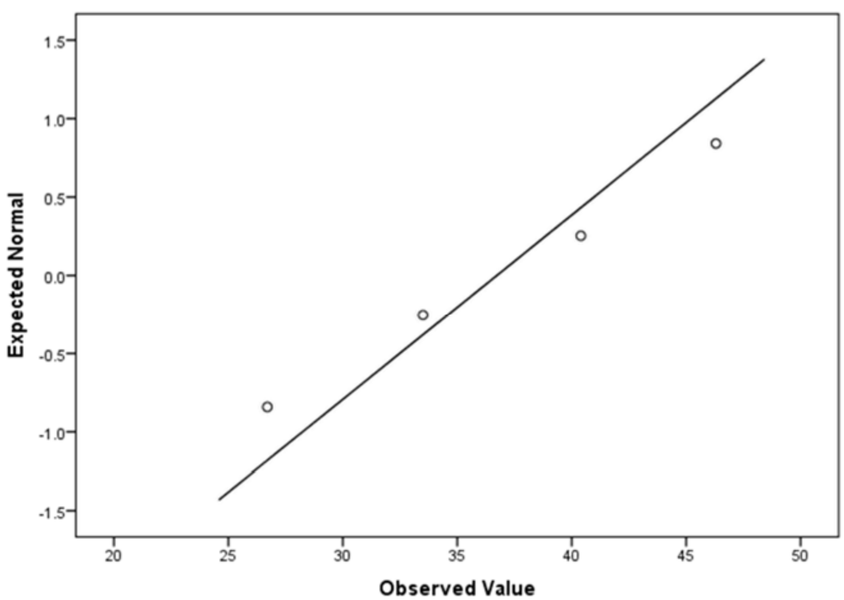

Figure J-108. Normal Q-Q Plot of 2015 SAGE % Mathematics Proficiency for Tot_Yrs_Teach = 11. This figure illustrates the observed value versus the expected normal for school leaders who spent 11 years total teaching based on their school's school-wide 2015 SAGE % mathematics proficiency.

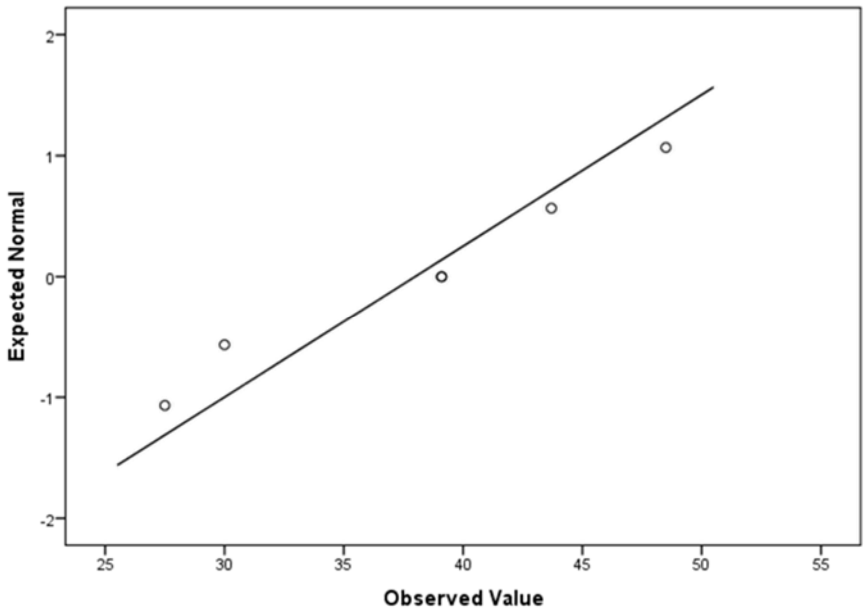

Figure J-109. Normal Q-Q Plot of 2015 SAGE % Mathematics Proficiency for Tot_Yrs_Teach = 12. This figure illustrates the observed value versus the expected normal for school leaders who spent 12 years total teaching based on their school's school-wide 2015 SAGE % mathematics proficiency.

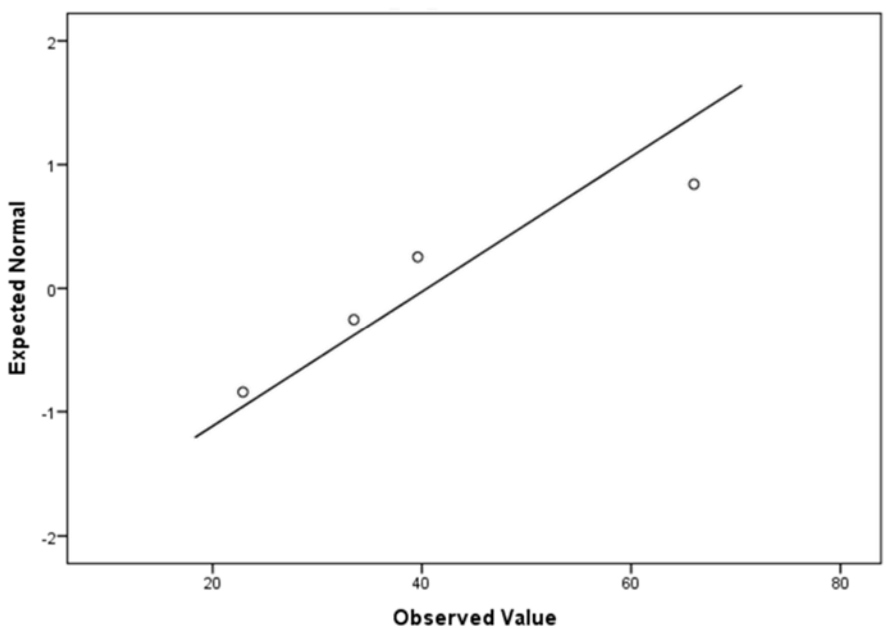

Figure J-110. Normal Q-Q Plot of 2015 SAGE % Mathematics Proficiency for Tot_Yrs_Teach = 13. This figure illustrates the observed value versus the expected normal for school leaders who spent 13 years total teaching based on their school's school-wide 2015 SAGE % mathematics proficiency.

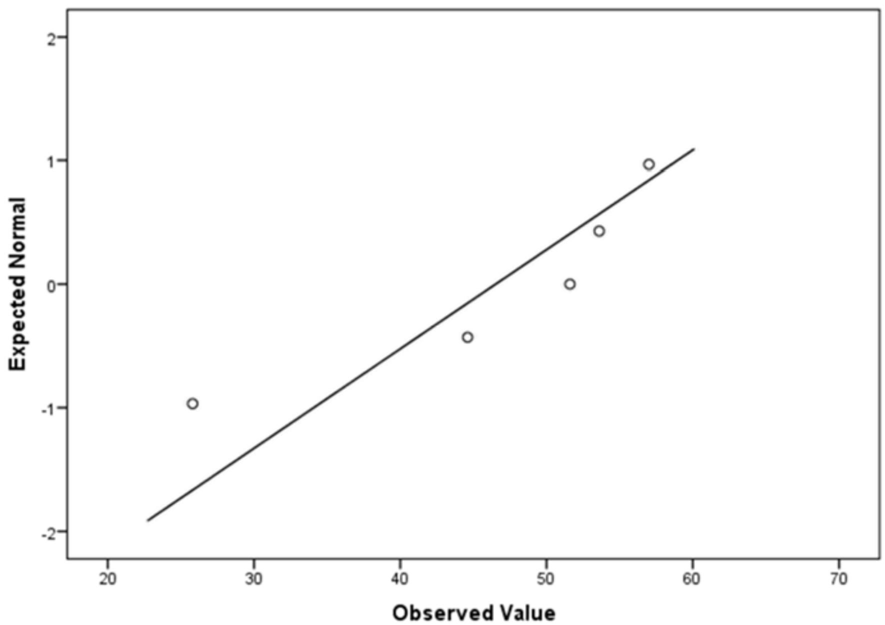

Figure J-111. Normal Q-Q Plot of 2015 SAGE % Mathematics Proficiency for Tot_Yrs_Teach = 14. This figure illustrates the observed value versus the expected normal for school leaders who spent 14 years total teaching based on their school's school-wide 2015 SAGE % mathematics proficiency.

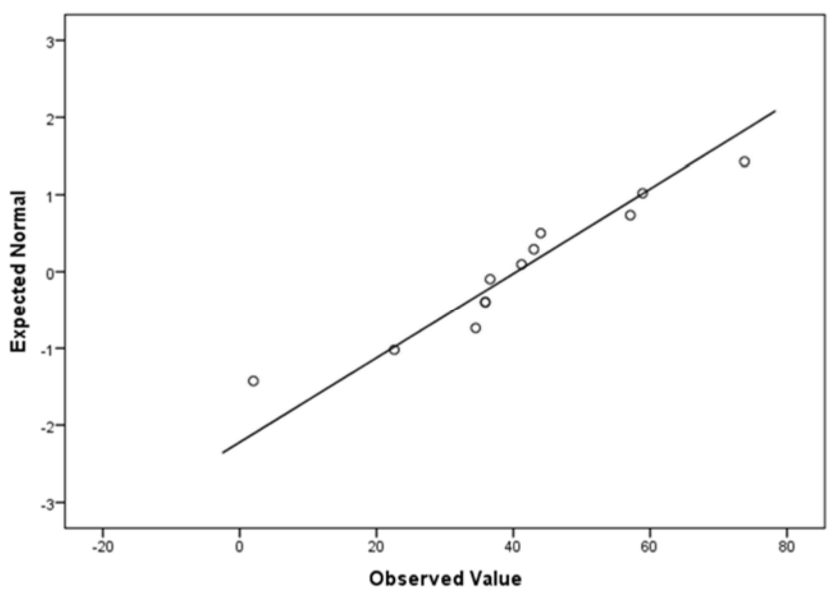

Figure J-112. Normal Q-Q Plot of 2015 SAGE % Mathematics Proficiency for Tot_Yrs_Teach = 15. This figure illustrates the observed value versus the expected normal for school leaders who spent 15 years total teaching based on their school's school-wide 2015 SAGE % mathematics proficiency.

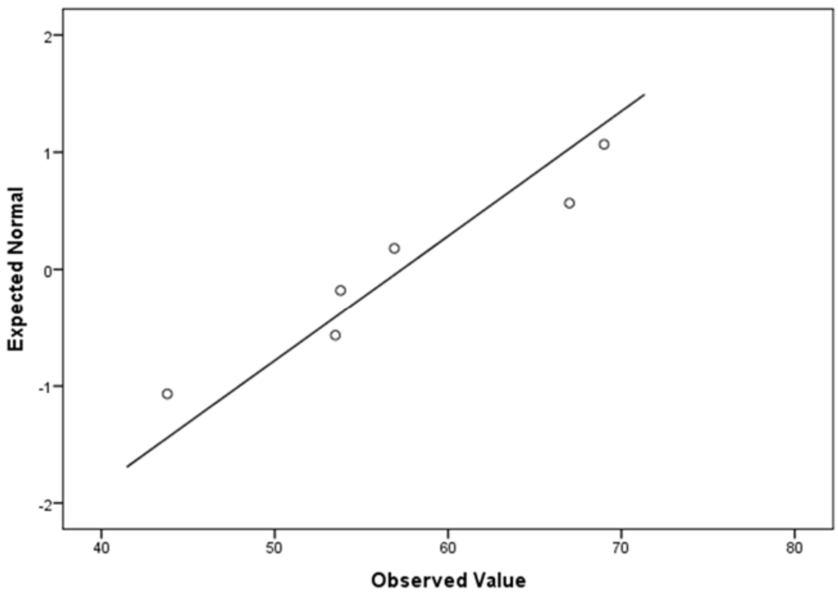

Figure J-113. Normal Q-Q Plot of 2015 SAGE % Mathematics Proficiency for Tot_Yrs_Teach = 16. This figure illustrates the observed value versus the expected normal for school leaders who spent 16 years total teaching based on their school's school-wide 2015 SAGE % mathematics proficiency.

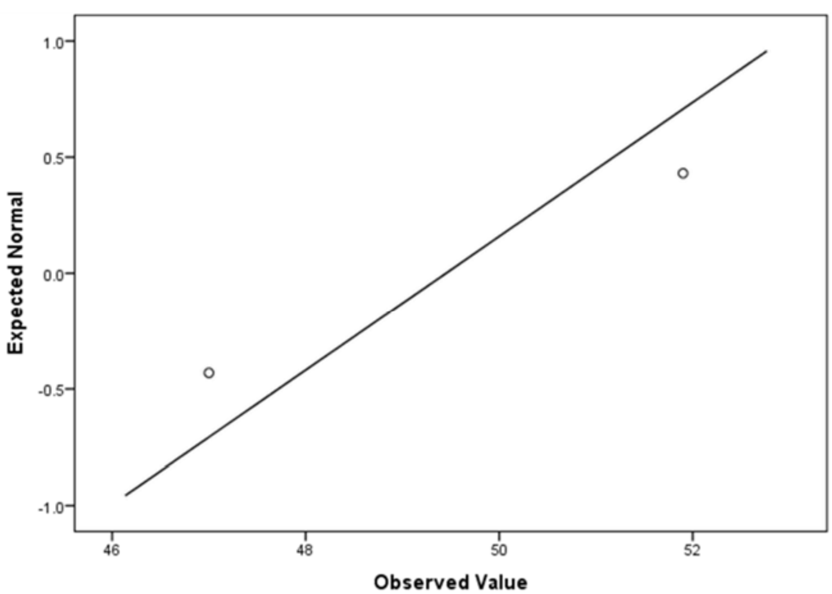

Figure J-114. Normal Q-Q Plot of 2015 SAGE % Mathematics Proficiency for Tot_Yrs_Teach = 17. This figure illustrates the observed value versus the expected normal for school leaders who spent 17 years total teaching based on their school's school-wide 2015 SAGE % mathematics proficiency.

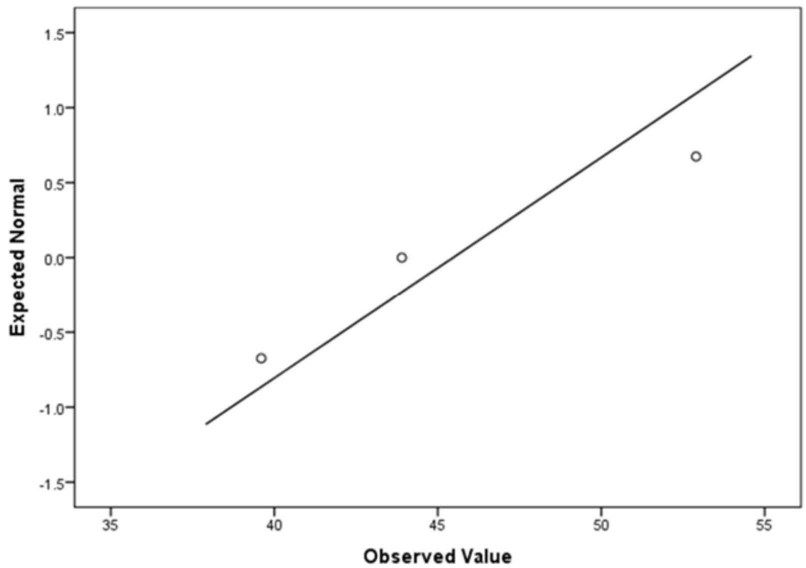

Figure J-115. Normal Q-Q Plot of 2015 SAGE % Mathematics Proficiency for Tot_Yrs_Teach = 18. This figure illustrates the observed value versus the expected normal for school leaders who spent 18 years total teaching based on their school's school-wide 2015 SAGE % mathematics proficiency.

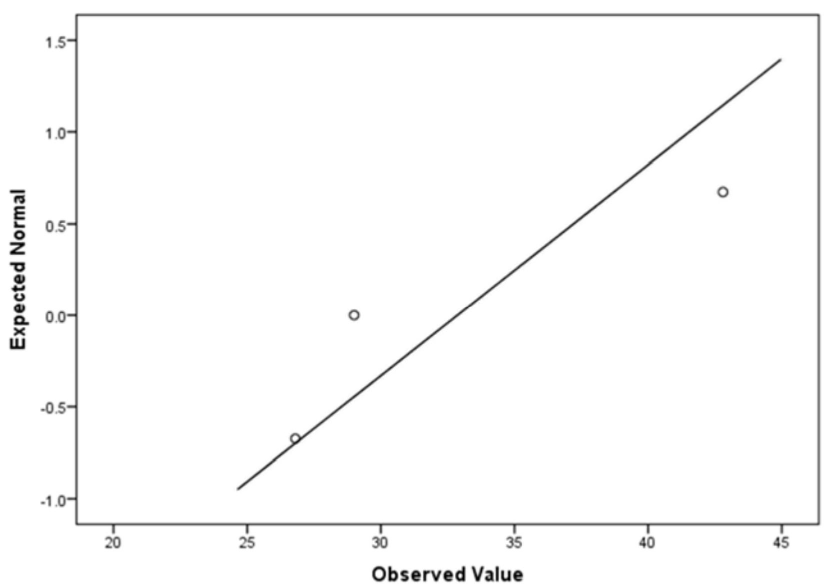

Figure J-116. Normal Q-Q Plot of 2015 SAGE % Mathematics Proficiency for Tot_Yrs_Teach = 19. This figure illustrates the observed value versus the expected normal for school leaders who spent 19 years total teaching based on their school's school-wide 2015 SAGE % mathematics proficiency.

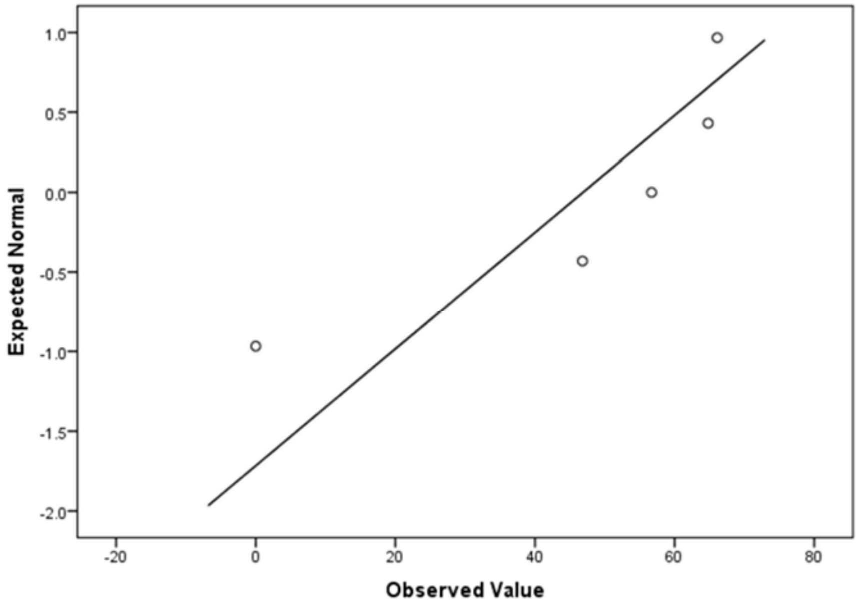

Figure J-117. Normal Q-Q Plot of 2015 SAGE % Mathematics Proficiency for Tot_Yrs_Teach =20. This figure illustrates the observed value versus the expected normal for school leaders who spent 20 years total teaching based on their school's school-wide 2015 SAGE % mathematics proficiency.

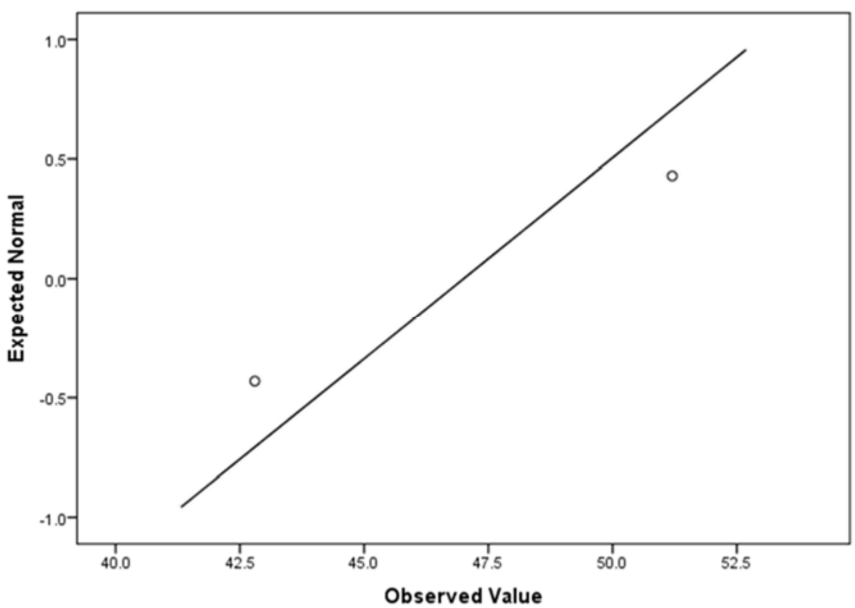

Figure J-118. Normal Q-Q Plot of 2015 SAGE % Mathematics Proficiency for Tot_Yrs_Teach = 22. This figure illustrates the observed value versus the expected normal for school leaders who spent 22 years total teaching based on their school's school-wide 2015 SAGE % mathematics proficiency.

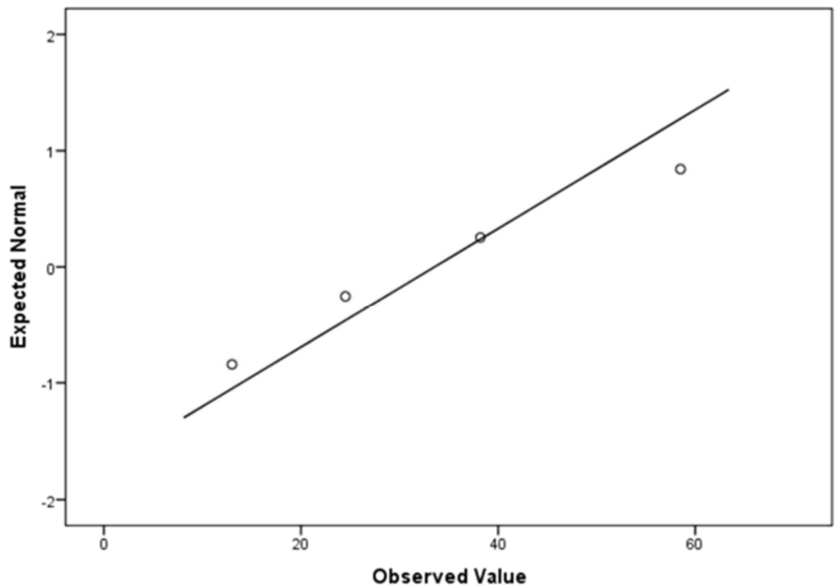

Figure J-119. Normal Q-Q Plot of 2015 SAGE % Mathematics Proficiency for Tot_Yrs_Teach = 24. This figure illustrates the observed value versus the expected normal for school leaders who spent 24 years total teaching based on their school's school-wide 2015 SAGE % mathematics proficiency.

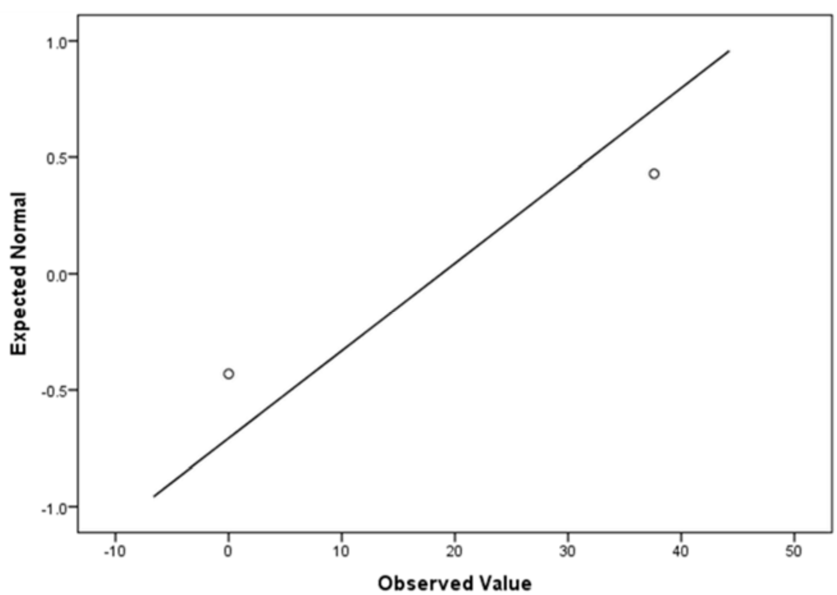

Figure J-120. Normal Q-Q Plot of 2015 SAGE % Mathematics Proficiency for Tot_Yrs_Teach = 29. This figure illustrates the observed value versus the expected normal for school leaders who spent 29 years total teaching based on their school's school-wide 2015 SAGE % mathematics proficiency.

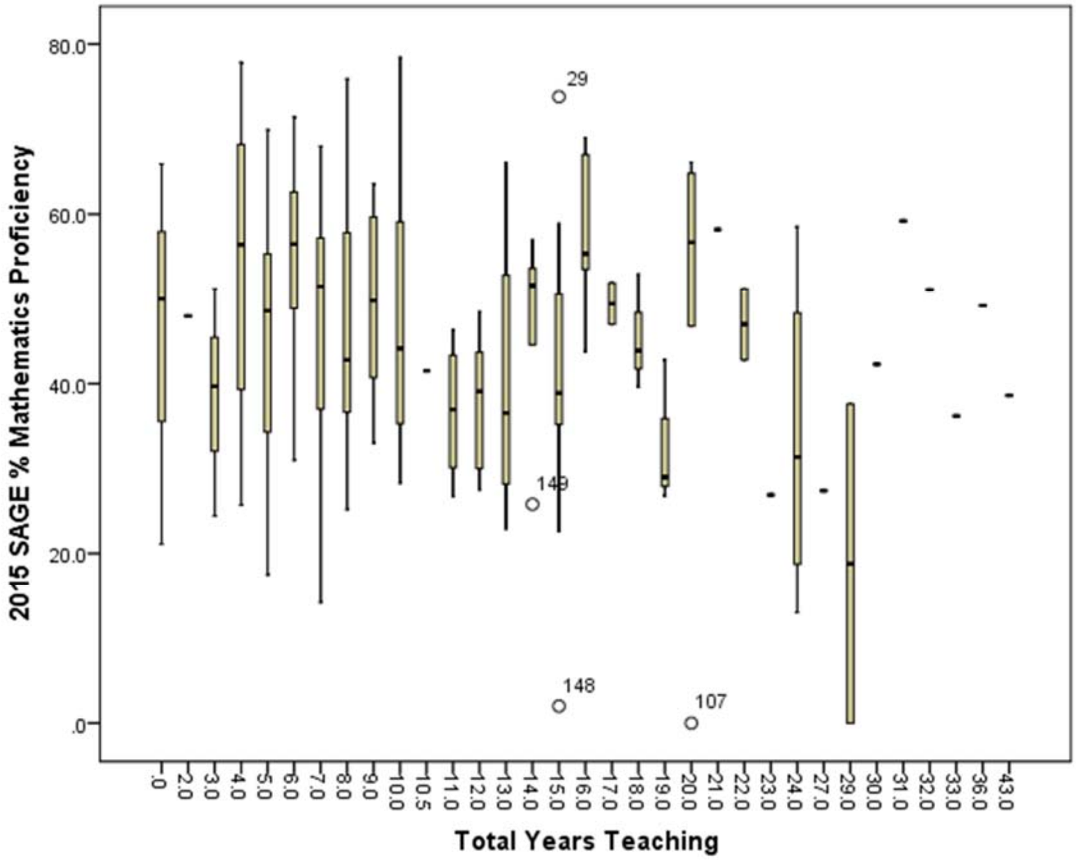

Figure J-121. Boxplot of 2015 SAGE % Mathematics Proficiency for Tot_Yrs_Teach. This figure illustrates spread of school-wide 2015 SAGE % Mathematics Proficiency scores based on school leaders' total number of years teaching.

Table J-6

Inf_Teach3: Tests of Normality

Variable		Shapiro-Wilk Statistic	df	Sig.	Skewness	Std. Error	Kurtosis	Std. Error
Inf_Teach3	1							
	2							
	3							
	4							
	5	.97	32	.502	-.43	.41	-.50	.81
	6	.99	114	.307	-.28	.23	.24	.45

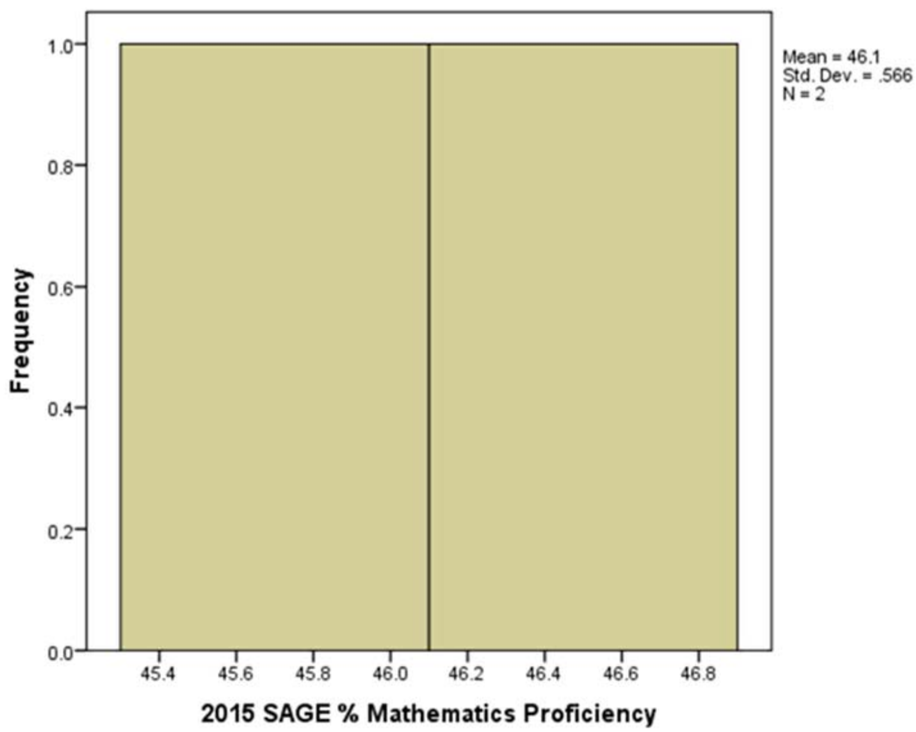

Figure J-122. Frequency by 2015 SAGE % Mathematics Proficiency for Inf_Teach3 = 3. This figure illustrates the number of school leaders who rated Inf_Teach3 at 3 based on their school's school-wide 2015 SAGE % mathematics proficiency.

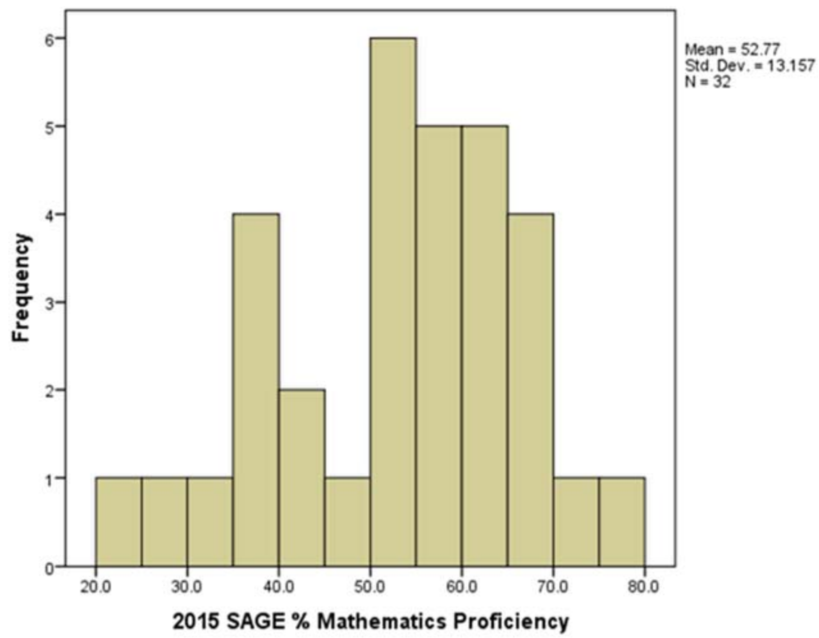

Figure J-123. Frequency by 2015 SAGE % Mathematics Proficiency for Inf_Teach3 = 5. This figure illustrates the number of school leaders who rated Inf_Teach3 at 5 based on their school's school-wide 2015 SAGE % mathematics proficiency.

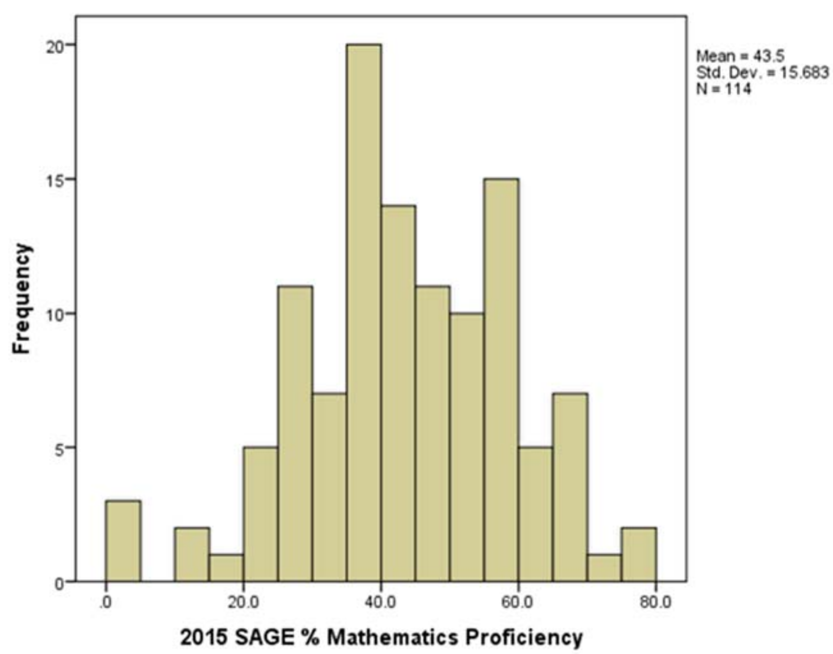

Figure J-124. Frequency by 2015 SAGE % Mathematics Proficiency for Inf_Teach3 = 6. This figure illustrates the number of school leaders who rated Inf_Teach3 at 6 based on their school's school-wide 2015 SAGE % mathematics proficiency.

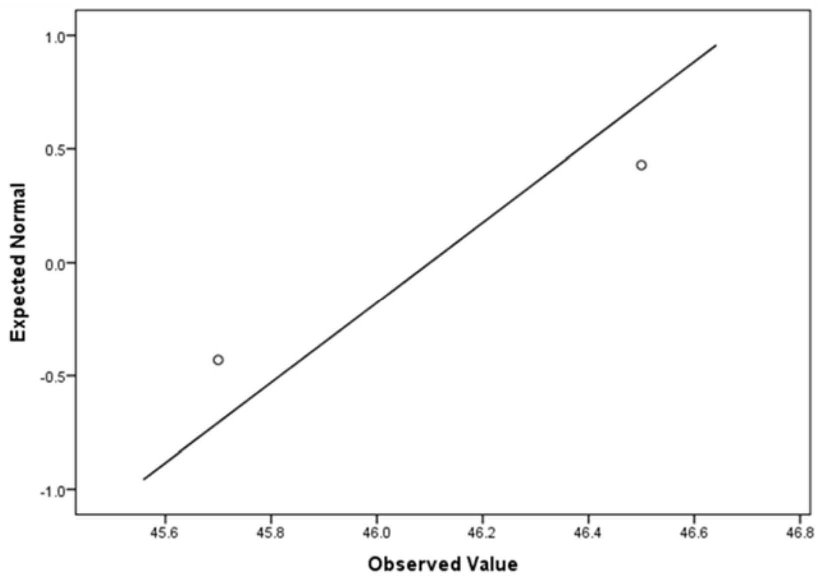

Figure J-125. Normal Q-Q Plot of 2015 SAGE % Mathematics Proficiency for Inf_Teach3 = 3. This figure illustrates the observed value versus the expected normal for school leaders who ranked Inf_Teach3 as 3 based on their school's school-wide 2015 SAGE % mathematics proficiency.

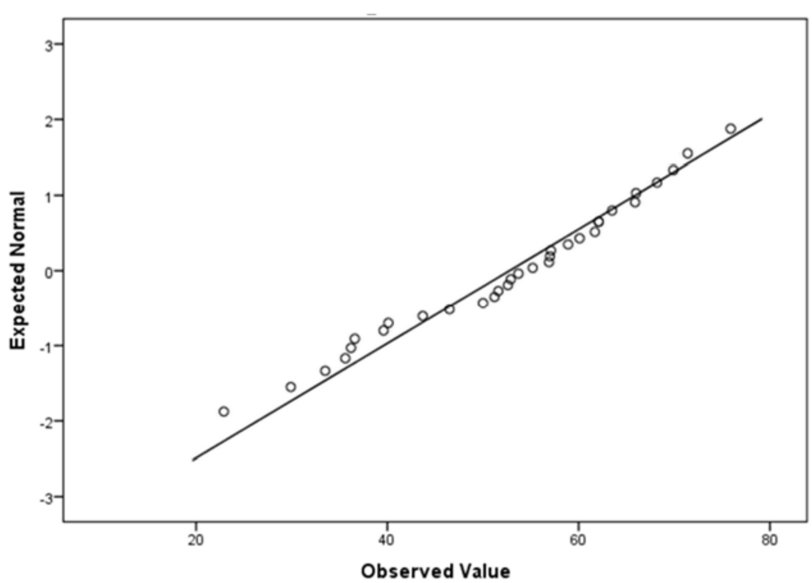

Figure J-126. Normal Q-Q Plot of 2015 SAGE % Mathematics Proficiency for Inf_Teach3 = 5. This figure illustrates the observed value versus the expected normal for school leaders who ranked Inf_Teach3 as 5 based on their school's school-wide 2015 SAGE % mathematics proficiency.

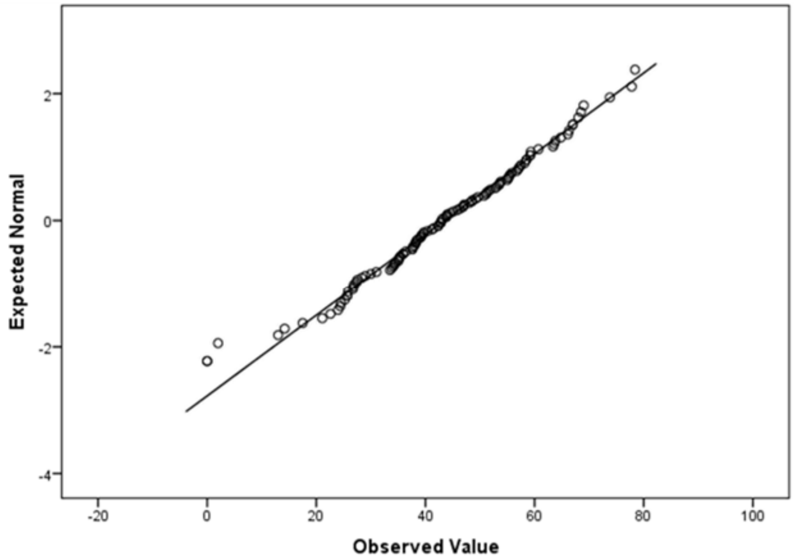

Figure J-127. Normal Q-Q Plot of 2015 SAGE % Mathematics Proficiency for Inf_Teach3 = 6. This figure illustrates the observed value versus the expected normal for school leaders who ranked Inf_Teach3 as 6 based on their school's school-wide 2015 SAGE % mathematics proficiency.

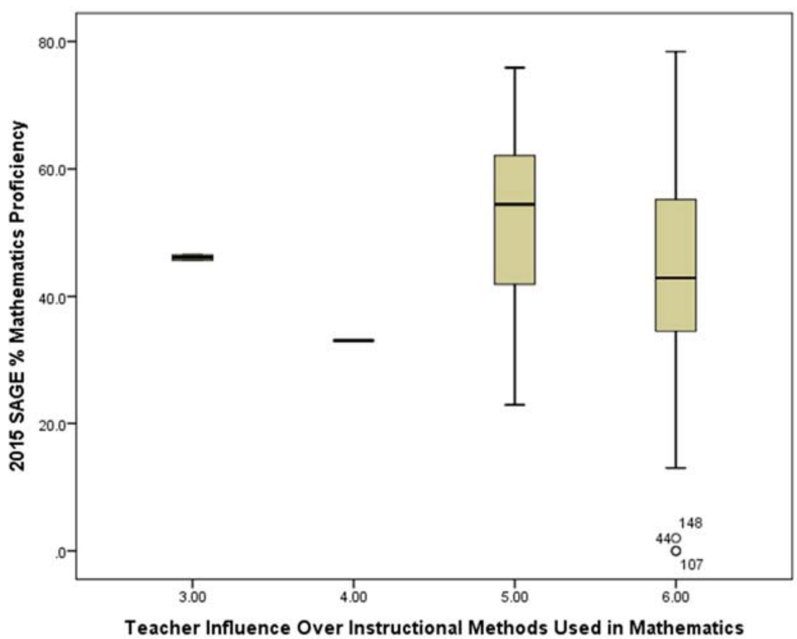

Figure J-128. Boxplot of 2015 SAGE % Mathematics Proficiency for Inf_Teach3. This figure illustrates spread of school-wide 2015 SAGE % Mathematics Proficiency scores based on school leaders' ranking of Inf_Teach3.

Table J-7

Math_Ed: Tests of Normality

Variable		Shapiro-Wilk Statistic	df	Sig.	Skewness	Std. Error	Kurtosis	Std. Error
Math_ Ed	No	.99	130	.173	-.33	.21	.33	.42
	Yes, Minor	.95	15	.547	-.33	.58	-.96	1.12
	Yes, Major	.74	4	.029	-1.91	1.01	3.73	2.62

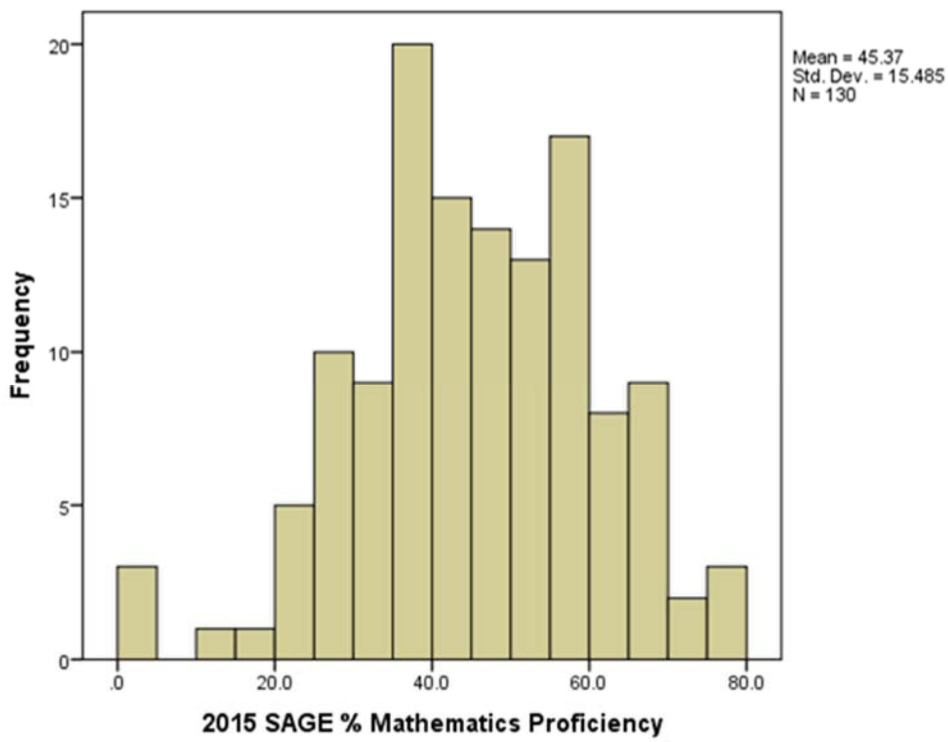

Figure J-129. Frequency by 2015 SAGE % Mathematics Proficiency for Math_Ed = No. This figure illustrates the number of school leaders who rated Math_Ed at No based on their school's school-wide 2015 SAGE % mathematics proficiency.

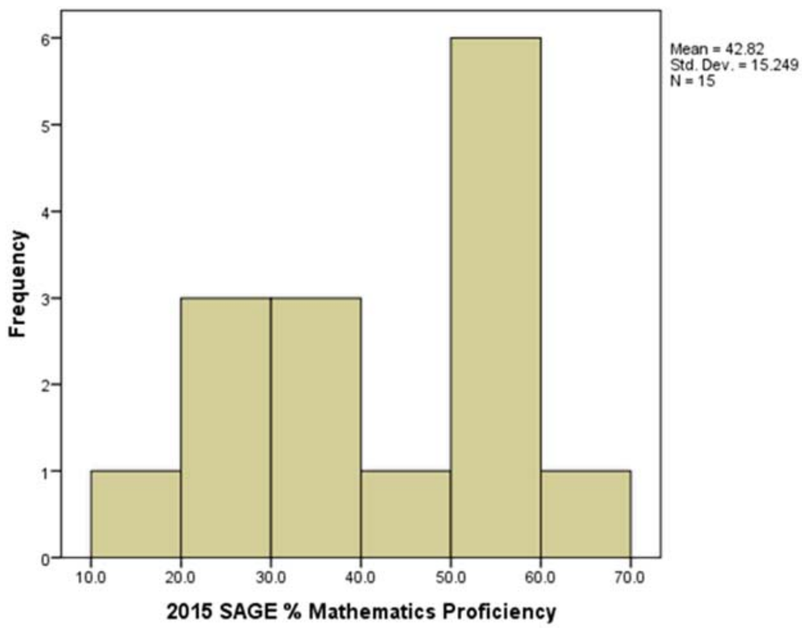

Figure J-130. Frequency by 2015 SAGE % Mathematics Proficiency for Math_Ed = Yes, Minor/Sp.Emphasis. This figure illustrates the number of school leaders who rated Math_Ed at Yes, Minor/Sp.Emphasis based on their school's school-wide 2015 SAGE % mathematics proficiency.

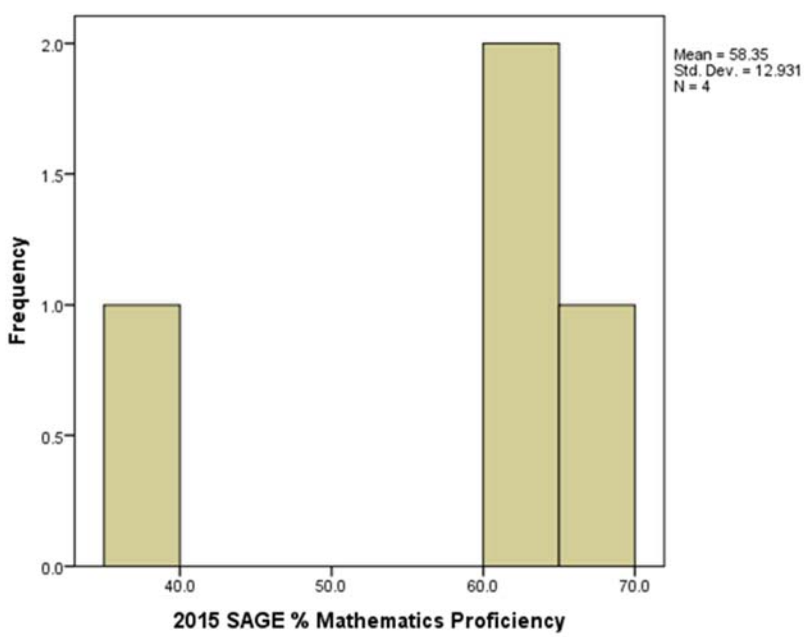

Figure J-131. Frequency by 2015 SAGE % Mathematics Proficiency for Math_Ed = Yes, Major. This figure illustrates the number of school leaders who rated Math_Ed at Yes, Major based on their school's school-wide 2015 SAGE % mathematics proficiency.

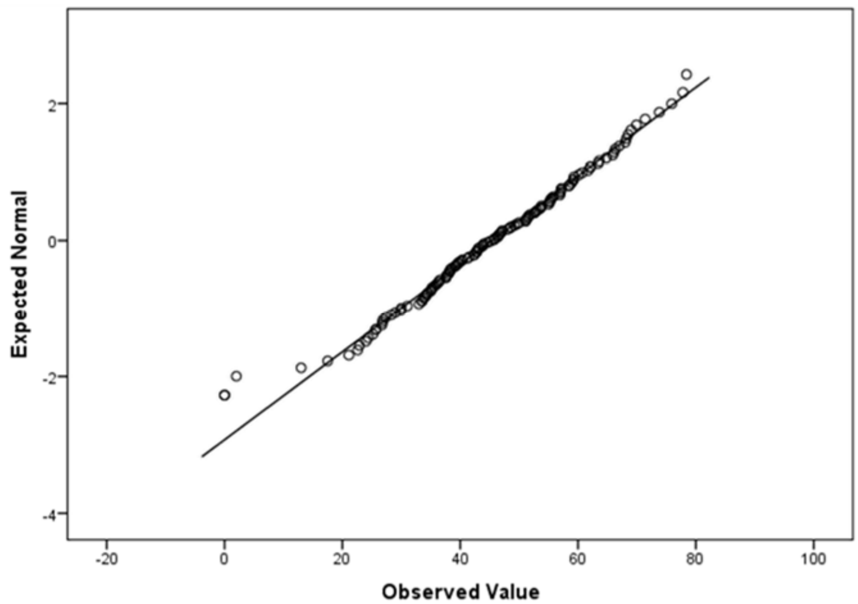

Figure J-132. Normal Q-Q Plot of 2015 SAGE % Mathematics Proficiency for Math _Ed = No. This figure illustrates the observed value versus the expected normal for school leaders who ranked Math_Ed as No based on their school's school-wide 2015 SAGE % mathematics proficiency.

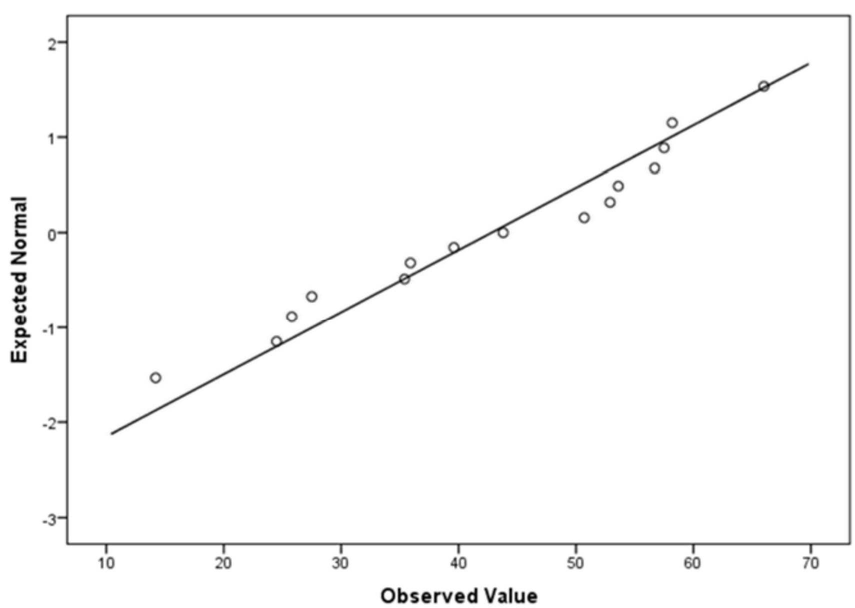

Figure J-133. Normal Q-Q Plot of 2015 SAGE % Mathematics Proficiency for Math _Ed = Yes, Minor/Sp.Emphasis. This figure illustrates the observed value versus the expected normal for school leaders who ranked Math_Ed as Yes, Minor/Sp.Emphasis based on their school's school-wide 2015 SAGE % mathematics proficiency.

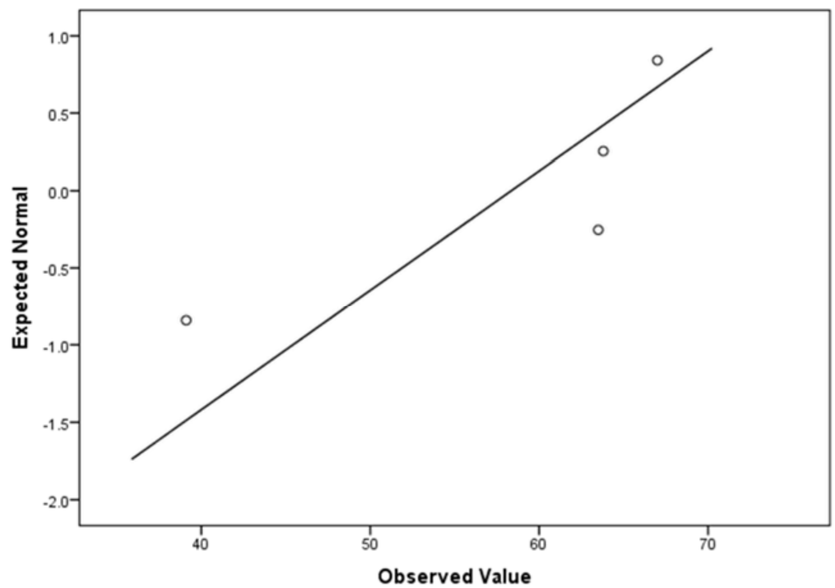

Figure J-134. Normal Q-Q Plot of 2015 SAGE % Mathematics Proficiency for Math _Ed = Yes, Major. This figure illustrates the observed value versus the expected normal for school leaders who ranked Math_Ed as Yes, Major based on their school's school-wide 2015 SAGE % mathematics proficiency.

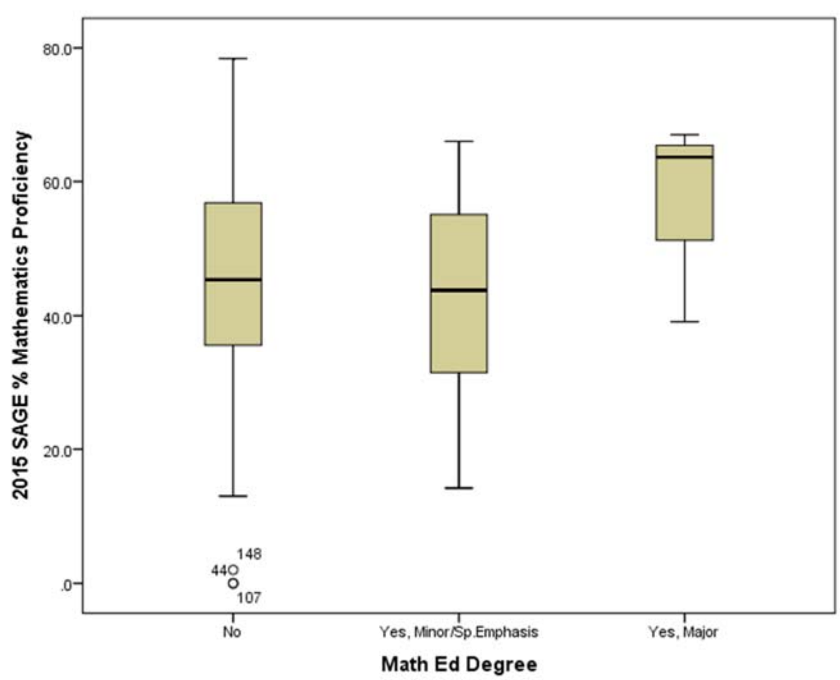

Figure J-135. Boxplot of 2015 SAGE % Mathematics Proficiency for Math_Ed. This figure illustrates spread of school-wide 2015 SAGE % Mathematics Proficiency scores based on school leaders' ranking of Math_Ed.

Table J-8

MTL12: Tests for Normality

Variable		Shapiro-Wilk Statistic	*df*	Sig.	Skewness	Std. Error	Kurtosis	Std. Error
MTL12	1	.91	12	.230	.71	.64	-.58	1.23
	2	.97	46	.309	-.09	.35	-.73	.69
	3	.97	49	.272	-.39	.34	.28	.67
	4	.98	34	.674	-.39	.40	-.16	.79
	5	.99	6	.980	-.15	.85	-.94	1.74

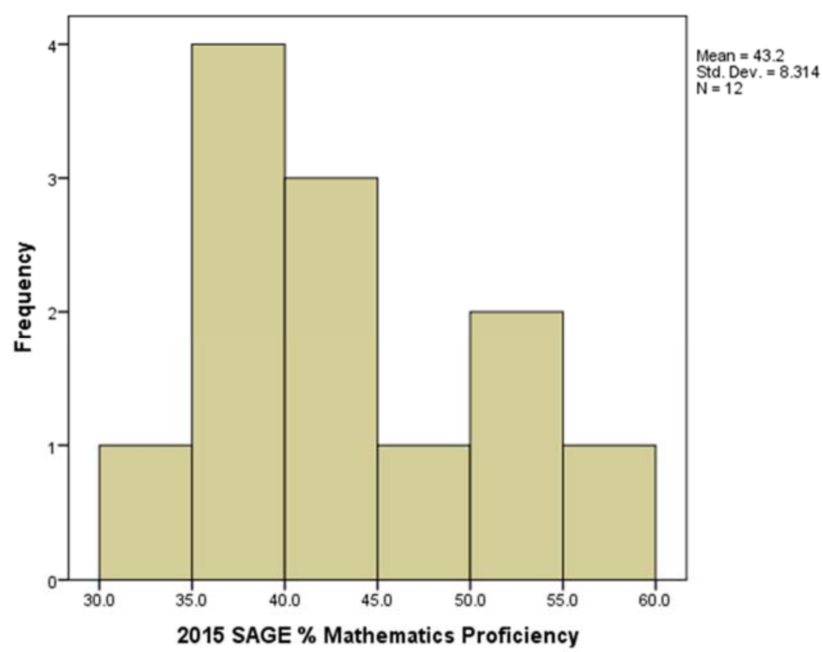

Figure J-136. Frequency by 2015 SAGE % Mathematics Proficiency for MTL12 = 1. This figure illustrates the number of school leaders who rated MTL12 at 1 based on their school's school-wide 2015 SAGE % mathematics proficiency.

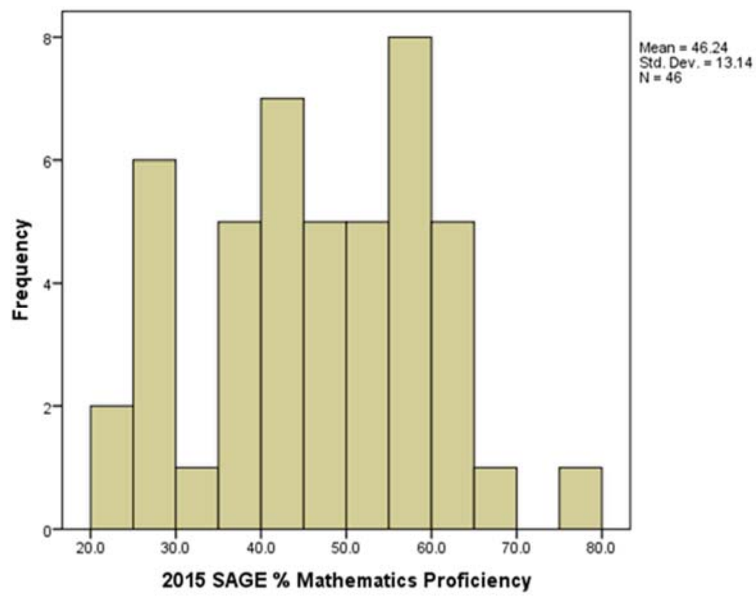

Figure J-137. Frequency by 2015 SAGE % Mathematics Proficiency for MTL12 = 2. This figure illustrates the number of school leaders who rated MTL12 at 2 based on their school's school-wide 2015 SAGE % mathematics proficiency.

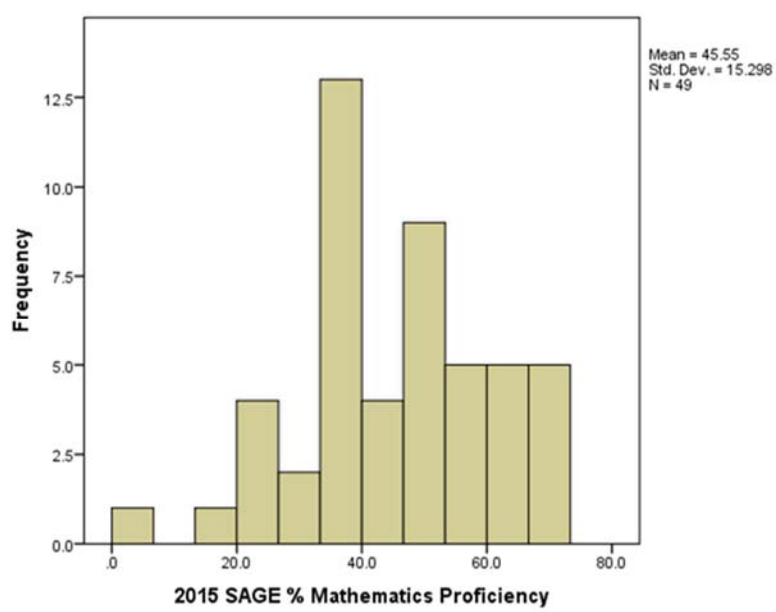

Figure J-138. Frequency by 2015 SAGE % Mathematics Proficiency for MTL12 = 3. This figure illustrates the number of school leaders who rated MTL12 at 3 based on their school's school-wide 2015 SAGE % mathematics proficiency.

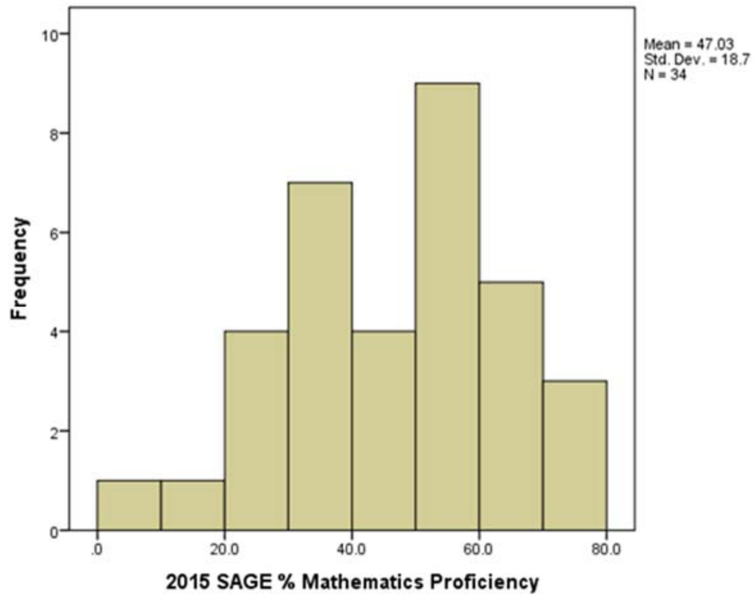

Figure J-139. Frequency by 2015 SAGE % Mathematics Proficiency for MTL12 = 4. This figure illustrates the number of school leaders who rated MTL12 at 4 based on their school's school-wide 2015 SAGE % mathematics proficiency.

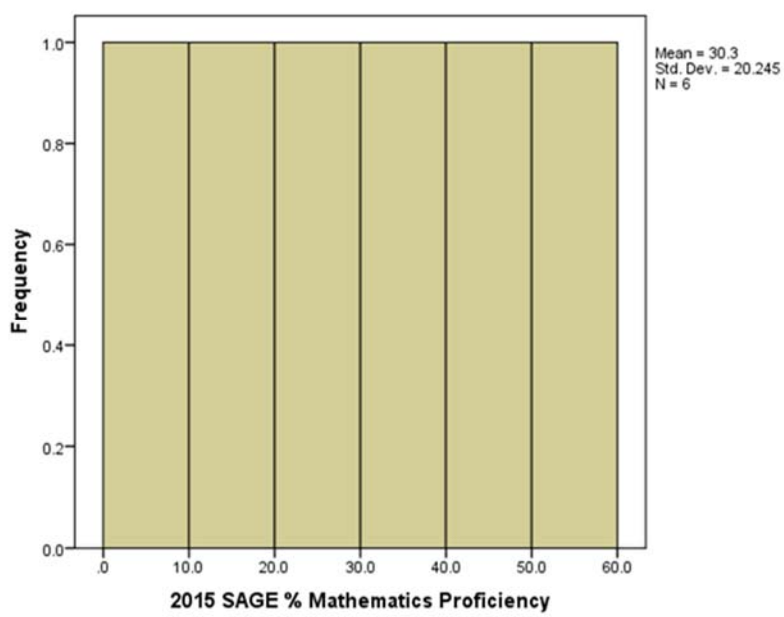

Figure J-140. Frequency by 2015 SAGE % Mathematics Proficiency for MTL12 = 5. This figure illustrates the number of school leaders who rated MTL12 at 5 based on their school's school-wide 2015 SAGE % mathematics proficiency.

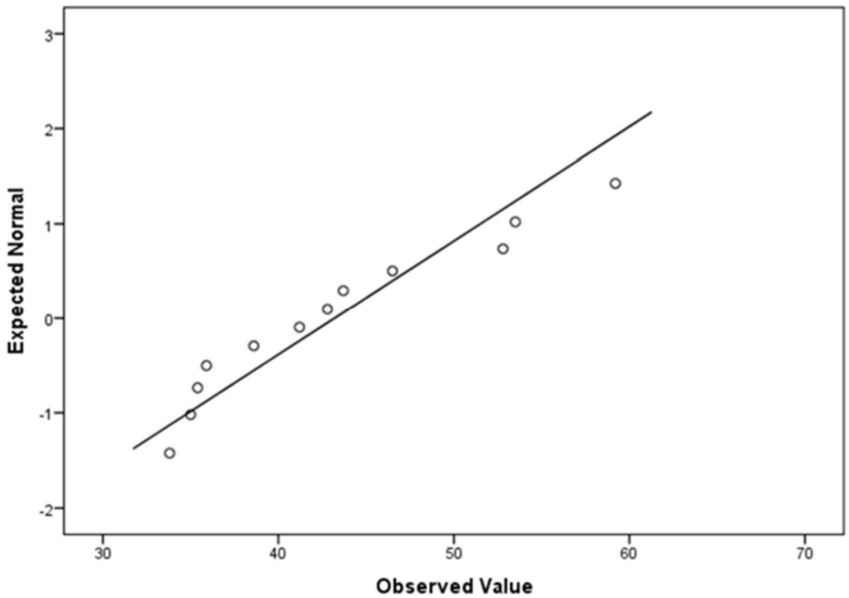

Figure J-141. Normal Q-Q Plot of 2015 SAGE % Mathematics Proficiency for MTL12 = 1. This figure illustrates the observed value versus the expected normal for school leaders who ranked MTL12 as 1 based on their school's school-wide 2015 SAGE % mathematics proficiency.

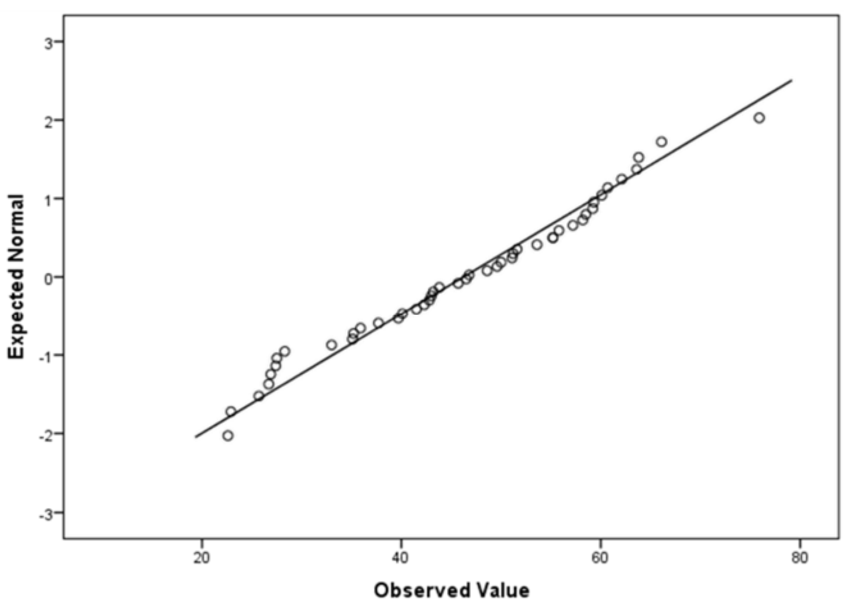

Figure J-142. Normal Q-Q Plot of 2015 SAGE % Mathematics Proficiency for MTL12 = 2. This figure illustrates the observed value versus the expected normal for school leaders who ranked MTL12 as 2 based on their school's school-wide 2015 SAGE % mathematics proficiency.

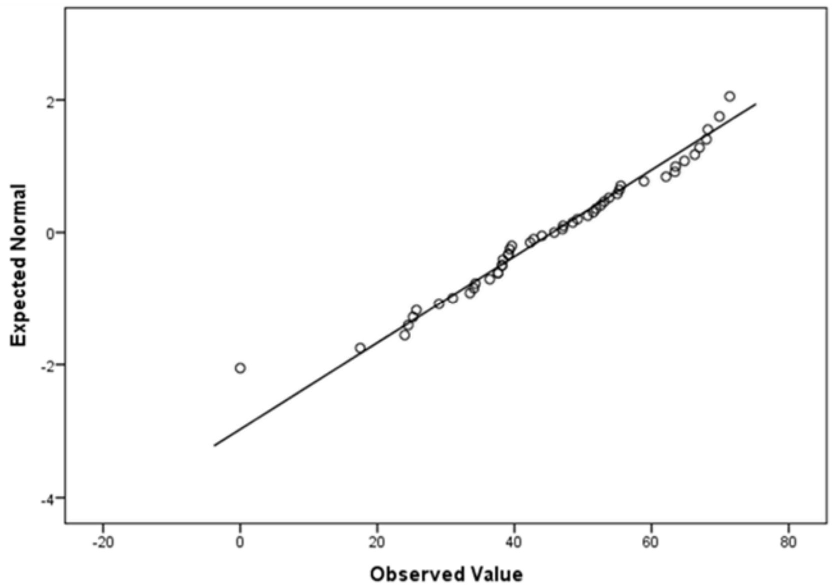

Figure J-143. Normal Q-Q Plot of 2015 SAGE % Mathematics Proficiency for MTL12 = 3. This figure illustrates the observed value versus the expected normal for school leaders who ranked MTL12 as 3 based on their school's school-wide 2015 SAGE % mathematics proficiency.

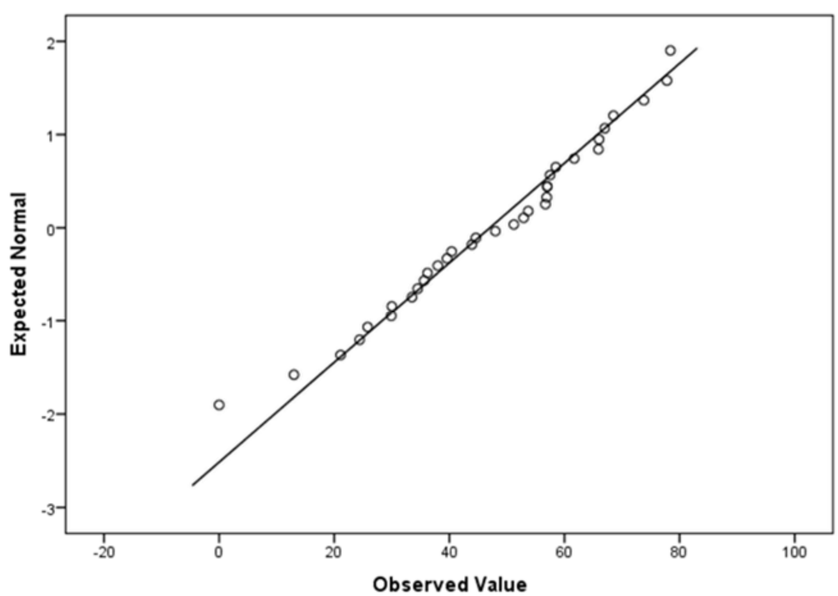

Figure J-144. Normal Q-Q Plot of 2015 SAGE % Mathematics Proficiency for MTL12 = 4. This figure illustrates the observed value versus the expected normal for school leaders who ranked MTL12 as 4 based on their school's school-wide 2015 SAGE % mathematics proficiency.

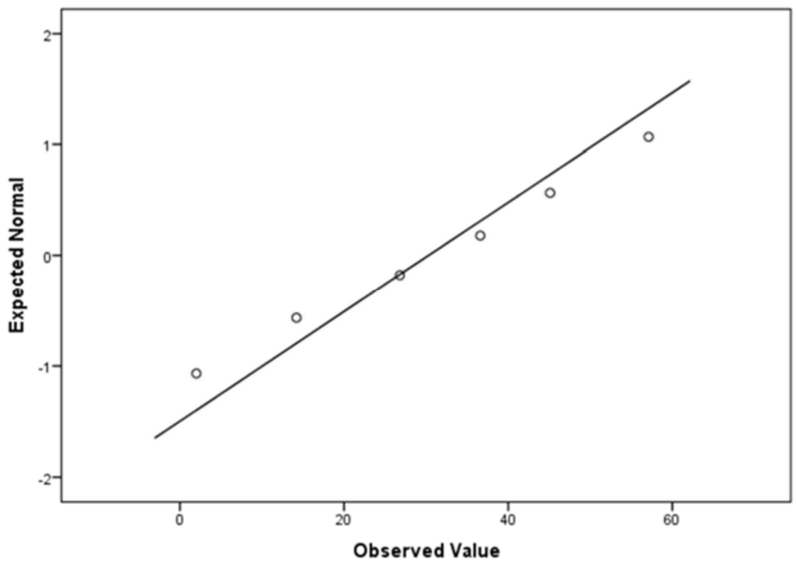

Figure J-145. Normal Q-Q Plot of 2015 SAGE % Mathematics Proficiency for MTL12 = 5. This figure illustrates the observed value versus the expected normal for school leaders who ranked MTL12 as 5 based on their school's school-wide 2015 SAGE % mathematics proficiency.

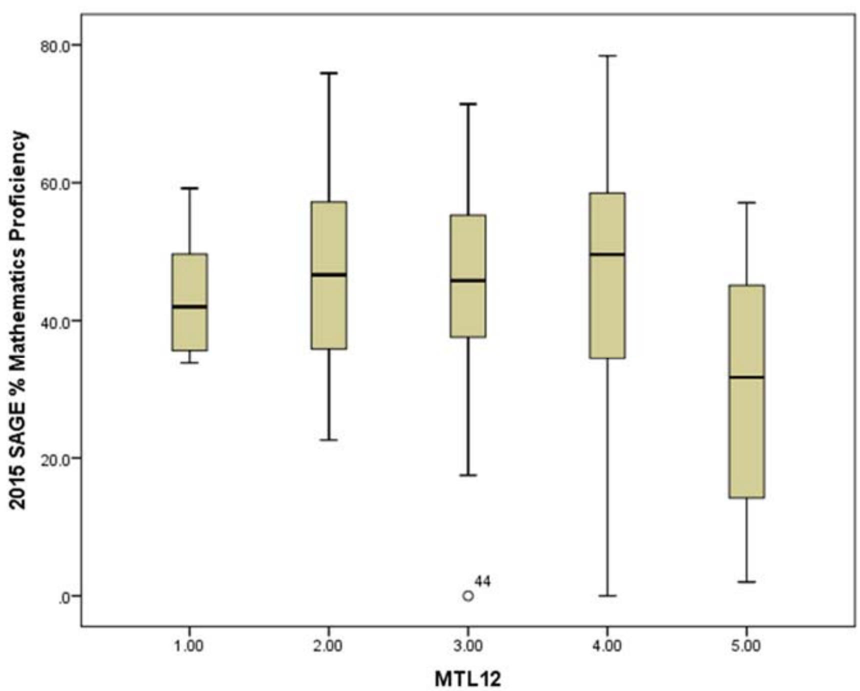

Figure J-146. Boxplot of 2015 SAGE % Mathematics Proficiency for MTL12. This figure illustrates spread of school-wide 2015 SAGE % Mathematics Proficiency scores based on school leaders' ranking of MTL12.

Table J-9

ISAM3: Tests for Normality

Variable		Shapiro-Wilk Statistic	*df*	Sig.	Skewness	Std. Error	Kurtosis	Std. Error
ISAM3	1							
	2	.97	10	.912	-.48	.69	.48	1.33
	3	.96	34	.257	-.38	.40	-.59	.79
	4	.98	76	.181	-.4	.28	-.01	.55
	5	.93	22	.132	-.51	.49	.39	.95

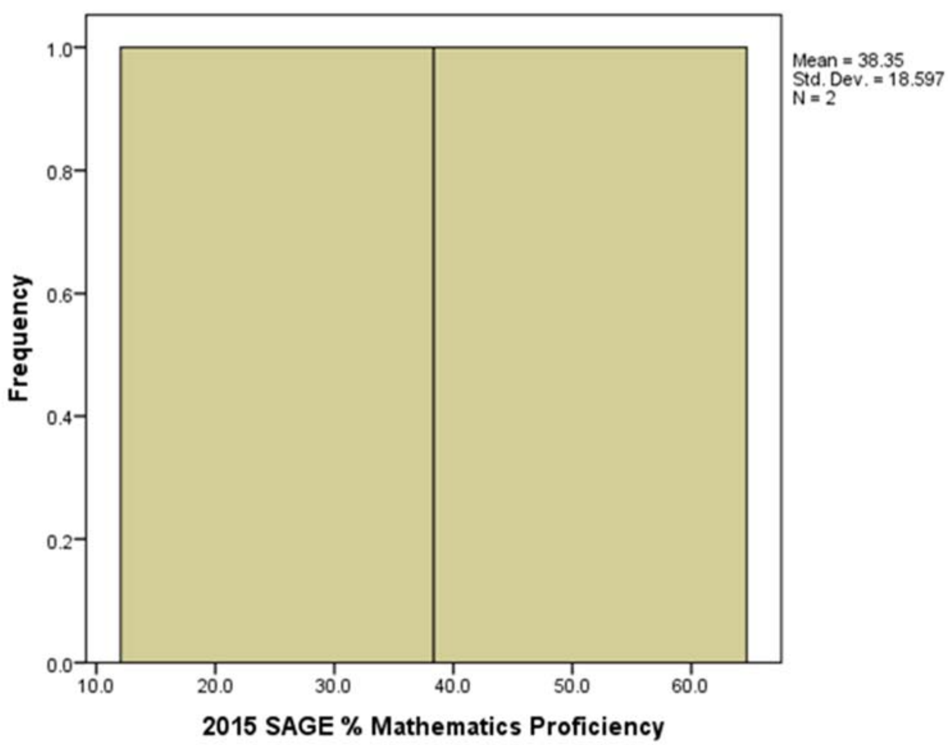

Figure J-147. Frequency by 2015 SAGE % Mathematics Proficiency for ISAM3 = 1. This figure illustrates the number of school leaders who rated ISAM3 at 1 based on their school's school-wide 2015 SAGE % mathematics proficiency.

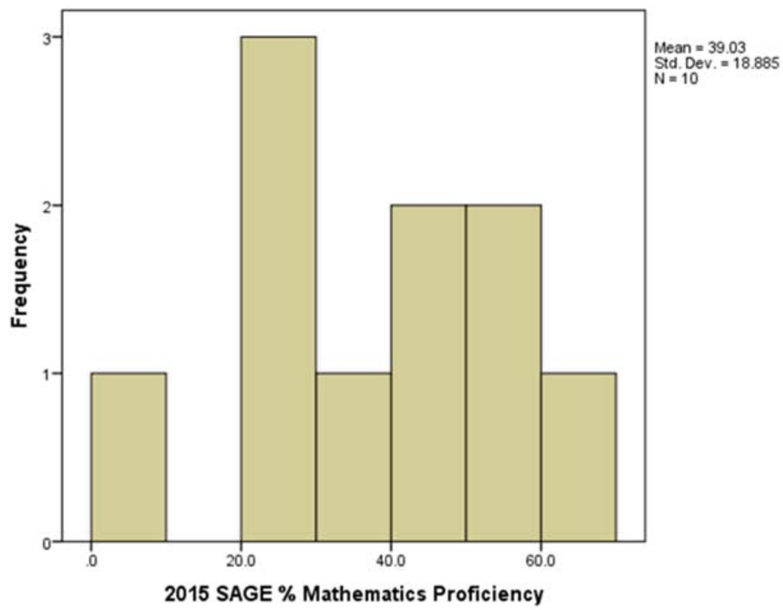

Figure J-148. Frequency by 2015 SAGE % Mathematics Proficiency for ISAM3 = 2. This figure illustrates the number of school leaders who rated ISAM3 at 2 based on their school's school-wide 2015 SAGE % mathematics proficiency.

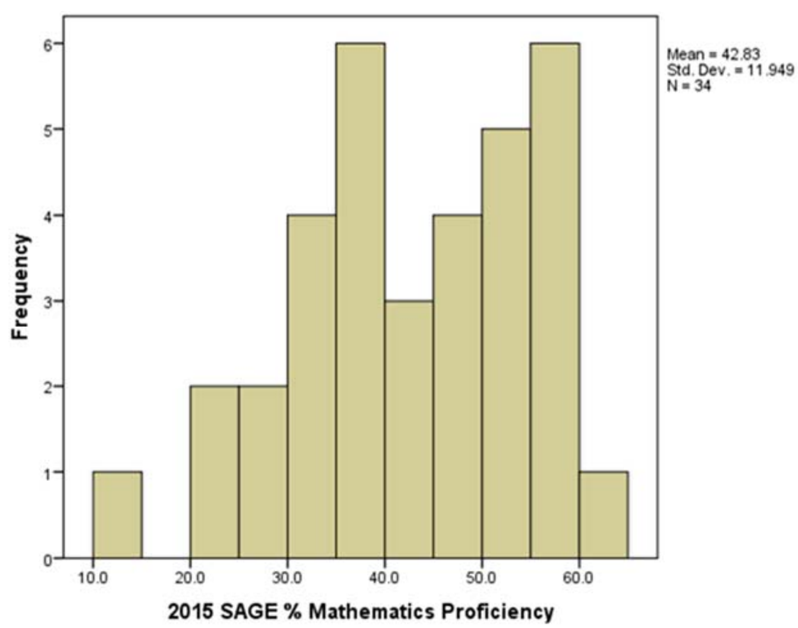

Figure J-149. Frequency by 2015 SAGE % Mathematics Proficiency for ISAM3 = 3. This figure illustrates the number of school leaders who rated ISAM3 at 3 based on their school's school-wide 2015 SAGE % mathematics proficiency.

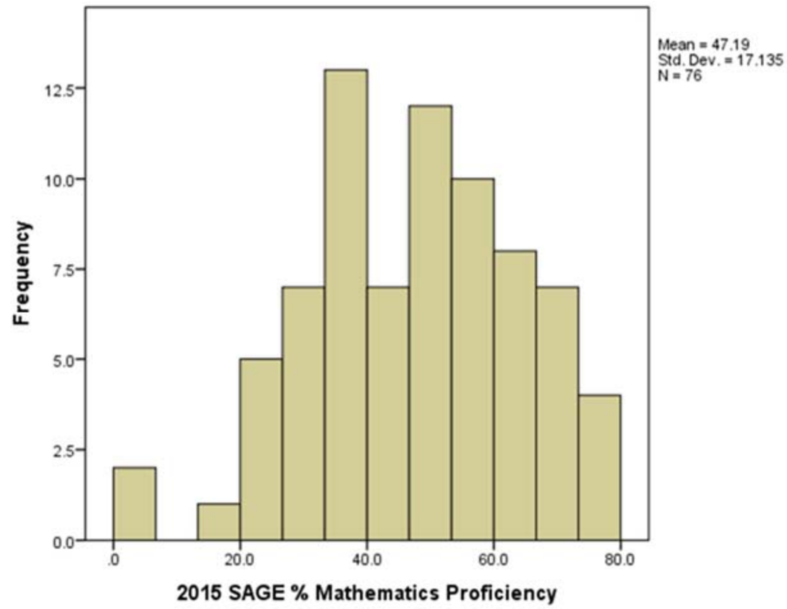

Figure J-150. Frequency by 2015 SAGE % Mathematics Proficiency for ISAM3 = 4. This figure illustrates the number of school leaders who rated ISAM3 at 4 based on their school's school-wide 2015 SAGE % mathematics proficiency.

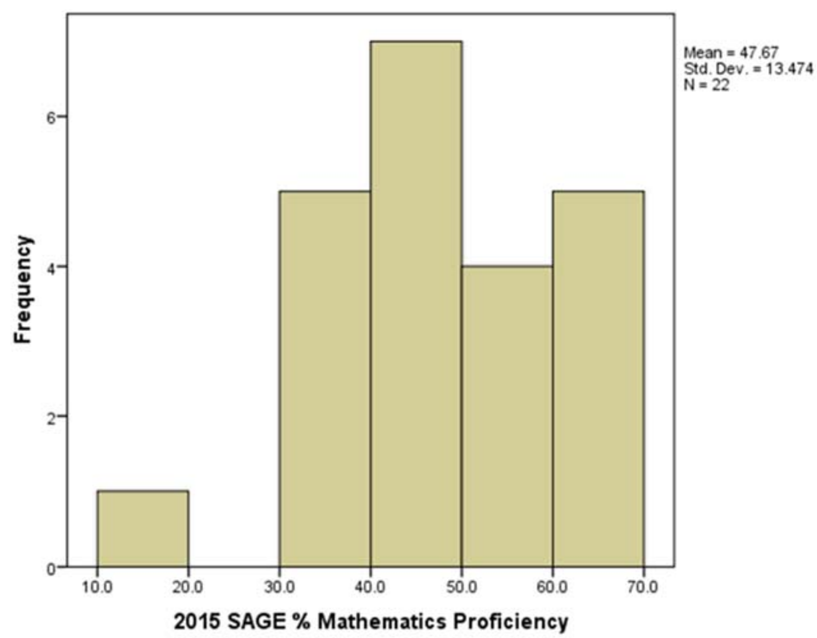

Figure J-151. Frequency by 2015 SAGE % Mathematics Proficiency for ISAM3 = 5. This figure illustrates the number of school leaders who rated ISAM3 at 5 based on their school's school-wide 2015 SAGE % mathematics proficiency.

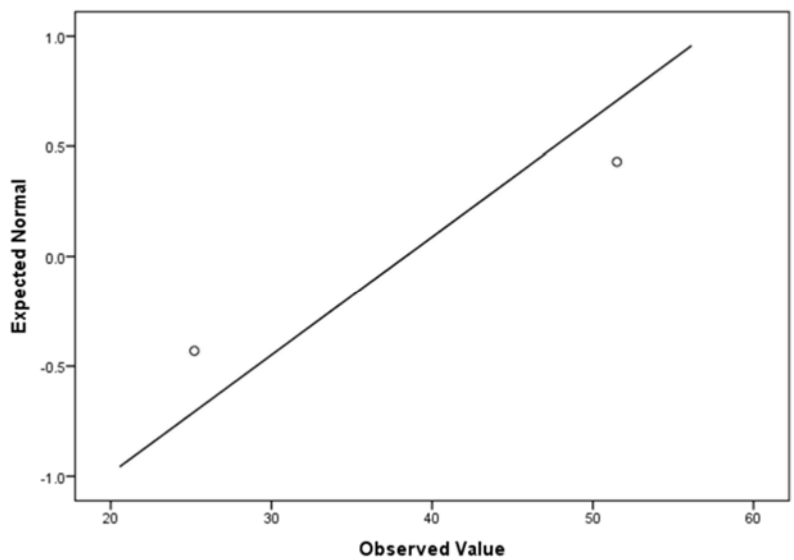

Figure J-152. Normal Q-Q Plot of 2015 SAGE % Mathematics Proficiency for ISAM3 = 1. This figure illustrates the observed value versus the expected normal for school leaders who ranked ISAM3 as 1 based on their school's school-wide 2015 SAGE % mathematics proficiency.

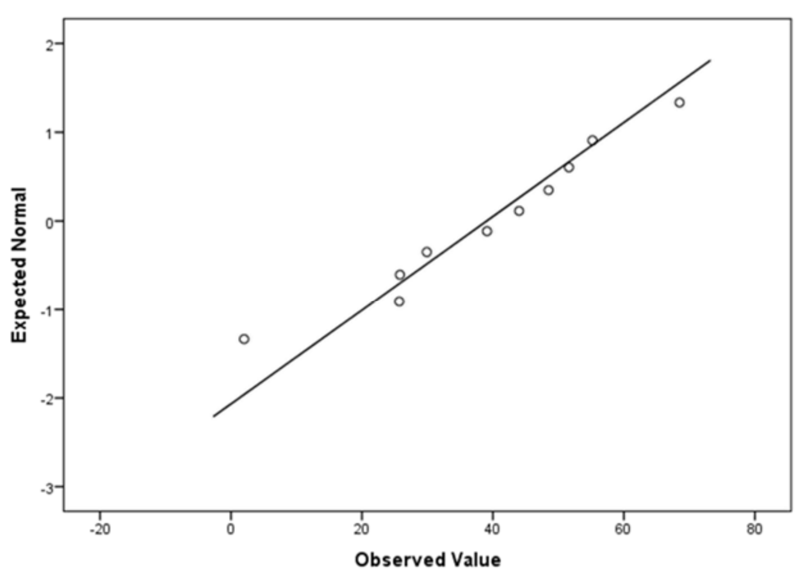

Figure J-153. Normal Q-Q Plot of 2015 SAGE % Mathematics Proficiency for ISAM3 = 2. This figure illustrates the observed value versus the expected normal for school leaders who ranked ISAM3 as 2 based on their school's school-wide 2015 SAGE % mathematics proficiency.

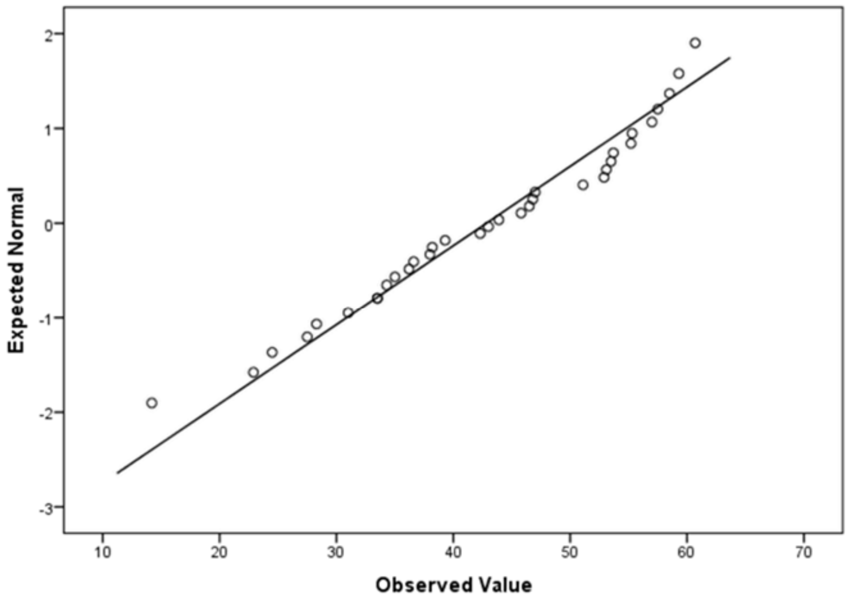

Figure J-154. Normal Q-Q Plot of 2015 SAGE % Mathematics Proficiency for ISAM3 = 3. This figure illustrates the observed value versus the expected normal for school leaders who ranked ISAM3 as 3 based on their school's school-wide 2015 SAGE % mathematics proficiency.

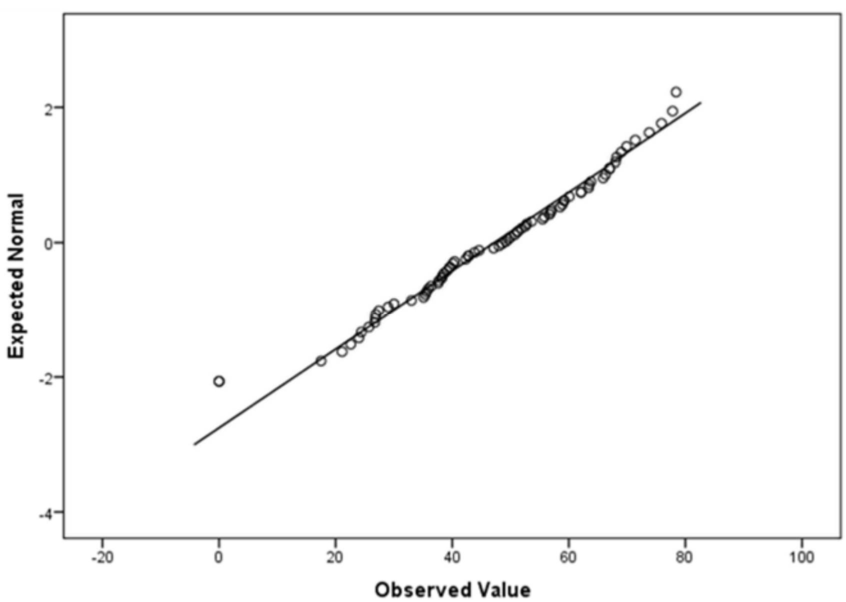

Figure J-155. Normal Q-Q Plot of 2015 SAGE % Mathematics Proficiency for ISAM3 = 4. This figure illustrates the observed value versus the expected normal for school leaders who ranked ISAM3 as 4 based on their school's school-wide 2015 SAGE % mathematics proficiency.

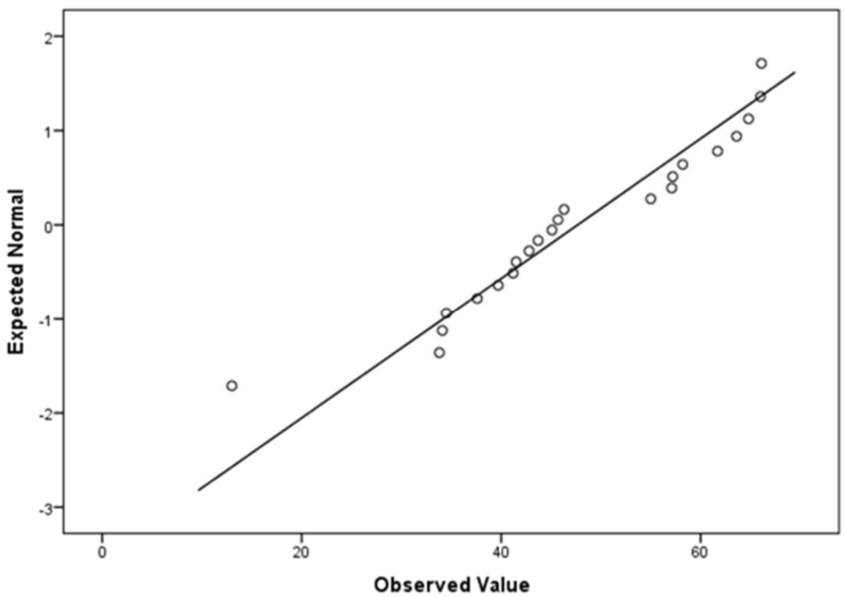

Figure J-156. Normal Q-Q Plot of 2015 SAGE % Mathematics Proficiency for ISAM3 = 5. This figure illustrates the observed value versus the expected normal for school leaders who ranked ISAM3 as 5 based on their school's school-wide 2015 SAGE % mathematics proficiency.

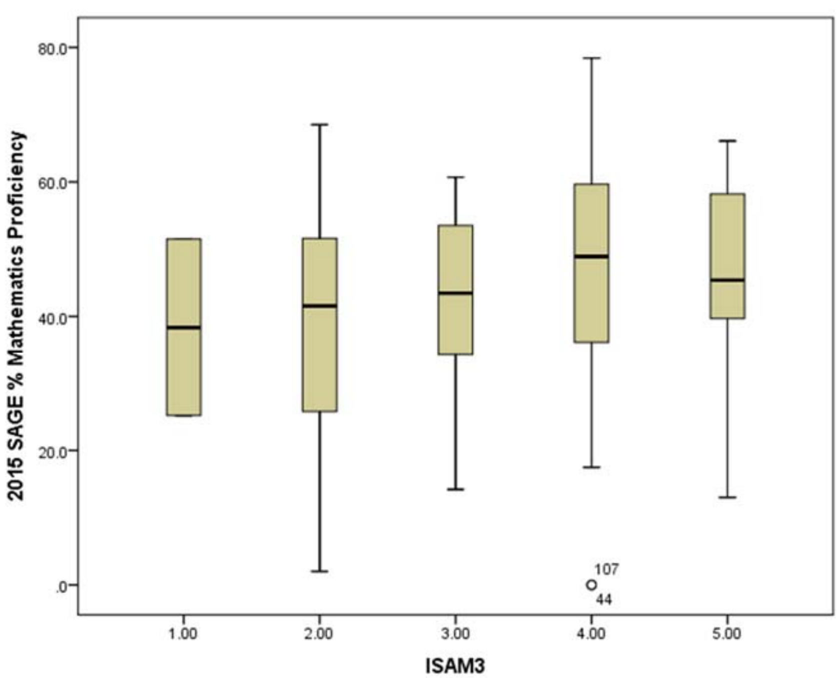

Figure J-157. Boxplot of 2015 SAGE % Mathematics Proficiency for ISAM3. This figure illustrates spread of school-wide 2015 SAGE % Mathematics Proficiency scores based on school leaders' ranking of ISAM3.

Table J-10

MTL35: Tests for Normality

Variable		Shapiro-Wilk Statistic	*df*	Sig.	Skewness	Std. Error	Kurtosis	Std. Error
MTL35	1	.92	5	.530	-.49	.91	-2.04	2.00
	2	.96	55	.050	-.59	.32	1.02	.63
	3	.97	45	.252	.31	.35	-.27	.70
	4	.93	25	.097	-.03	.46	-1.25	.90
	5	.96	7	.808	-.52	.79	-.48	1.59

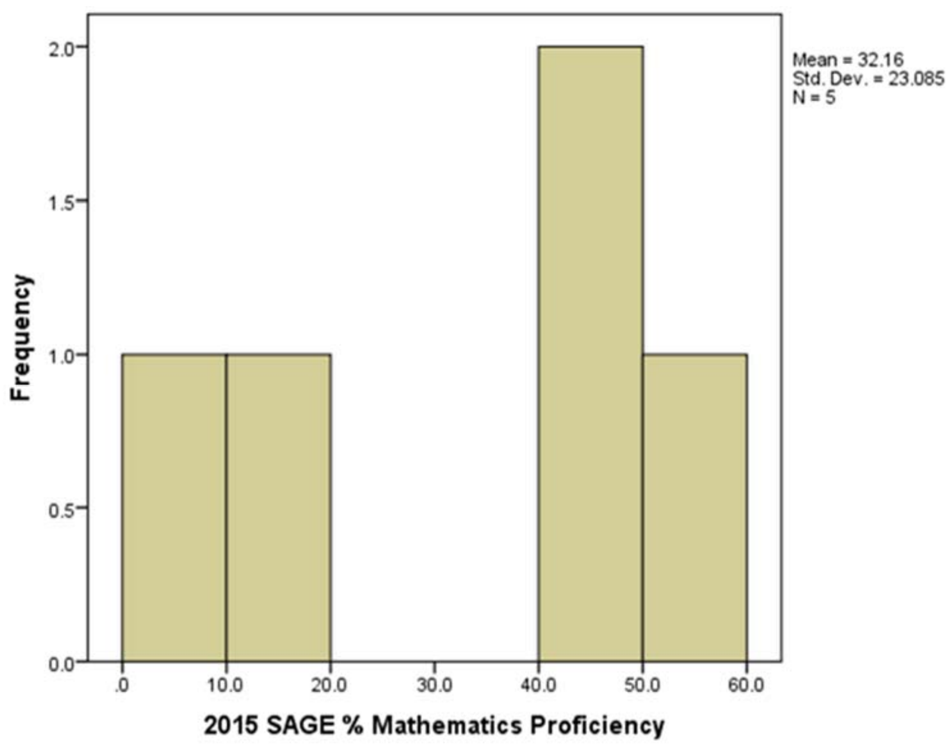

Figure J-158. Frequency by 2015 SAGE % Mathematics Proficiency for MTL35 = 1. This figure illustrates the number of school leaders who rated MTL35 at 1 based on their school's school-wide 2015 SAGE % mathematics proficiency.

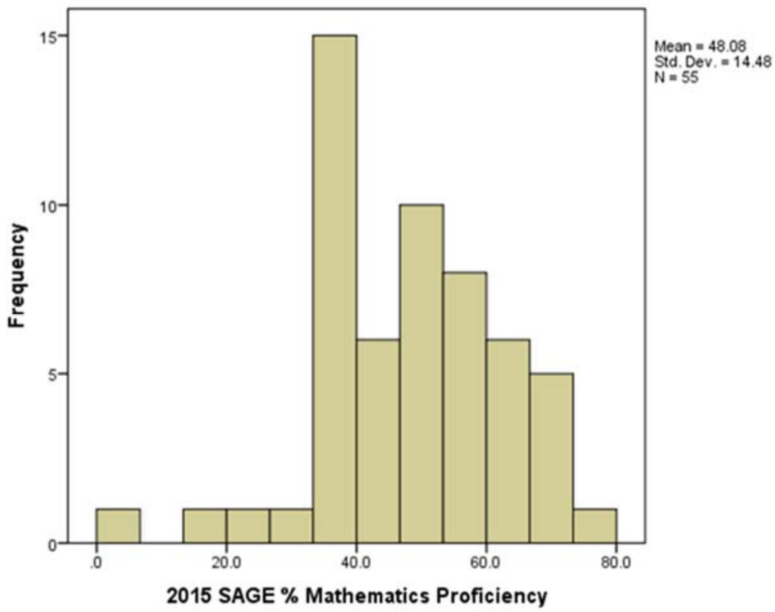

Figure J-159. Frequency by 2015 SAGE % Mathematics Proficiency for MTL35 = 2. This figure illustrates the number of school leaders who rated MTL35 at 2 based on their school's school-wide 2015 SAGE % mathematics proficiency.

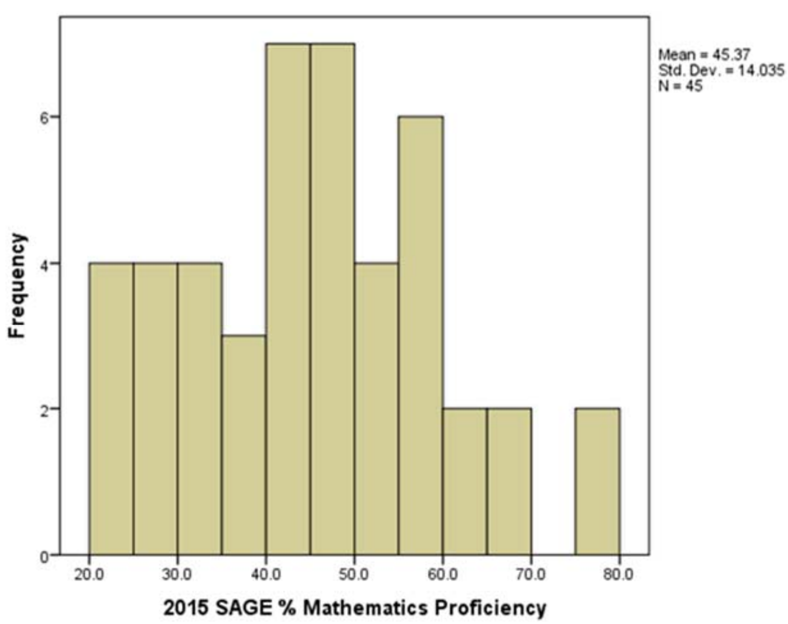

Figure J-160. Frequency by 2015 SAGE % Mathematics Proficiency for MTL35 = 3. This figure illustrates the number of school leaders who rated MTL35 at 3 based on their school's school-wide 2015 SAGE % mathematics proficiency.

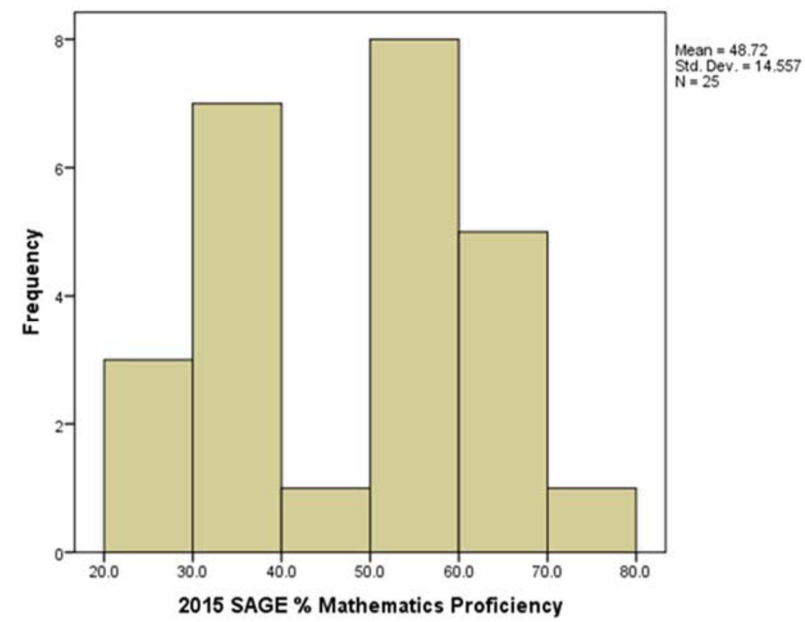

Figure J-161. Frequency by 2015 SAGE % Mathematics Proficiency for MTL35 = 4. This figure illustrates the number of school leaders who rated MTL35 at 4 based on their school's school-wide 2015 SAGE % mathematics proficiency.

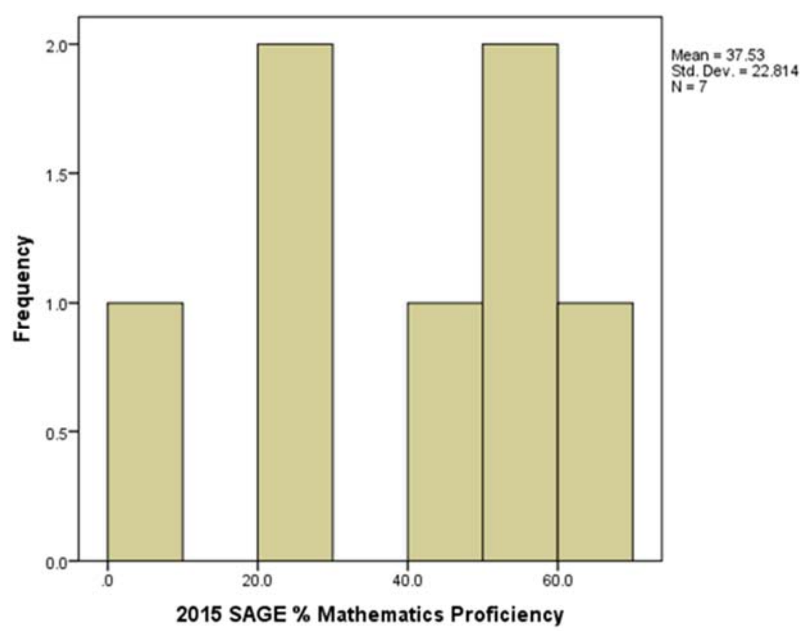

Figure J-162. Frequency by 2015 SAGE % Mathematics Proficiency for MTL35 = 5. This figure illustrates the number of school leaders who rated MTL35 at 5 based on their school's school-wide 2015 SAGE % mathematics proficiency.

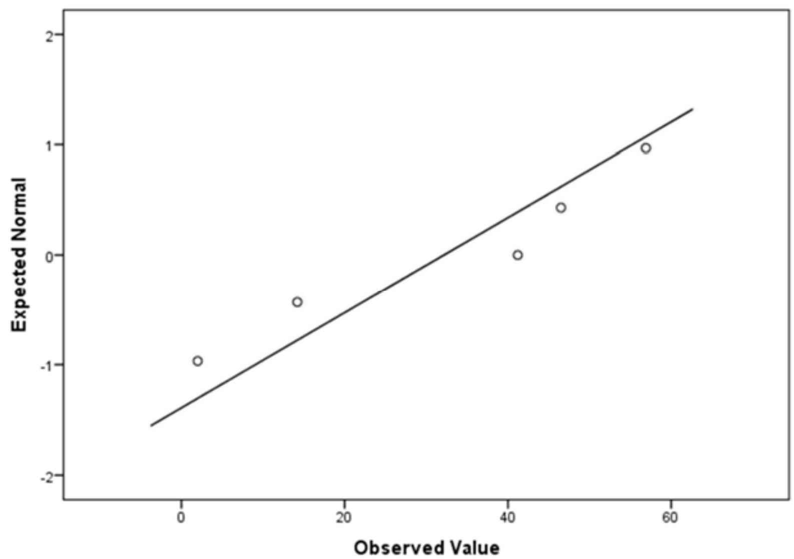

Figure J-163. Normal Q-Q Plot of 2015 SAGE % Mathematics Proficiency for MTL35 = 1. This figure illustrates the observed value versus the expected normal for school leaders who ranked MTL35 as 1 based on their school's school-wide 2015 SAGE % mathematics proficiency.

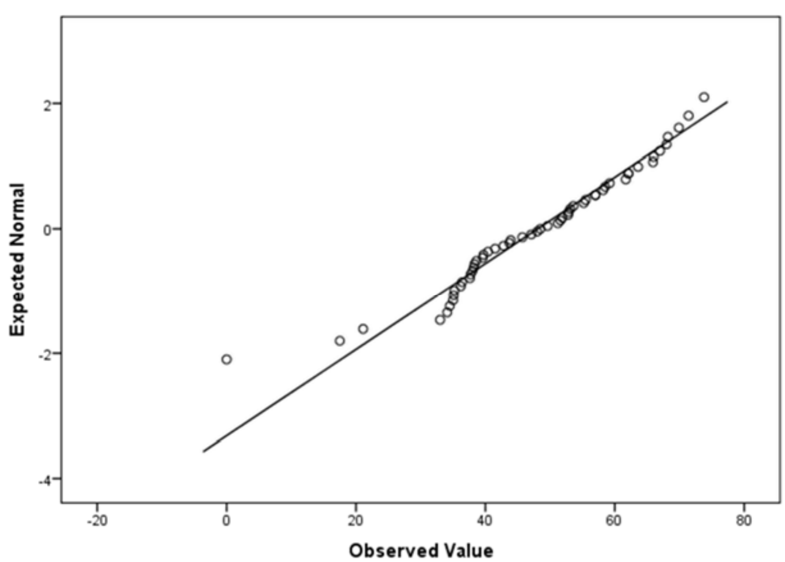

Figure J-164. Normal Q-Q Plot of 2015 SAGE % Mathematics Proficiency for MTL35 = 2. This figure illustrates the observed value versus the expected normal for school leaders who ranked MTL35 as 2 based on their school's school-wide 2015 SAGE % mathematics proficiency.

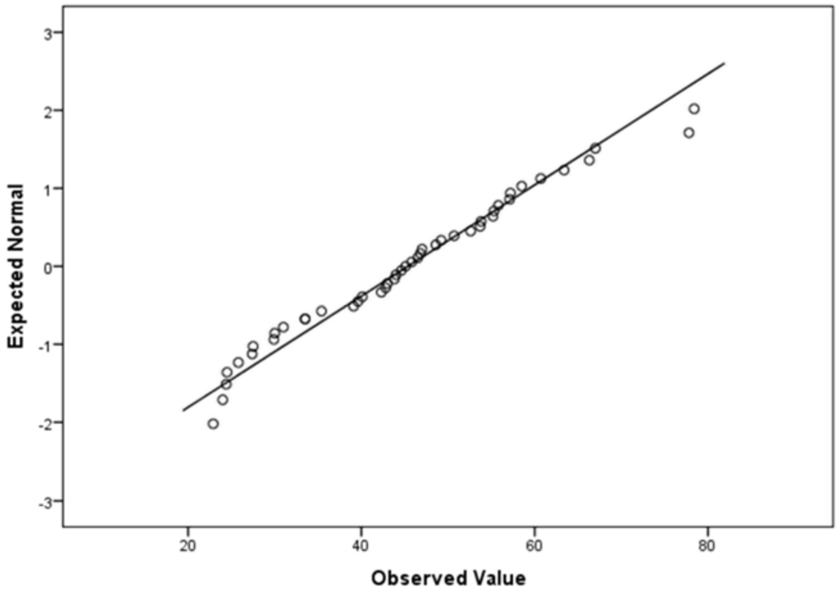

Figure J-165. Normal Q-Q Plot of 2015 SAGE % Mathematics Proficiency for MTL35 = 3. This figure illustrates the observed value versus the expected normal for school leaders who ranked MTL35 as 3 based on their school's school-wide 2015 SAGE % mathematics proficiency.

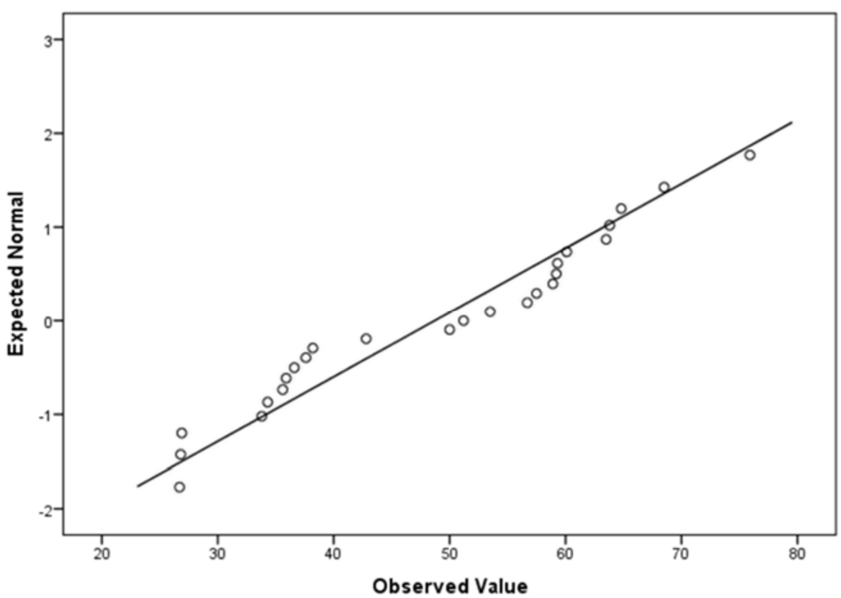

Figure J-166. Normal Q-Q Plot of 2015 SAGE % Mathematics Proficiency for MTL35 = 4. This figure illustrates the observed value versus the expected normal for school leaders who ranked MTL35 as 4 based on their school's school-wide 2015 SAGE % mathematics proficiency.

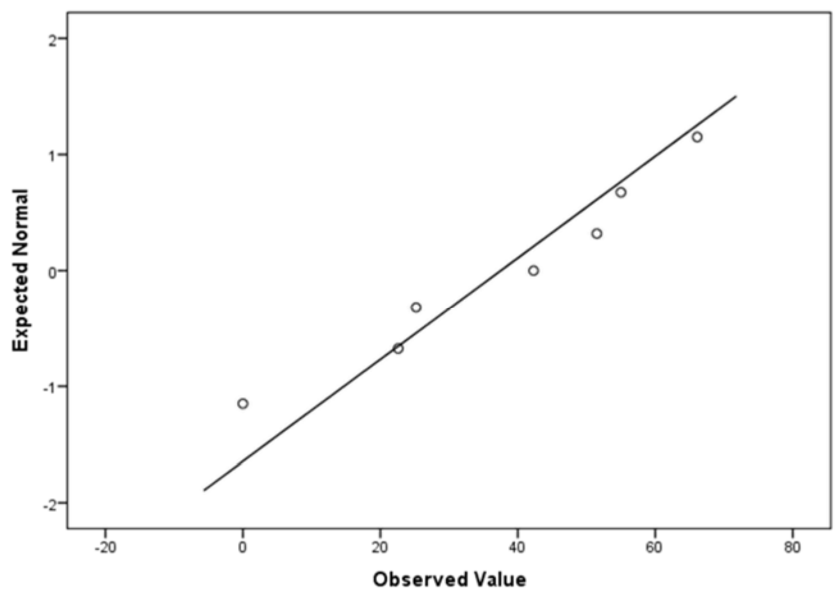

Figure J-167. Normal Q-Q Plot of 2015 SAGE % Mathematics Proficiency for MTL35 = 5. This figure illustrates the observed value versus the expected normal for school leaders who ranked MTL35 as 5 based on their school's school-wide 2015 SAGE % mathematics proficiency.

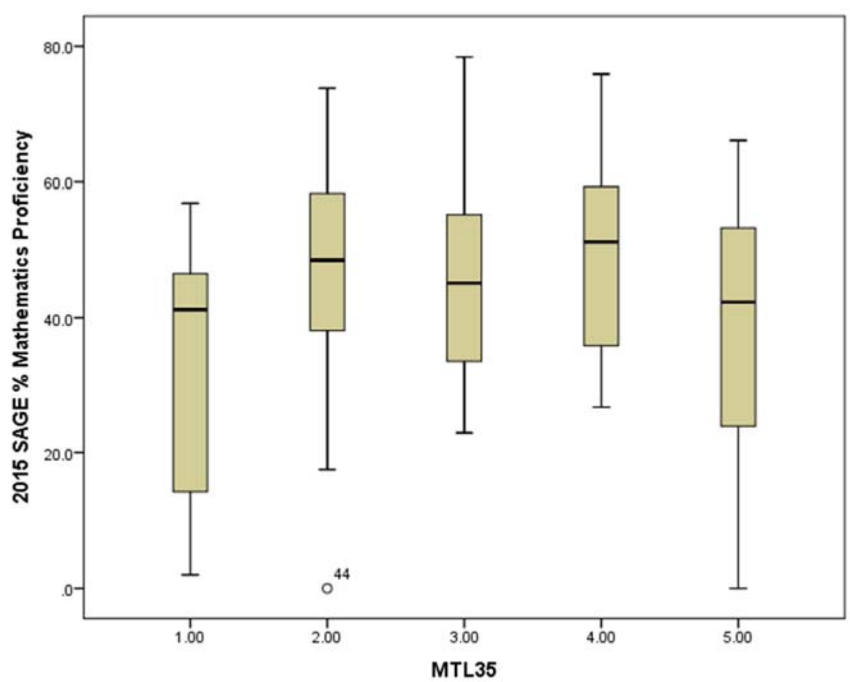

Figure J-168. Boxplot of 2015 SAGE % Mathematics Proficiency for MTL35. This figure illustrates spread of school-wide 2015 SAGE % Mathematics Proficiency scores based on school leaders' ranking of MTL35.

Table J-11

Inf_Nat_Org2: Tests for Normality

Variable		Shapiro-Wilk Statistic	*df*	Sig.	Skewness	Std. Error	Kurtosis	Std. Error
Inf_Nat_ Org2	1	.96	38	.183	-.74	.38	.98	.75
	2	.97	30	.565	.20	.43	-.77	.83
	3	.95	39	.061	-.88	.38	1.51	.74
	4	.94	20	.193	-.75	.51	.03	.99
	5	.98	19	.971	.12	.52	-.23	1.01
	6	.95	3	.551	1.12	1.23		

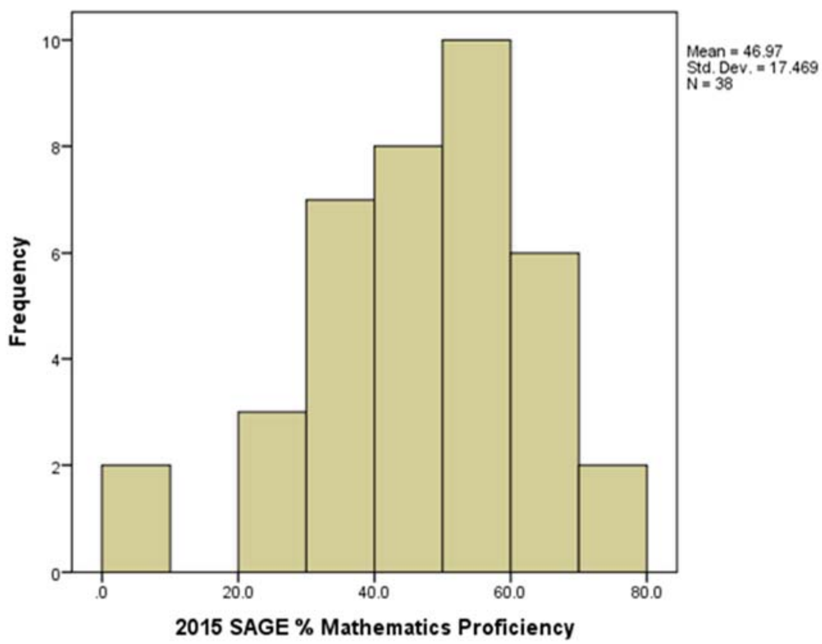

Figure J-169. Frequency by 2015 SAGE % Mathematics Proficiency for Inf_Nat_Org2 = 1. This figure illustrates the number of school leaders who rated Inf_Nat_Org2 at 1 based on their school's school-wide 2015 SAGE % mathematics proficiency.

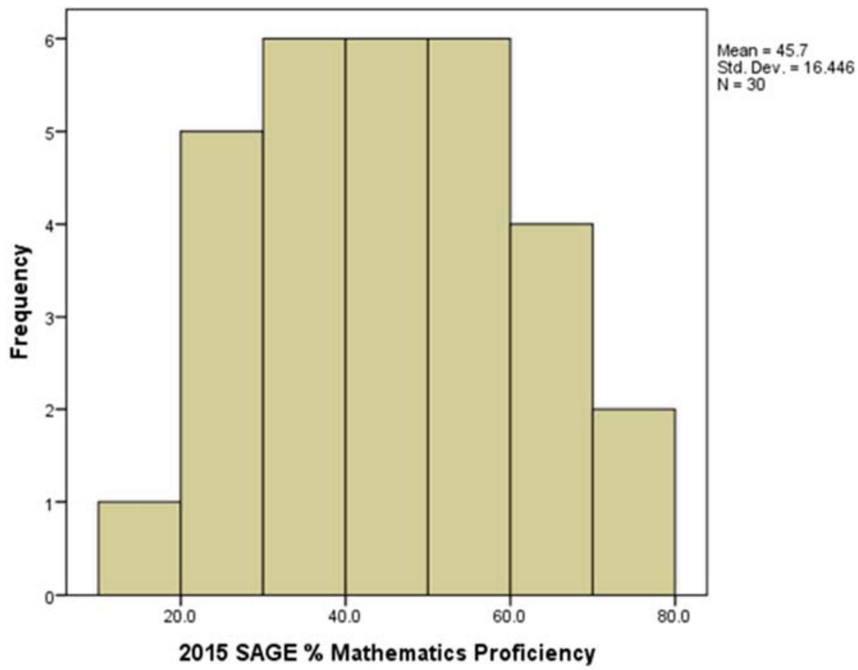

Figure J-170. Frequency by 2015 SAGE % Mathematics Proficiency for Inf_Nat_Org2 = 2. This figure illustrates the number of school leaders who rated Inf_Nat_Org2 at 2 based on their school's school-wide 2015 SAGE % mathematics proficiency.

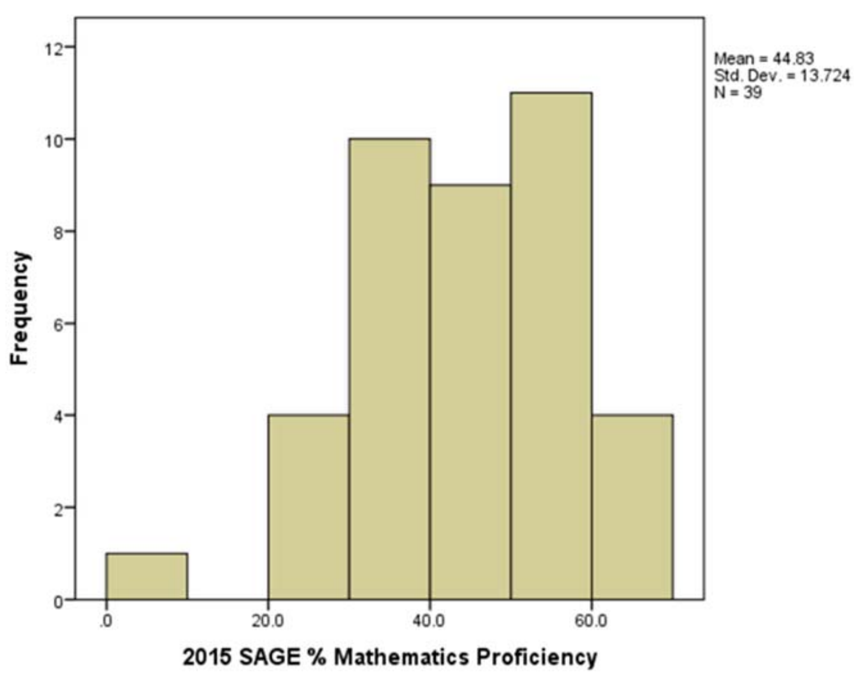

Figure J-171. Frequency by 2015 SAGE % Mathematics Proficiency for Inf_Nat_Org2 = 3. This figure illustrates the number of school leaders who rated Inf_Nat_Org2 at 3 based on their school's school-wide 2015 SAGE % mathematics proficiency.

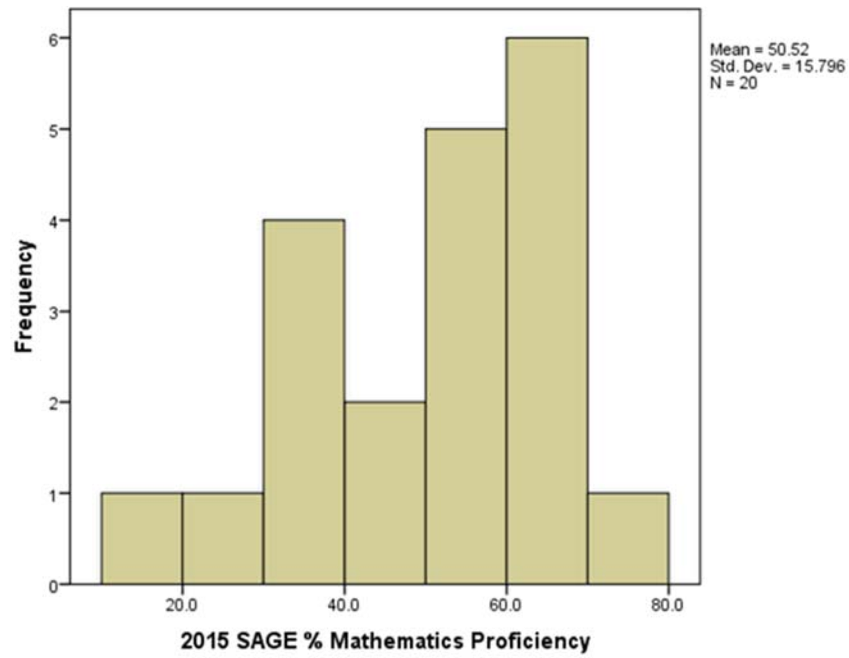

Figure J-172. Frequency by 2015 SAGE % Mathematics Proficiency for Inf_Nat_Org2 = 4. This figure illustrates the number of school leaders who rated Inf_Nat_Org2 at 4 based on their school's school-wide 2015 SAGE % mathematics proficiency.

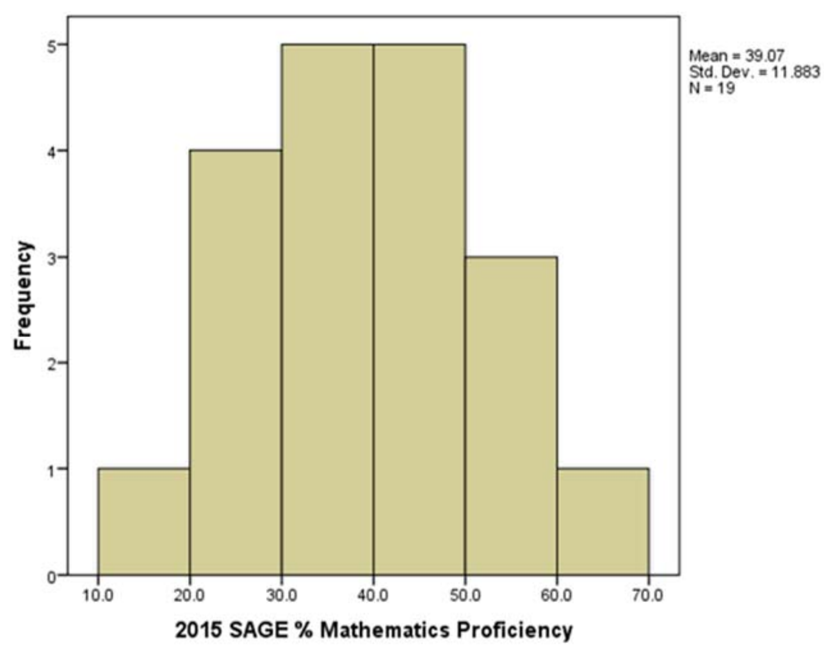

Figure J-173. Frequency by 2015 SAGE % Mathematics Proficiency for Inf_Nat_Org2 = 5. This figure illustrates the number of school leaders who rated Inf_Nat_Org2 at 5 based on their school's school-wide 2015 SAGE % mathematics proficiency.

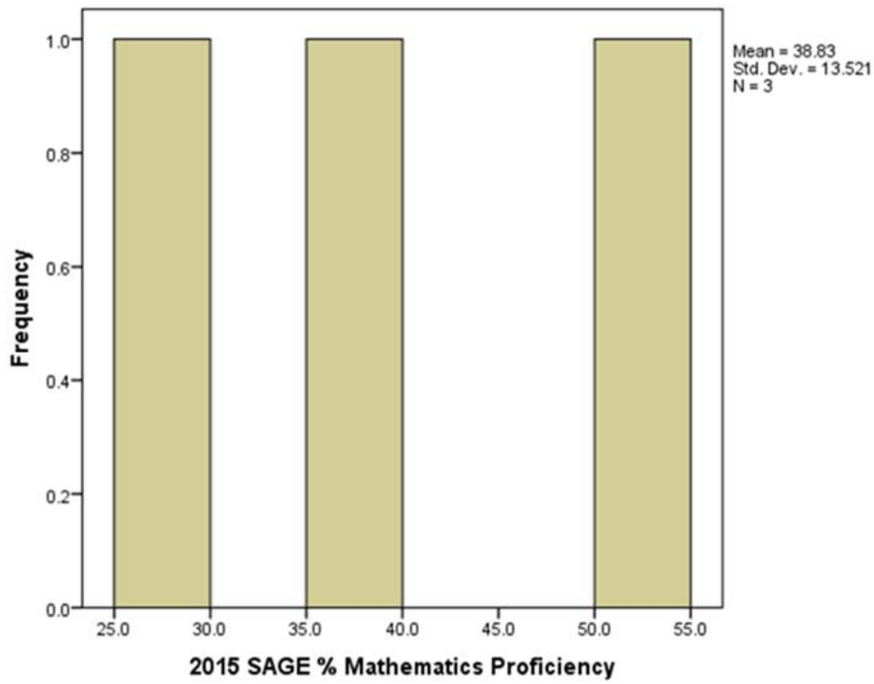

Figure J-174. Frequency by 2015 SAGE % Mathematics Proficiency for Inf_Nat_Org2 = 6. This figure illustrates the number of school leaders who rated Inf_Nat_Org2 at 6 based on their school's school-wide 2015 SAGE % mathematics proficiency.

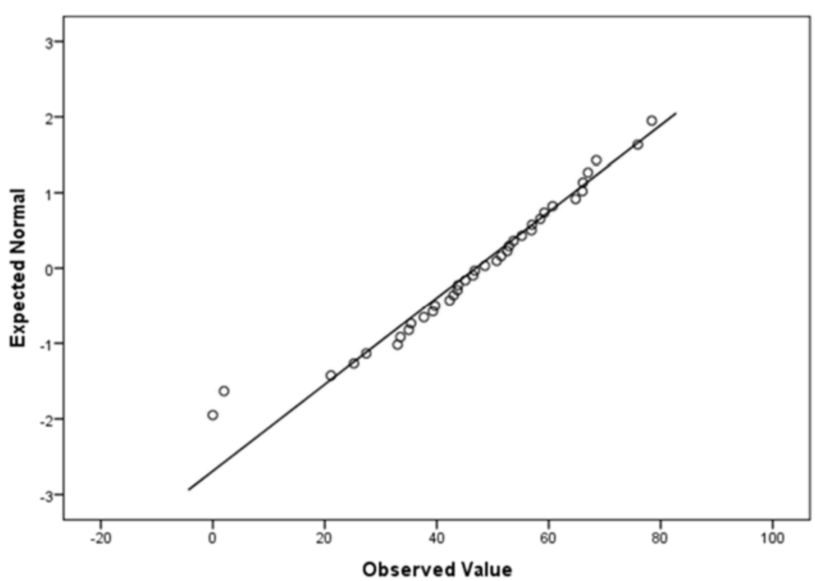

Figure J-175. Normal Q-Q Plot of 2015 SAGE % Mathematics Proficiency for Inf_Nat_Org2 = 1. This figure illustrates the observed value versus the expected normal for school leaders who ranked Inf_Nat_Org2 as 1 based on their school's school-wide 2015 SAGE % mathematics proficiency.

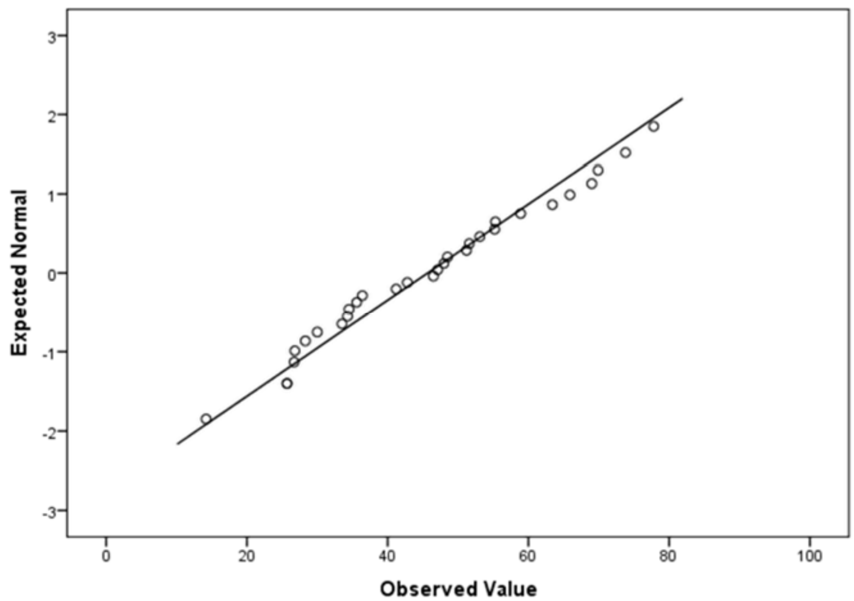

Figure J-176. Normal Q-Q Plot of 2015 SAGE % Mathematics Proficiency for Inf_Nat_Org2 = 2. This figure illustrates the observed value versus the expected normal for school leaders who ranked Inf_Nat_Org2 as 2 based on their school's school-wide 2015 SAGE % mathematics proficiency.

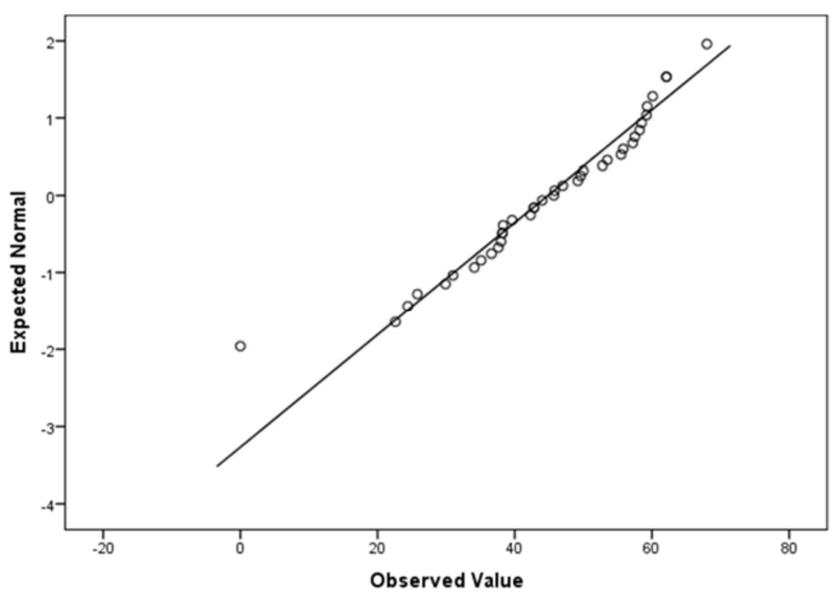

Figure J-177. Normal Q-Q Plot of 2015 SAGE % Mathematics Proficiency for Inf_Nat_Org2 = 3. This figure illustrates the observed value versus the expected normal for school leaders who ranked Inf_Nat_Org2 as 3 based on their school's school-wide 2015 SAGE % mathematics proficiency.

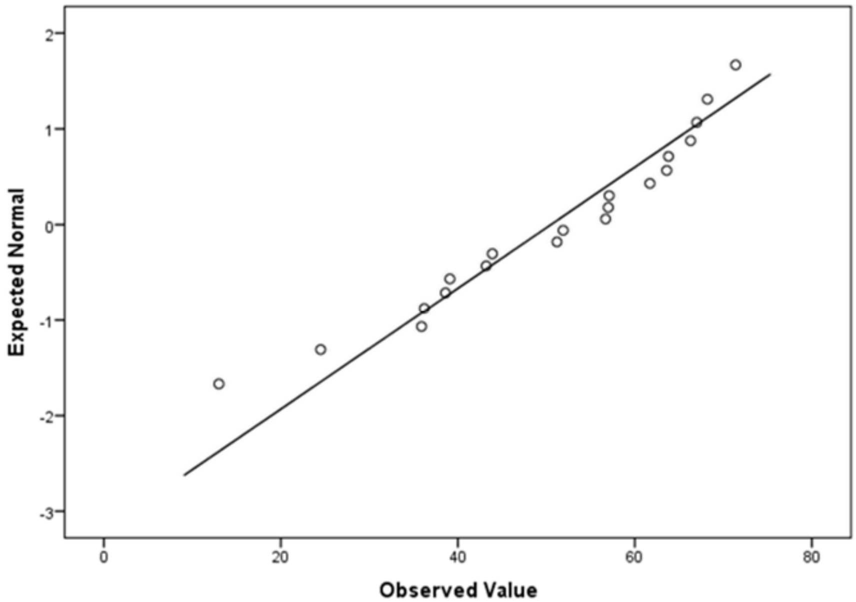

Figure J-178. Normal Q-Q Plot of 2015 SAGE % Mathematics Proficiency for Inf_Nat_Org2 = 4. This figure illustrates the observed value versus the expected normal for school leaders who ranked Inf_Nat_Org2 as 4 based on their school's school-wide 2015 SAGE % mathematics proficiency.

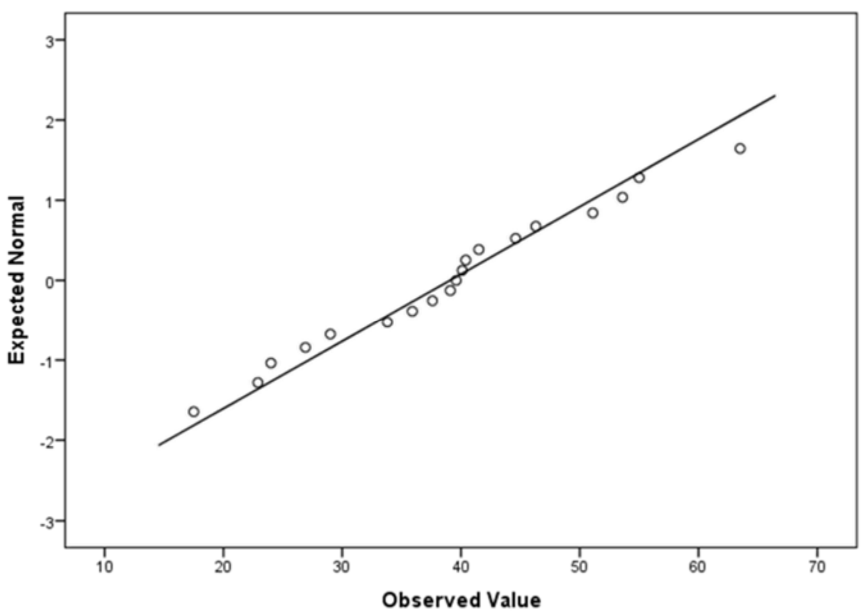

Figure J-179. Normal Q-Q Plot of 2015 SAGE % Mathematics Proficiency for Inf_Nat_Org2 = 5. This figure illustrates the observed value versus the expected normal for school leaders who ranked Inf_Nat_Org2 as 5 based on their school's school-wide 2015 SAGE % mathematics proficiency.

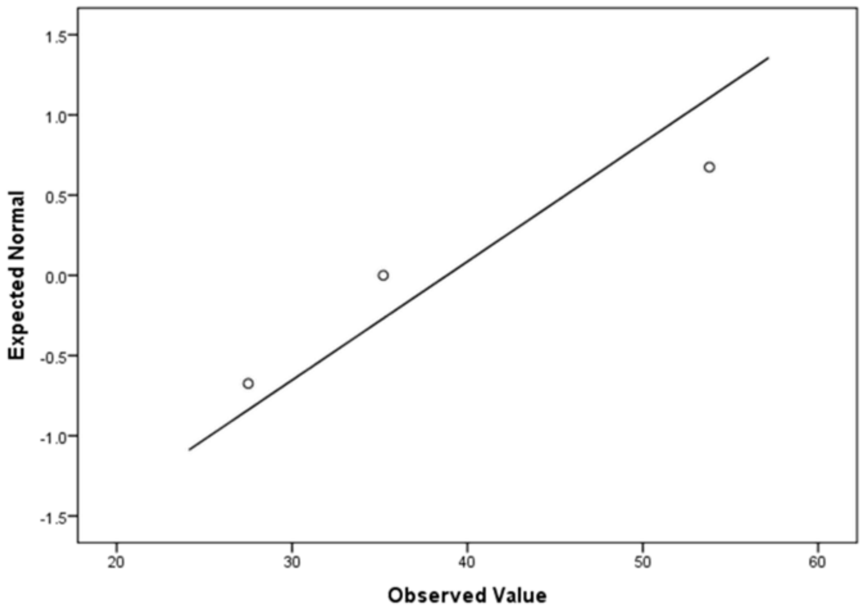

Figure J-180. Normal Q-Q Plot of 2015 SAGE % Mathematics Proficiency for Inf_Nat_Org2 = 6. This figure illustrates the observed value versus the expected normal for school leaders who ranked Inf_Nat_Org2 as 6 based on their school's school-wide 2015 SAGE % mathematics proficiency.

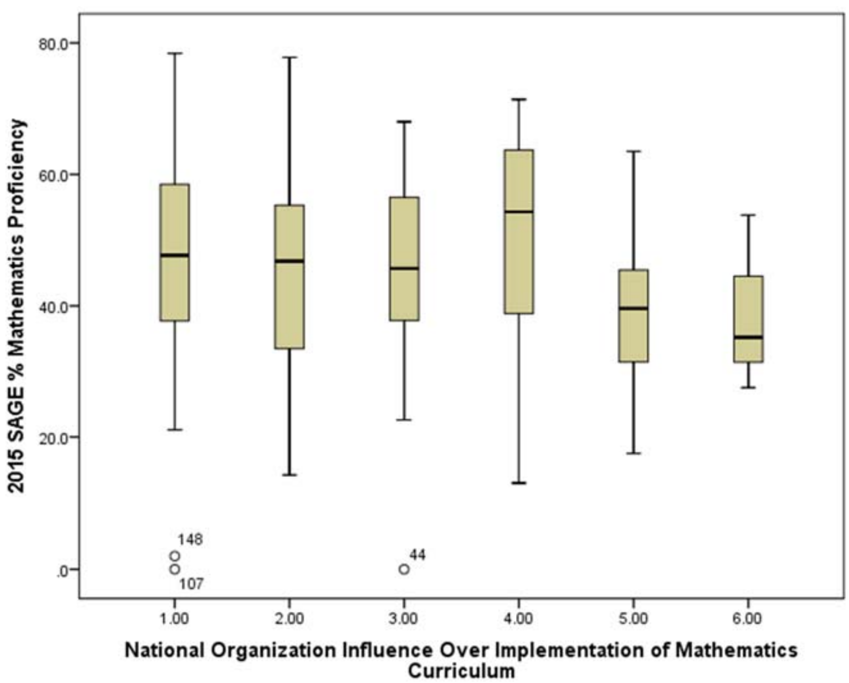

Figure J-181. Boxplot of 2015 SAGE % Mathematics Proficiency for Inf_Nat_Org2. This figure illustrates spread of school-wide 2015 SAGE % Mathematics Proficiency scores based on school leaders' ranking of Inf_Nat_Org2.

Table J-12

ISAM16: Tests for Normality

Variable		Shapiro-Wilk Statistic	*df*	Sig.	Skewness	Std. Error	Kurtosis	Std. Error
ISAM16	1	.80	3	.113	-1.71	1.23		
	2	.96	19	.498	-.19	.52	-.62	1.01
	3	.99	51	.829	.06	.33	-.45	.66
	4	.98	60	.253	-.61	.31	.63	.61
	5	.89	10	.177	.62	.69	-1.11	1.33

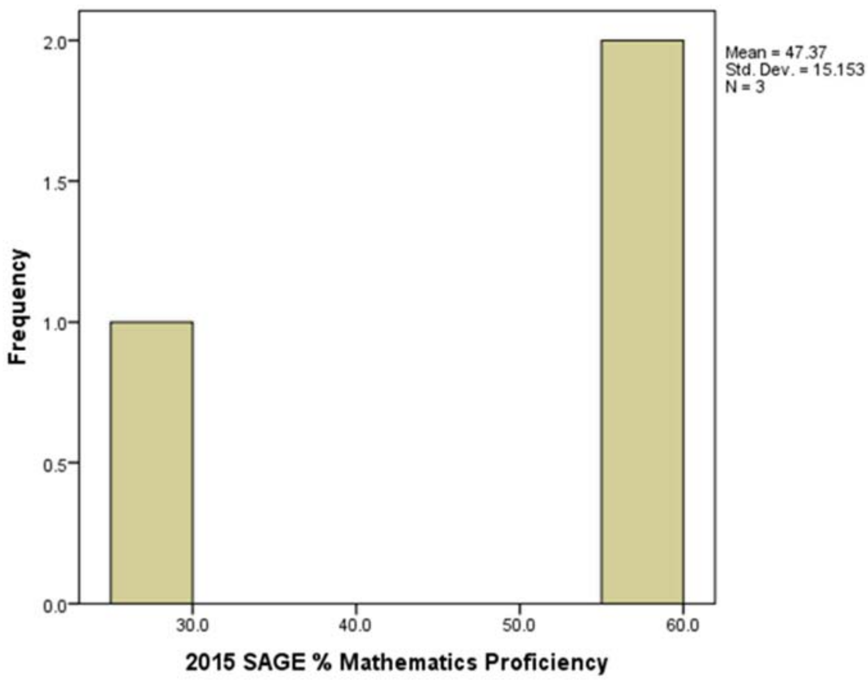

Figure J-182. Frequency by 2015 SAGE % Mathematics Proficiency for ISAM16 = 1. This figure illustrates the number of school leaders who rated ISAM16 at 1 based on their school's school-wide 2015 SAGE % mathematics proficiency.

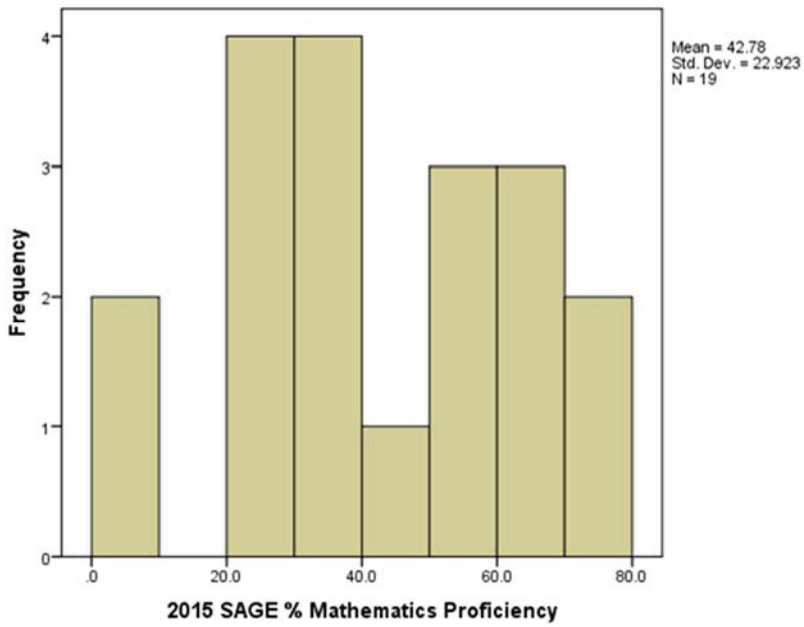

Figure J-183. Frequency by 2015 SAGE % Mathematics Proficiency for ISAM16 = 2. This figure illustrates the number of school leaders who rated ISAM16 at 2 based on their school's school-wide 2015 SAGE % mathematics proficiency.

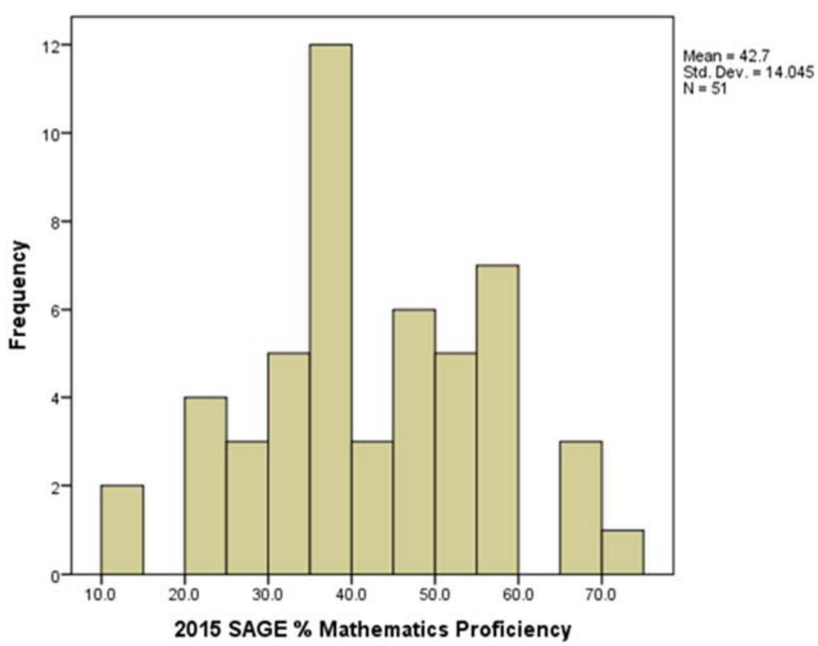

Figure J-184. Frequency by 2015 SAGE % Mathematics Proficiency for ISAM16 = 3. This figure illustrates the number of school leaders who rated ISAM16 at 3 based on their school's school-wide 2015 SAGE % mathematics proficiency.

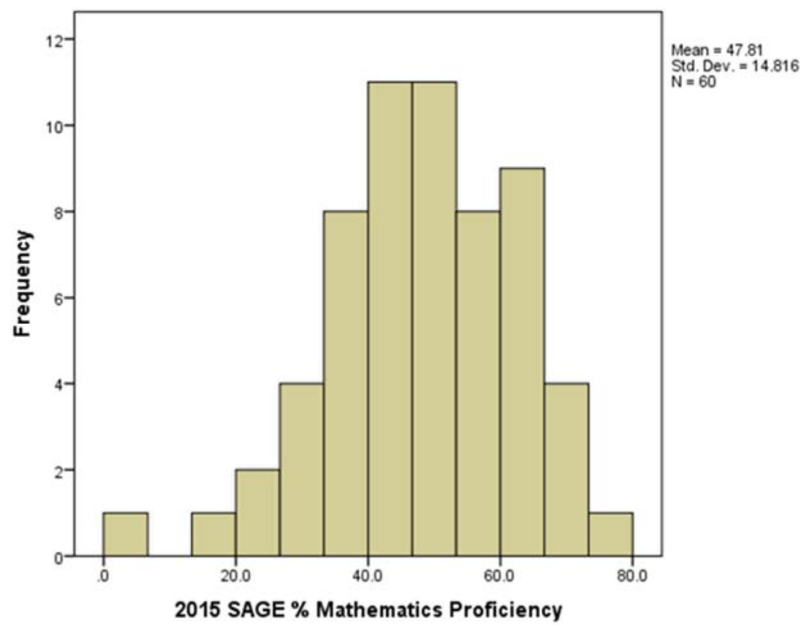

Figure J-185. Frequency by 2015 SAGE % Mathematics Proficiency for ISAM16 = 4. This figure illustrates the number of school leaders who rated ISAM16 at 4 based on their school's school-wide 2015 SAGE % mathematics proficiency.

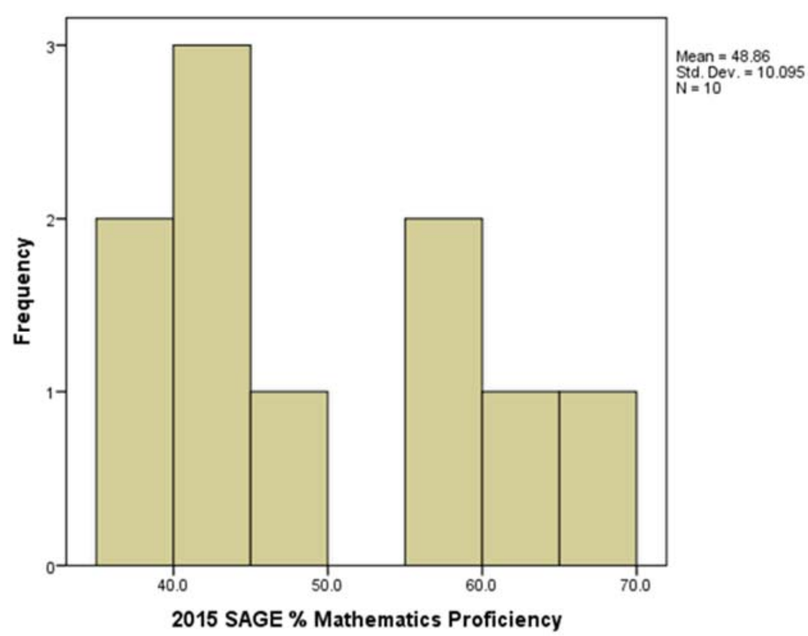

Figure J-186. Frequency by 2015 SAGE % Mathematics Proficiency for ISAM16 = 5. This figure illustrates the number of school leaders who rated ISAM16 at 5 based on their school's school-wide 2015 SAGE % mathematics proficiency.

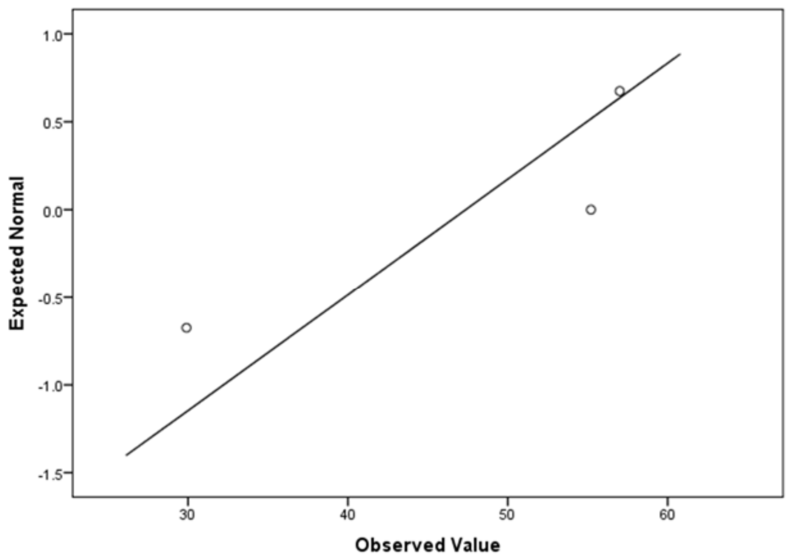

Figure J-187. Normal Q-Q Plot of 2015 SAGE % Mathematics Proficiency for ISAM16 = 1. This figure illustrates the observed value versus the expected normal for school leaders who ranked ISAM16 as 1 based on their school's school-wide 2015 SAGE % mathematics proficiency.

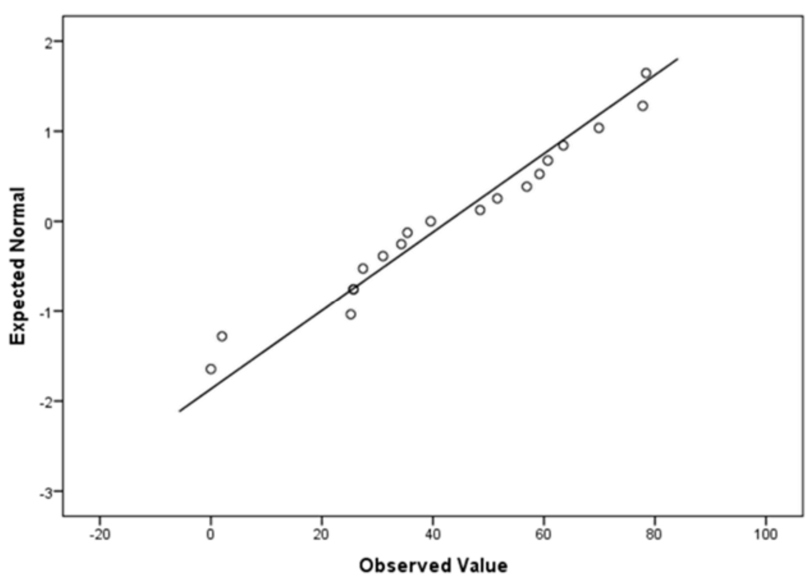

Figure J-188. Normal Q-Q Plot of 2015 SAGE % Mathematics Proficiency for ISAM16 = 2. This figure illustrates the observed value versus the expected normal for school leaders who ranked ISAM16 as 2 based on their school's school-wide 2015 SAGE % mathematics proficiency.

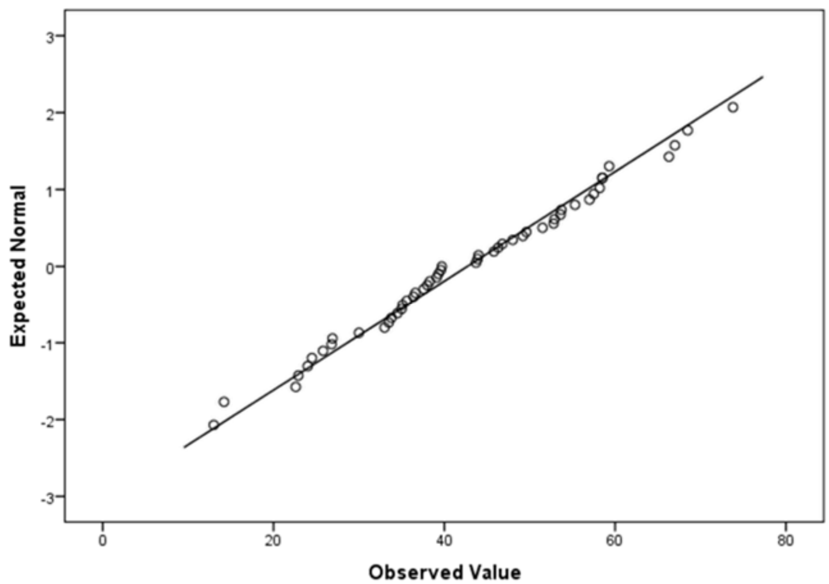

Figure J-189. Normal Q-Q Plot of 2015 SAGE % Mathematics Proficiency for ISAM16 = 3. This figure illustrates the observed value versus the expected normal for school leaders who ranked ISAM16 as 3 based on their school's school-wide 2015 SAGE % mathematics proficiency.

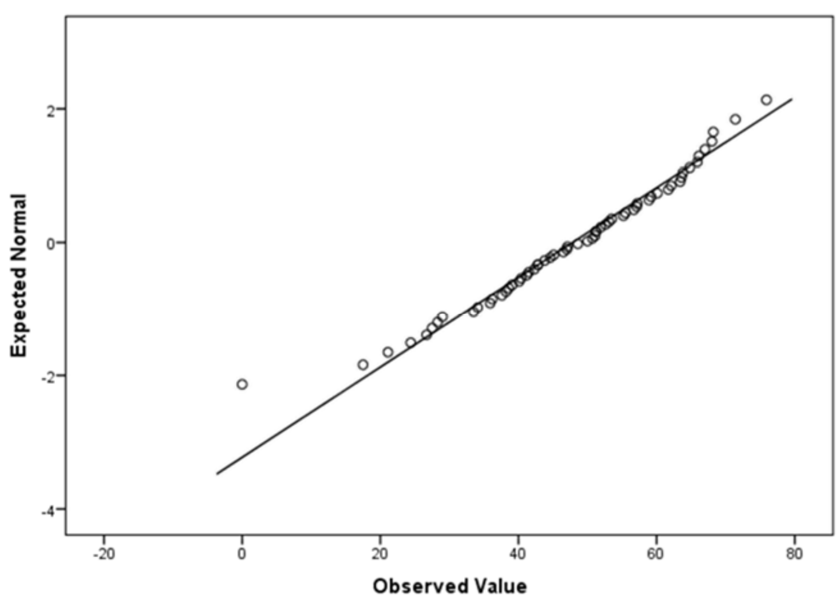

Figure J-190. Normal Q-Q Plot of 2015 SAGE % Mathematics Proficiency for ISAM16 = 4. This figure illustrates the observed value versus the expected normal for school leaders who ranked ISAM16 as 4 based on their school's school-wide 2015 SAGE % mathematics proficiency.

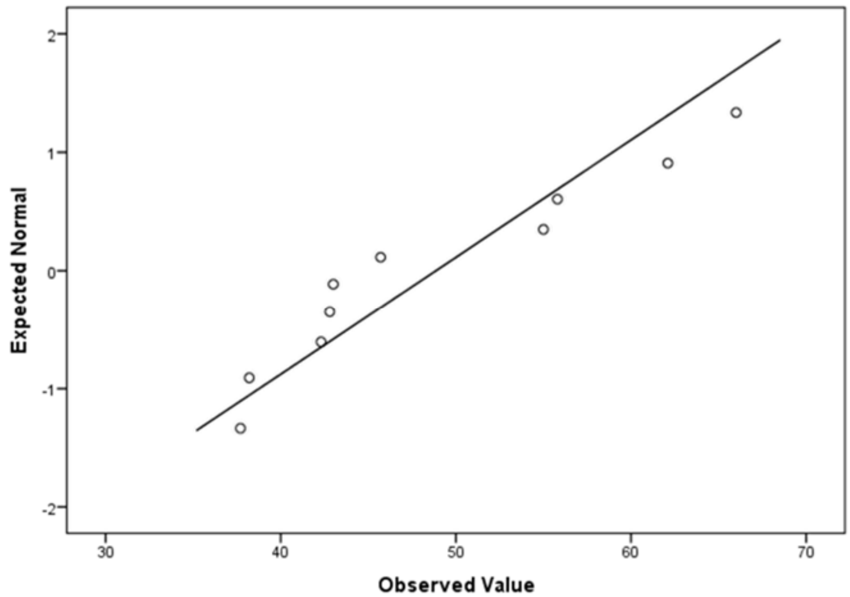

Figure J-191. Normal Q-Q Plot of 2015 SAGE % Mathematics Proficiency for ISAM16 = 5. This figure illustrates the observed value versus the expected normal for school leaders who ranked ISAM16 as 5 based on their school's school-wide 2015 SAGE % mathematics proficiency.

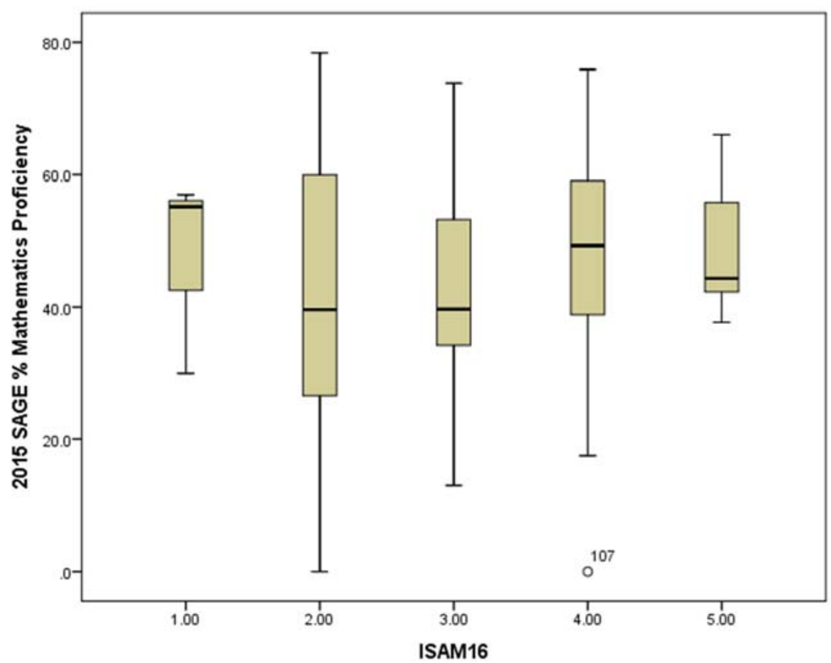

Figure J-192. Boxplot of 2015 SAGE % Mathematics Proficiency for ISAM16. This figure illustrates spread of school-wide 2015 SAGE % Mathematics Proficiency scores based on school leaders' ranking of ISAM16.

Table J-13

ISAM17: Tests for Normality

Variable		Shapiro-Wilk Statistic	*df*	Sig.	Skewness	Std. Error	Kurtosis	Std. Error
ISAM17	1	.95	8	.678	-.68	.75	.60	1.48
	2	.97	24	.735	.28	.47	.02	.92
	3	.97	43	.335	-.10	.36	-.75	.71
	4	.98	61	.354	-.48	.31	.28	.60
	5	.92	7	.500	.95	.79	1.03	1.59

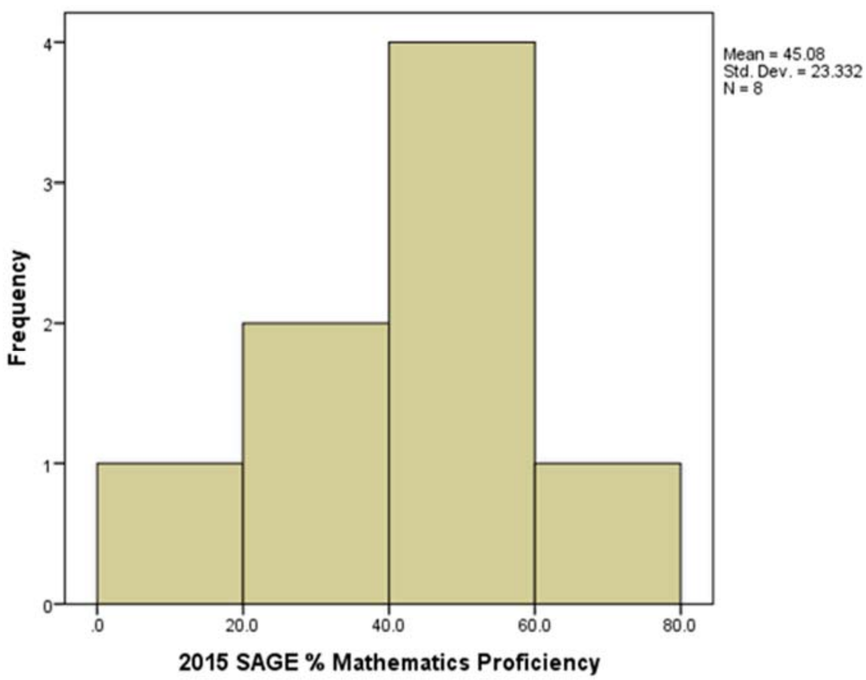

Figure J-193. Frequency by 2015 SAGE % Mathematics Proficiency for ISAM17 = 1. This figure illustrates the number of school leaders who rated ISAM17 at 1 based on their school's school-wide 2015 SAGE % mathematics proficiency.

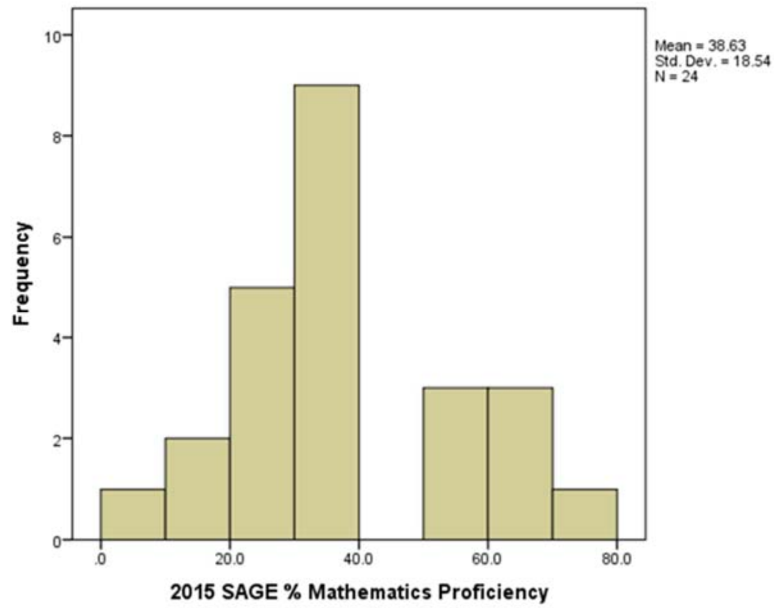

Figure J-194. Frequency by 2015 SAGE % Mathematics Proficiency for ISAM17 = 2. This figure illustrates the number of school leaders who rated ISAM17 at 2 based on their school's school-wide 2015 SAGE % mathematics proficiency.

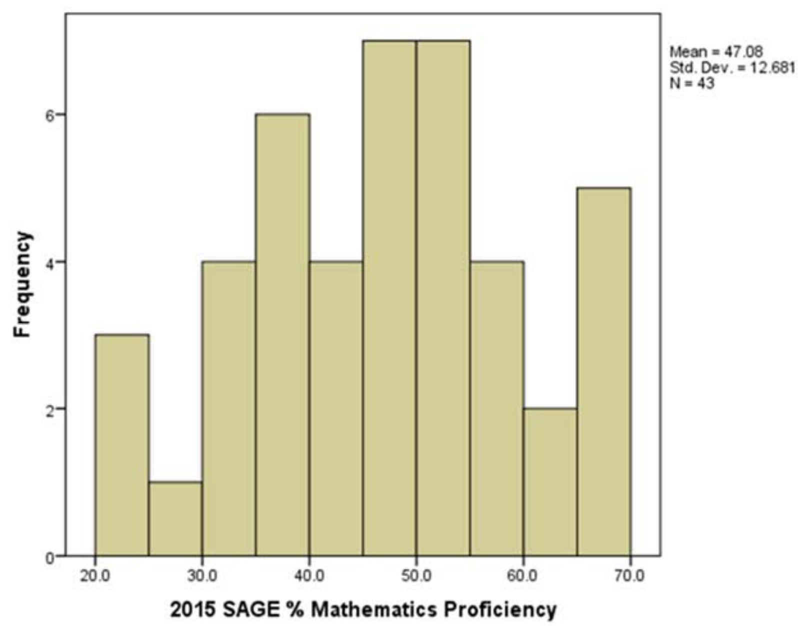

Figure J-195. Frequency by 2015 SAGE % Mathematics Proficiency for ISAM17 = 3. This figure illustrates the number of school leaders who rated ISAM17 at 3 based on their school's school-wide 2015 SAGE % mathematics proficiency.

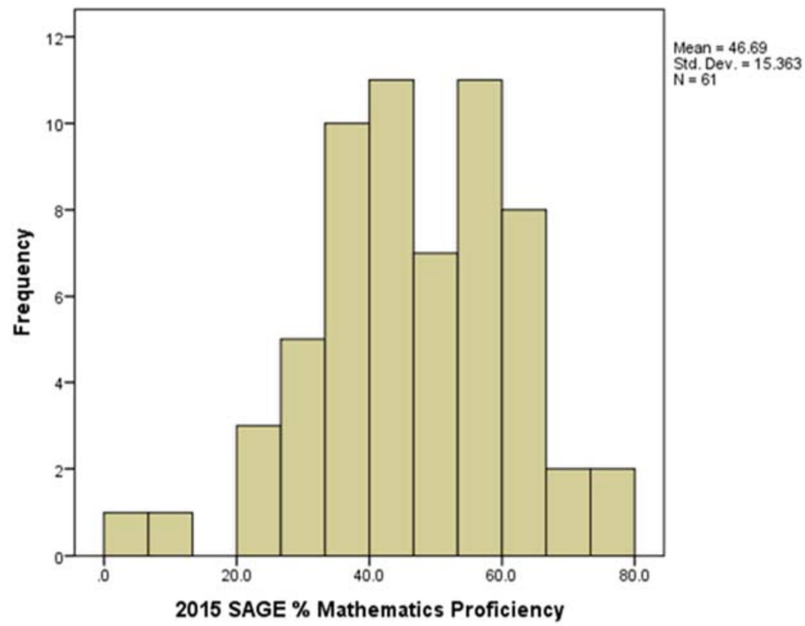

Figure J-196. Frequency by 2015 SAGE % Mathematics Proficiency for ISAM17 = 4. This figure illustrates the number of school leaders who rated ISAM17 at 4 based on their school's school-wide 2015 SAGE % mathematics proficiency.

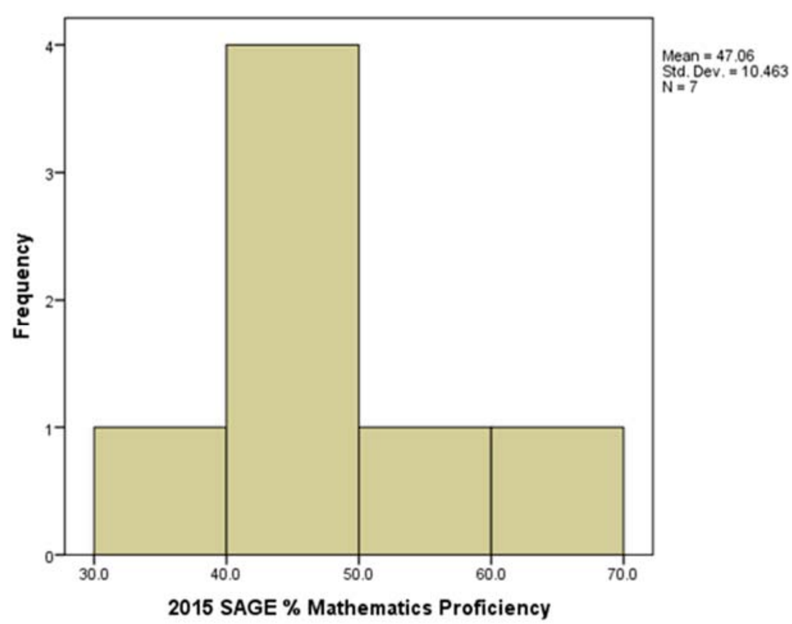

Figure J-197. Frequency by 2015 SAGE % Mathematics Proficiency for ISAM17 = 5. This figure illustrates the number of school leaders who rated ISAM17 at 5 based on their school's school-wide 2015 SAGE % mathematics proficiency.

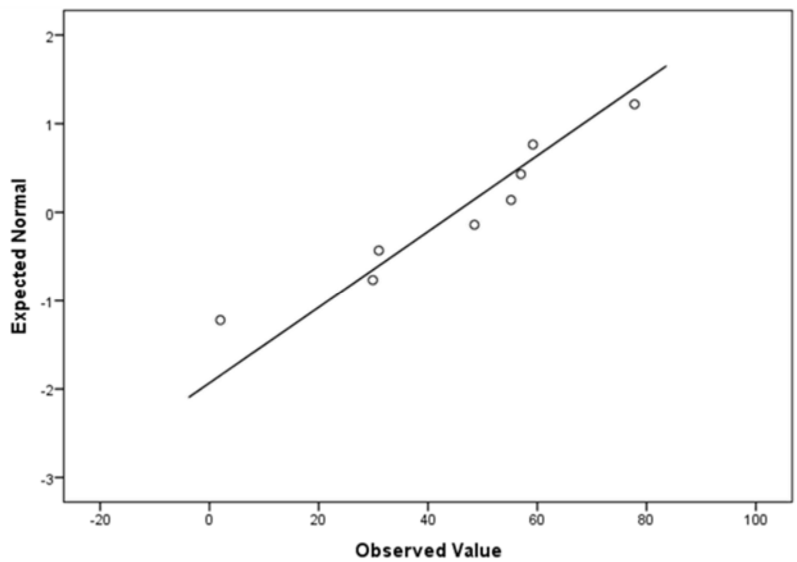

Figure J-198. Normal Q-Q Plot of 2015 SAGE % Mathematics Proficiency for ISAM17 = 1. This figure illustrates the observed value versus the expected normal for school leaders who ranked ISAM17 as 1 based on their school's school-wide 2015 SAGE % mathematics proficiency.

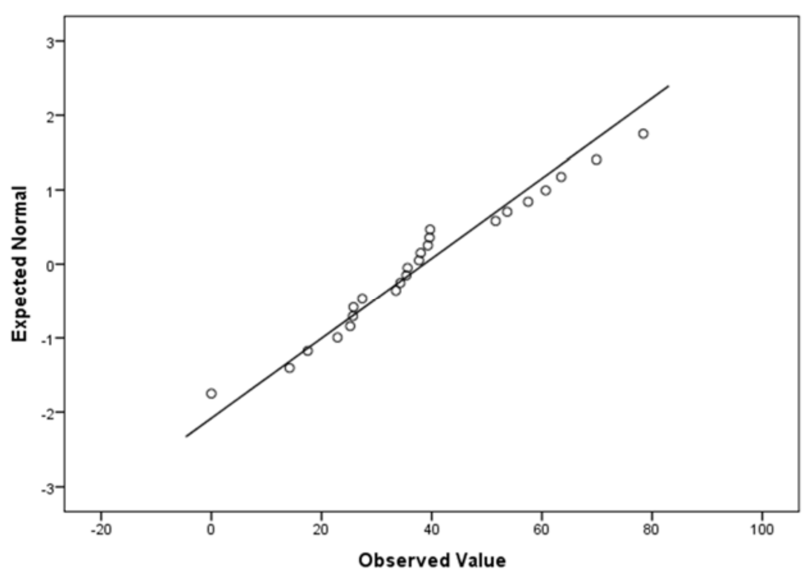

Figure J-199. Normal Q-Q Plot of 2015 SAGE % Mathematics Proficiency for ISAM17 = 2. This figure illustrates the observed value versus the expected normal for school leaders who ranked ISAM17 as 2 based on their school's school-wide 2015 SAGE % mathematics proficiency.

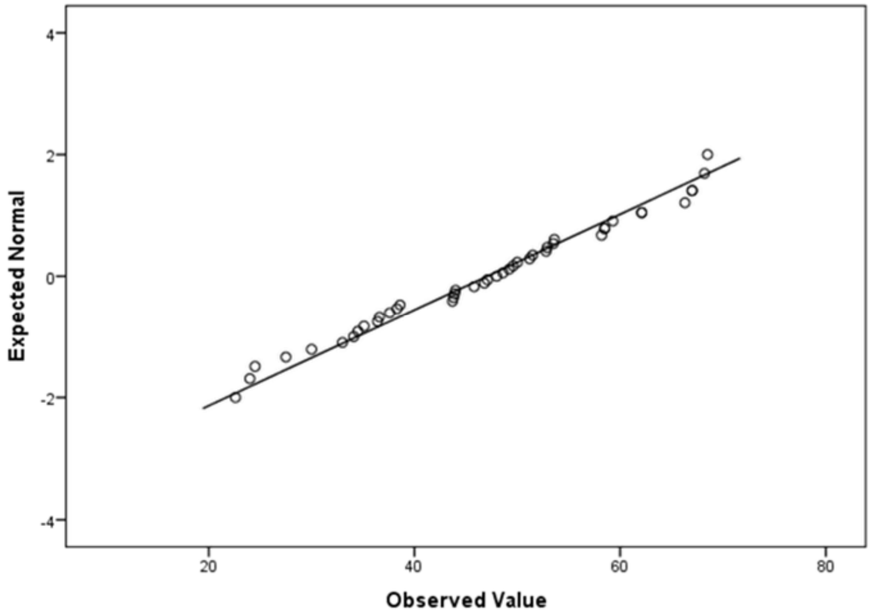

Figure J-200. Normal Q-Q Plot of 2015 SAGE % Mathematics Proficiency for ISAM17 = 3. This figure illustrates the observed value versus the expected normal for school leaders who ranked ISAM17 as 3 based on their school's school-wide 2015 SAGE % mathematics proficiency.

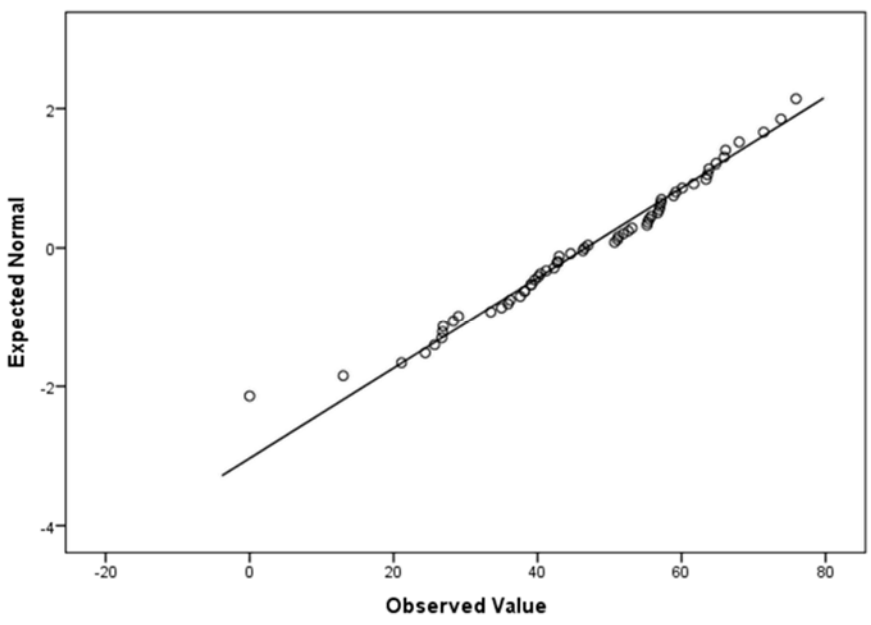

Figure J-201. Normal Q-Q Plot of 2015 SAGE % Mathematics Proficiency for ISAM17 = 4. This figure illustrates the observed value versus the expected normal for school leaders who ranked ISAM17 as 4 based on their school's school-wide 2015 SAGE % mathematics proficiency.

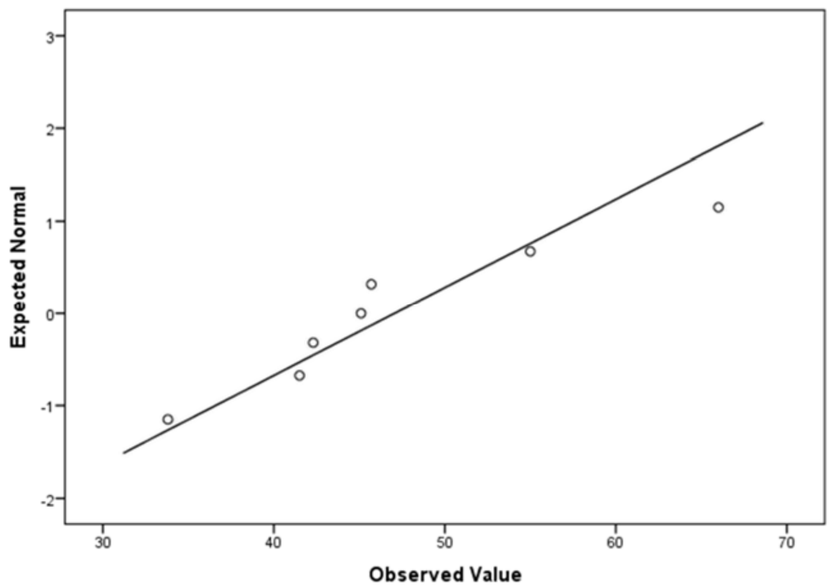

Figure J-202. Normal Q-Q Plot of 2015 SAGE % Mathematics Proficiency for ISAM17 = 5. This figure illustrates the observed value versus the expected normal for school leaders who ranked ISAM17 as 5 based on their school's school-wide 2015 SAGE % mathematics proficiency.

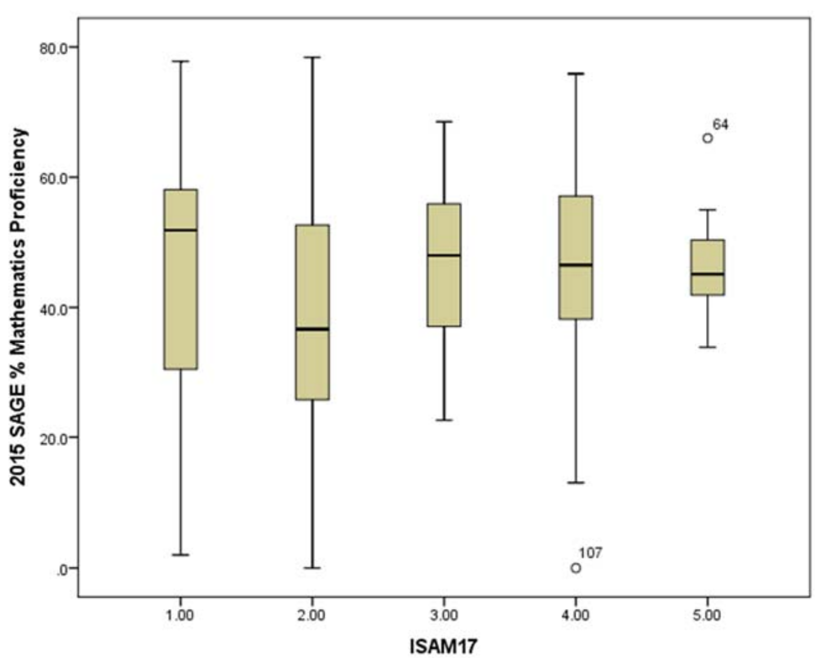

Figure J-203. Boxplot of 2015 SAGE % Mathematics Proficiency for ISAM17. This figure illustrates spread of school-wide 2015 SAGE % Mathematics Proficiency scores based on school leaders' ranking of ISAM17.

Table J-14

Fam_PD_CI_Doc: Tests for Normality

Variable		Shapiro-Wilk Statistic	*df*	Sig.	Skewness	Std. Error	Kurtosis	Std. Error
Fam_PD_CI_Doc	1	.86	5	.232	-.48	.91	-2.79	2.00
	2	.98	24	.909	-.2	.47	.06	.92
	3	.96	32	.333	-.34	.41	.40	.81
	4	.98	40	.498	.00	.37	-.72	.73
	5	.97	37	.397	-.59	.39	.57	.76
	6	.92	9	.393	.53	.72	-.34	1.40

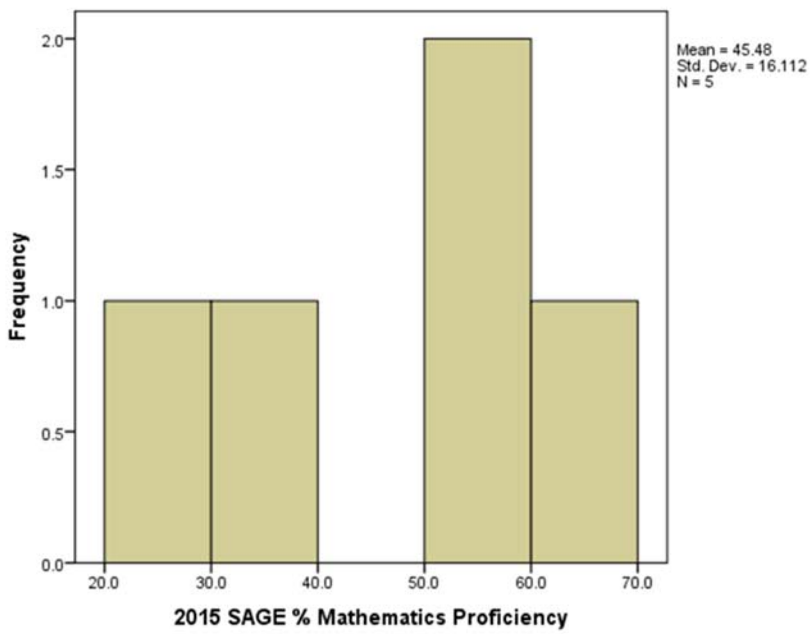

Figure J-204. Frequency by 2015 SAGE % Mathematics Proficiency for Fam_PD_CI_Doc = 1. This figure illustrates the number of school leaders who rated Fam_PD_CI_Doc at 1 based on their school's school-wide 2015 SAGE % mathematics proficiency.

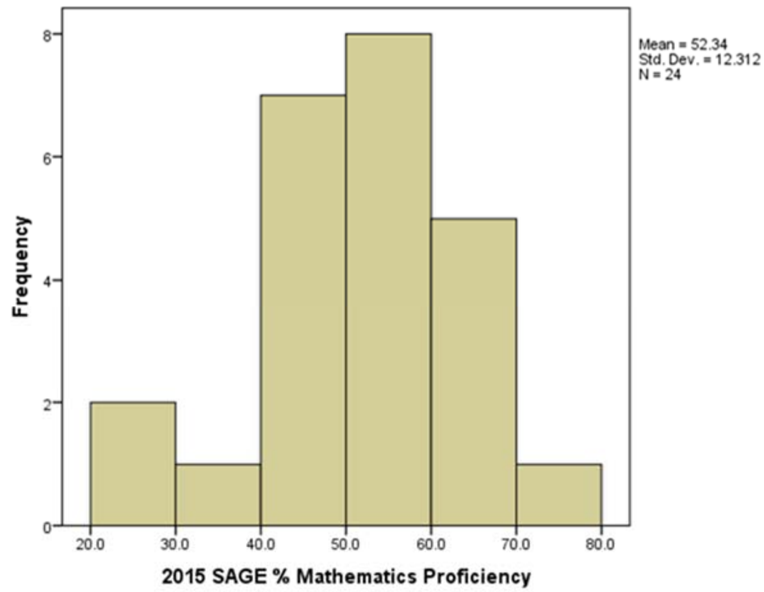

Figure J-205. Frequency by 2015 SAGE % Mathematics Proficiency for Fam_PD_CI_Doc = 2. This figure illustrates the number of school leaders who rated Fam_PD_CI_Doc at 2 based on their school's school-wide 2015 SAGE % mathematics proficiency.

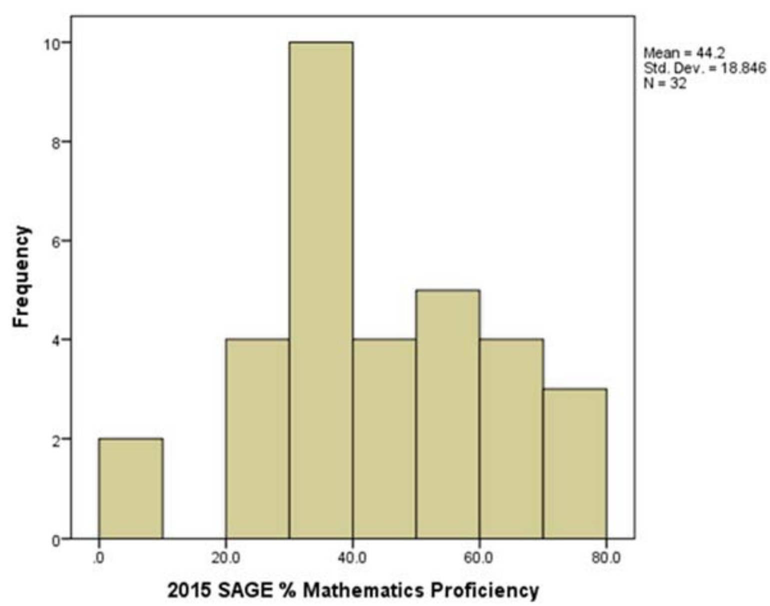

Figure J-206. Frequency by 2015 SAGE % Mathematics Proficiency for Fam_PD_CI_Doc = 3. This figure illustrates the number of school leaders who rated Fam_PD_CI_Doc at 3 based on their school's school-wide 2015 SAGE % mathematics proficiency.

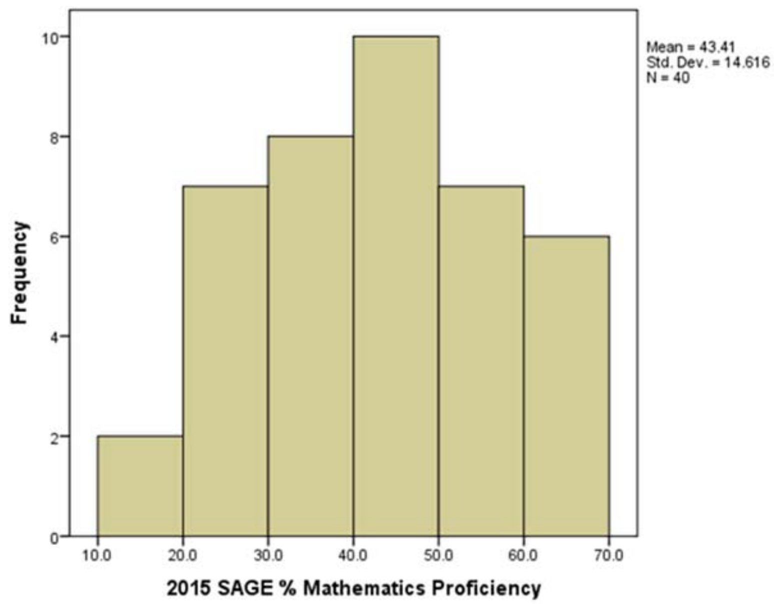

Figure J-207. Frequency by 2015 SAGE % Mathematics Proficiency for Fam_PD_CI_Doc = 4. This figure illustrates the number of school leaders who rated Fam_PD_CI_Doc at 4 based on their school's school-wide 2015 SAGE % mathematics proficiency.

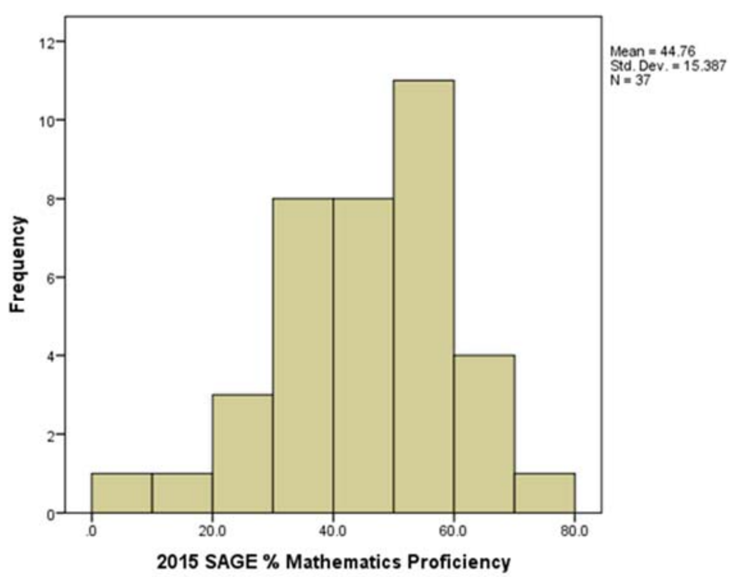

Figure J-208. Frequency by 2015 SAGE % Mathematics Proficiency for Fam_PD_CI_Doc = 5. This figure illustrates the number of school leaders who rated Fam_PD_CI_Doc at 5 based on their school's school-wide 2015 SAGE % mathematics proficiency.

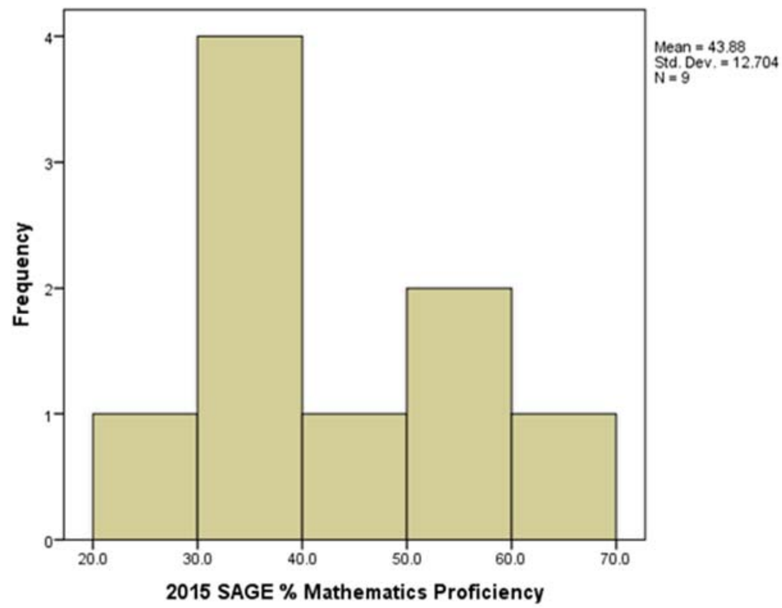

Figure J-209. Frequency by 2015 SAGE % Mathematics Proficiency for Fam_PD_CI_Doc = 6. This figure illustrates the number of school leaders who rated Fam_PD_CI_Doc at 6 based on their school's school-wide 2015 SAGE % mathematics proficiency.

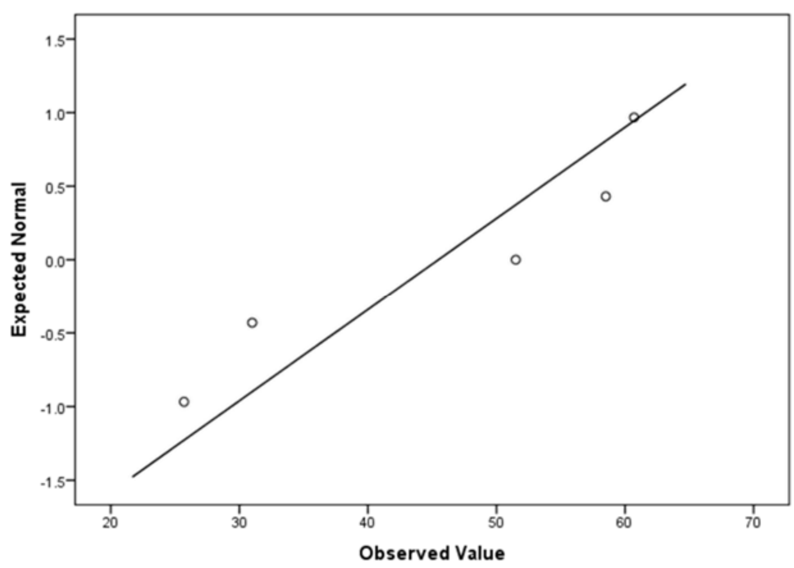

Figure J-210. Normal Q-Q Plot of 2015 SAGE % Mathematics Proficiency for Fam_PD_CI_Doc = 1. This figure illustrates the observed value versus the expected normal for school leaders who ranked Fam_PD_CI_Doc as 1 based on their school's school-wide 2015 SAGE % mathematics proficiency.

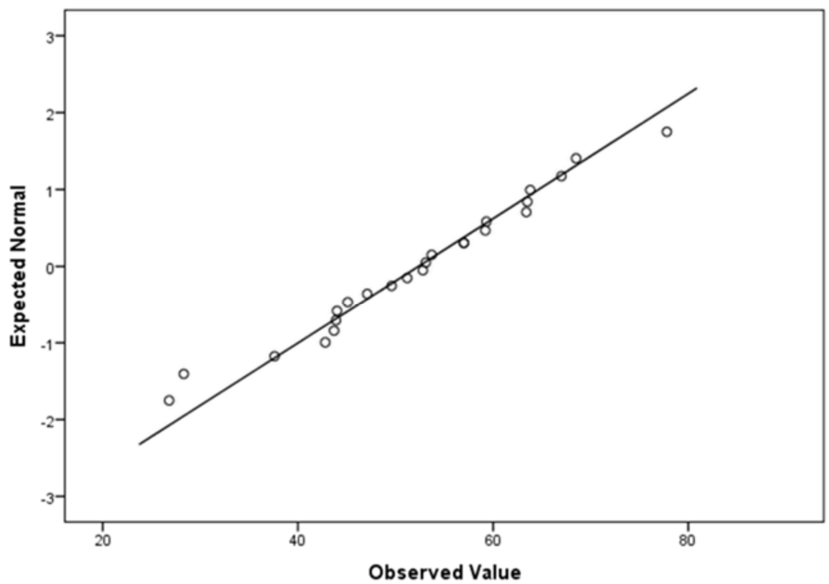

Figure J-211. Normal Q-Q Plot of 2015 SAGE % Mathematics Proficiency for Fam_PD_CI_Doc = 2. This figure illustrates the observed value versus the expected normal for school leaders who ranked Fam_PD_CI_Doc as 2 based on their school's school-wide 2015 SAGE % mathematics proficiency.

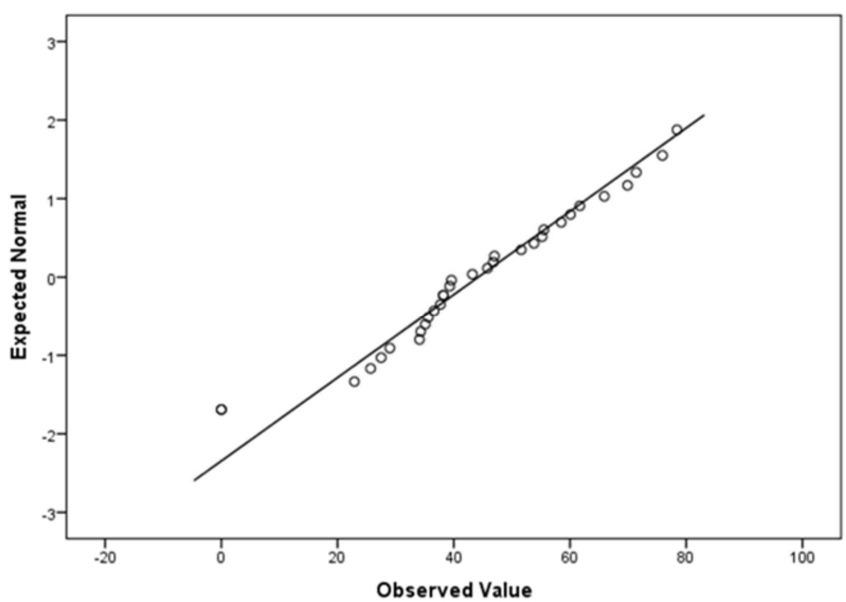

Figure J-212. Normal Q-Q Plot of 2015 SAGE % Mathematics Proficiency for Fam_PD_CI_Doc = 3. This figure illustrates the observed value versus the expected normal for school leaders who ranked Fam_PD_CI_Doc as 3 based on their school's school-wide 2015 SAGE % mathematics proficiency.

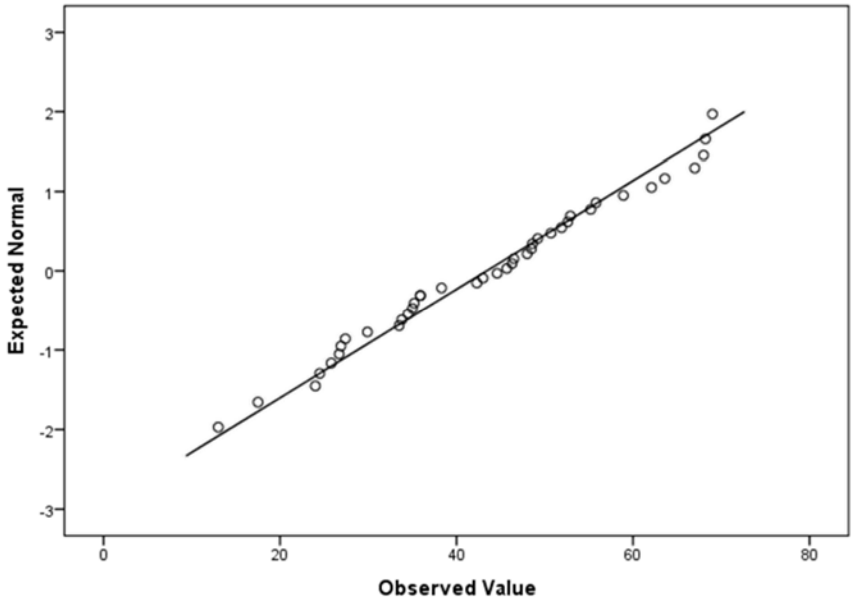

Figure J-213. Normal Q-Q Plot of 2015 SAGE % Mathematics Proficiency for Fam_PD_CI_Doc = 4. This figure illustrates the observed value versus the expected normal for school leaders who ranked Fam_PD_CI_Doc as 4 based on their school's school-wide 2015 SAGE % mathematics proficiency.

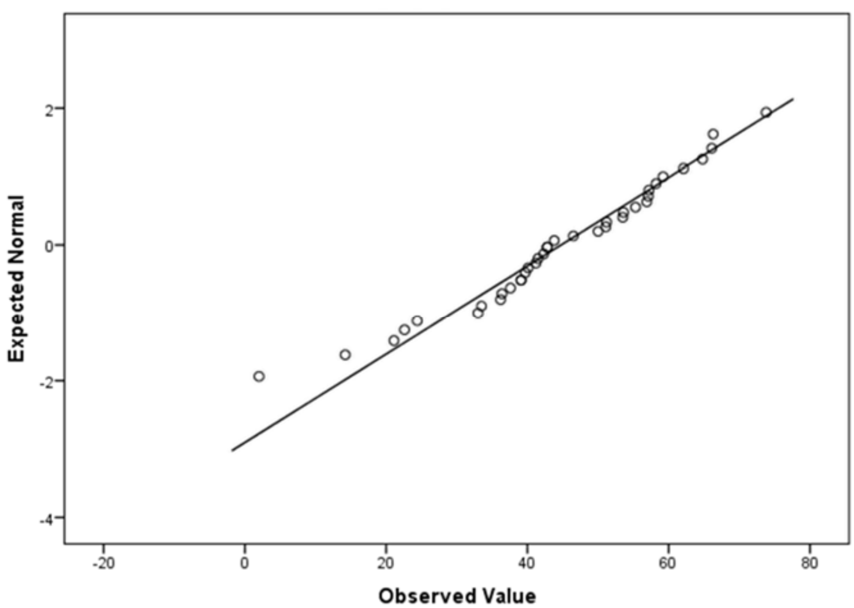

Figure J-214. Normal Q-Q Plot of 2015 SAGE % Mathematics Proficiency for Fam_PD_CI_Doc = 5. This figure illustrates the observed value versus the expected normal for school leaders who ranked Fam_PD_CI_Doc as 5 based on their school's school-wide 2015 SAGE % mathematics proficiency.

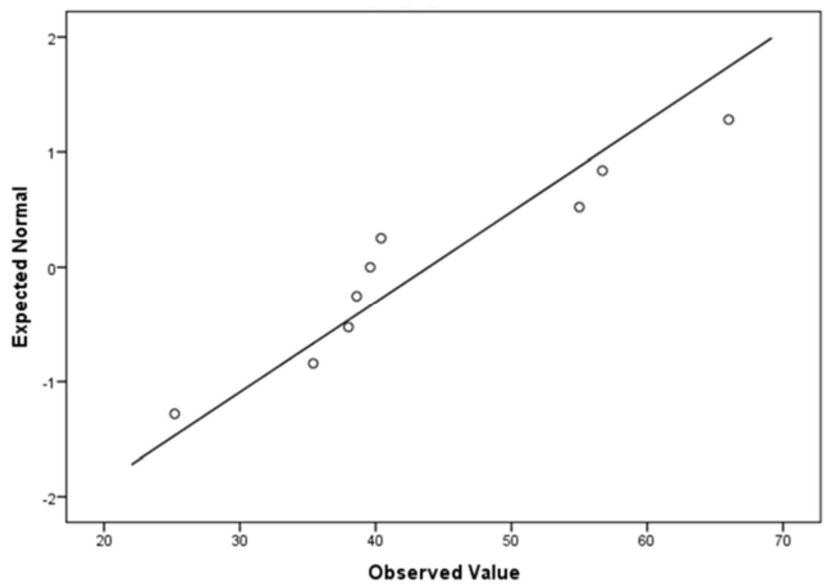

Figure J-215. Normal Q-Q Plot of 2015 SAGE % Mathematics Proficiency for Fam_PD_CI_Doc = 6. This figure illustrates the observed value versus the expected normal for school leaders who ranked Fam_PD_CI_Doc as 6 based on their school's school-wide 2015 SAGE % mathematics proficiency.

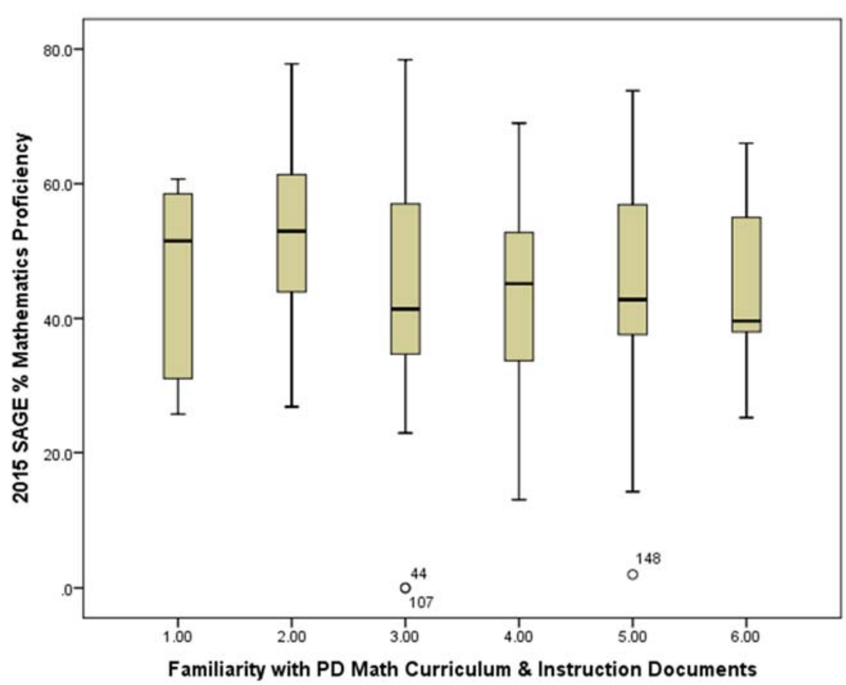

Figure J-216. Boxplot of 2015 SAGE % Mathematics Proficiency for Fam_PD_CI_Doc. This figure illustrates spread of school-wide 2015 SAGE % Mathematics Proficiency scores based on school leaders' ranking of Fam_PD_CI_Doc.

Table J-15

Sec_Ed: Tests for Normality

		Shapiro-Wilk						
Variable		Statistic	df	Sig.	Skewness	Std. Error	Kurtosis	Std. Error
Sec_ Ed	No	.99	94	.383	-.39	.25	.06	.49
	Yes, Minor	.95	18	.460	-.55	.54	1.36	1.04
	Yes, Major	.97	37	.519	.17	.39	-.85	.76

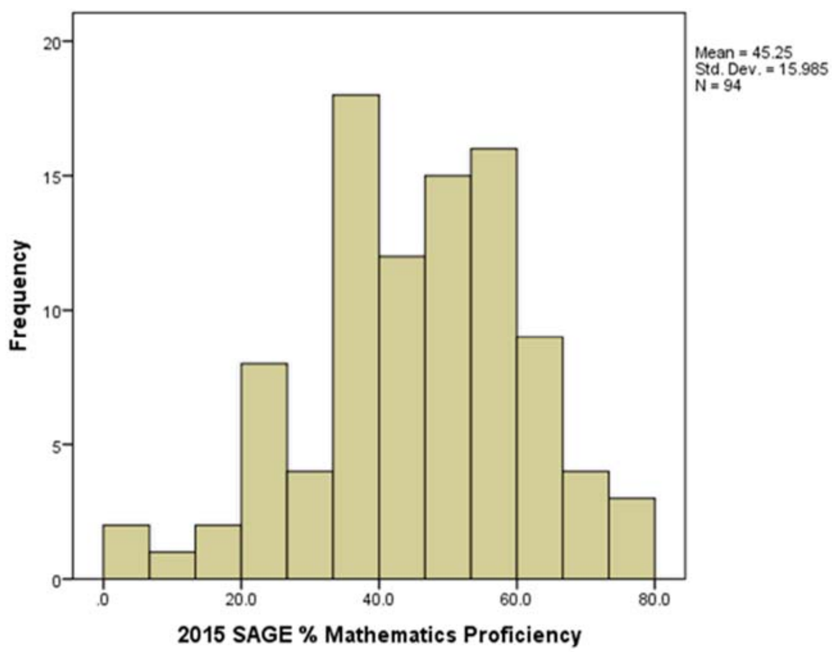

Figure J-217. Frequency by 2015 SAGE % Mathematics Proficiency for Sec_Ed = No. This figure illustrates the number of school leaders who rated Sec_Ed at No based on their school's school-wide 2015 SAGE % mathematics proficiency.

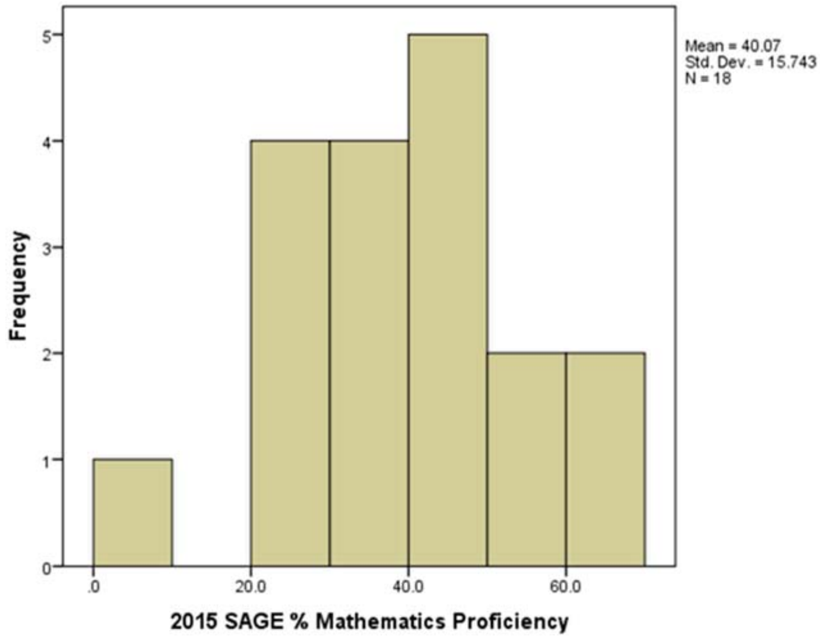

Figure J-218. Frequency by 2015 SAGE % Mathematics Proficiency for Sec_Ed = Yes, Minor/Sp.Emphasis. This figure illustrates the number of school leaders who rated Sec_Ed at Yes, Minor/Sp.Emphasis based on their school's school-wide 2015 SAGE % mathematics proficiency.

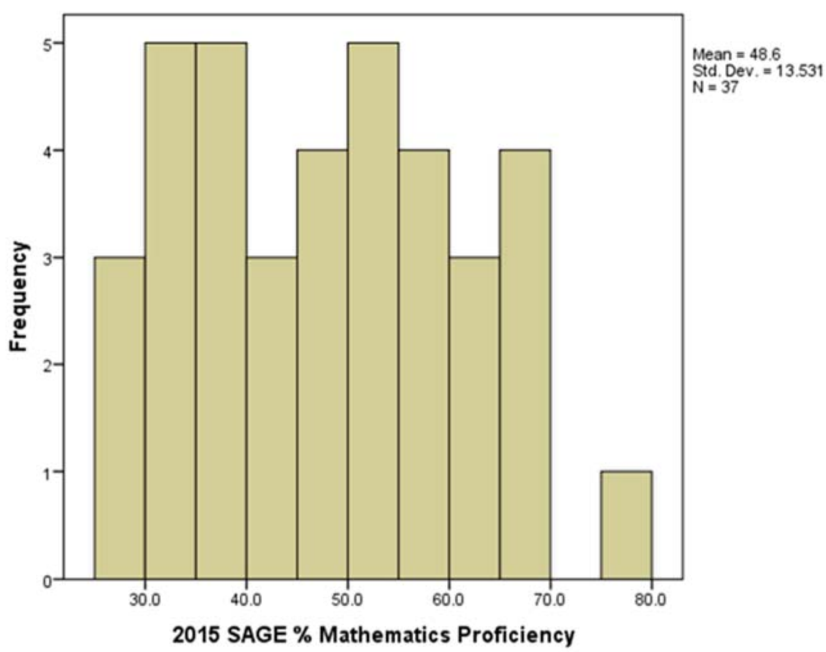

Figure J-219. Frequency by 2015 SAGE % Mathematics Proficiency for Sec_Ed = Yes, Major. This figure illustrates the number of school leaders who rated Sec_Ed at Yes, Major based on their school's school-wide 2015 SAGE % mathematics proficiency.

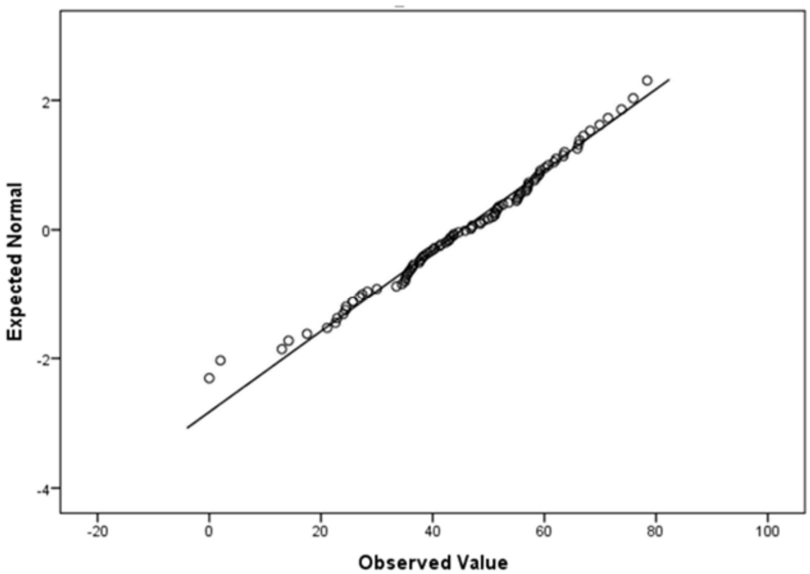

Figure J-220. Normal Q-Q Plot of 2015 SAGE % Mathematics Proficiency for Sec_Ed = No. This figure illustrates the observed value versus the expected normal for school leaders who ranked Sec_Ed as No based on their school's school-wide 2015 SAGE % mathematics proficiency.

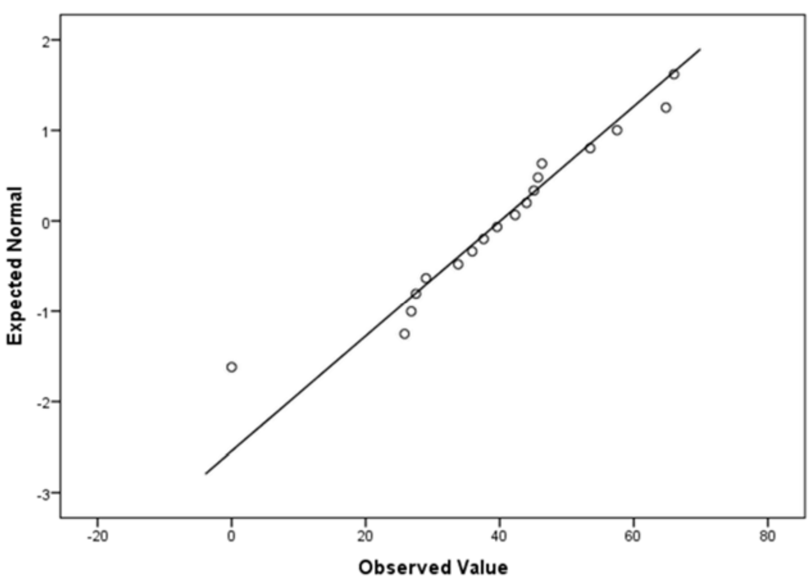

Figure J-221. Normal Q-Q Plot of 2015 SAGE % Mathematics Proficiency for Sec_Ed = Yes, Minor/Sp.Emphasis. This figure illustrates the observed value versus the expected normal for school leaders who ranked Sec_Ed as Yes, Minor/Sp.Emphasis based on their school's school-wide 2015 SAGE % mathematics proficiency.

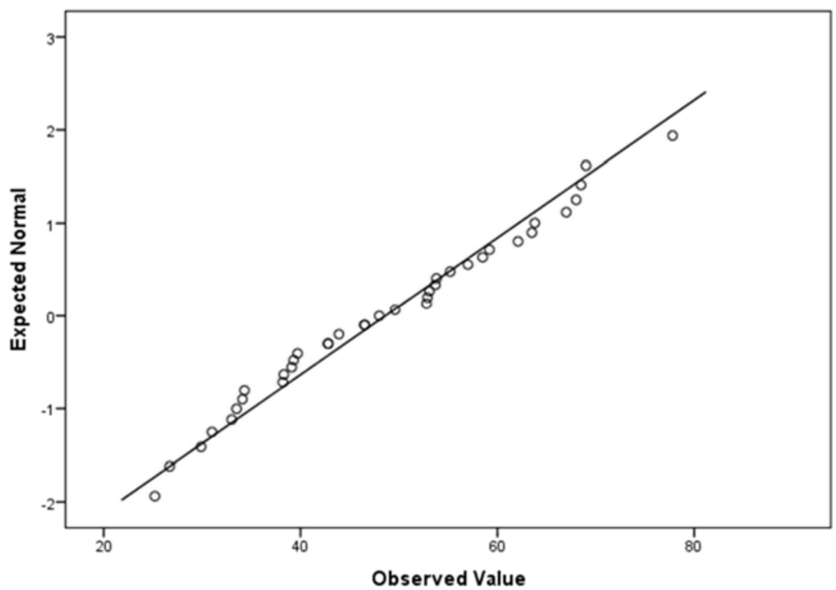

Figure J-222. Normal Q-Q Plot of 2015 SAGE % Mathematics Proficiency for Sec_Ed = Yes, Major. This figure illustrates the observed value versus the expected normal for school leaders who ranked Sec_Ed as Yes, Major based on their school's school-wide 2015 SAGE % mathematics proficiency.

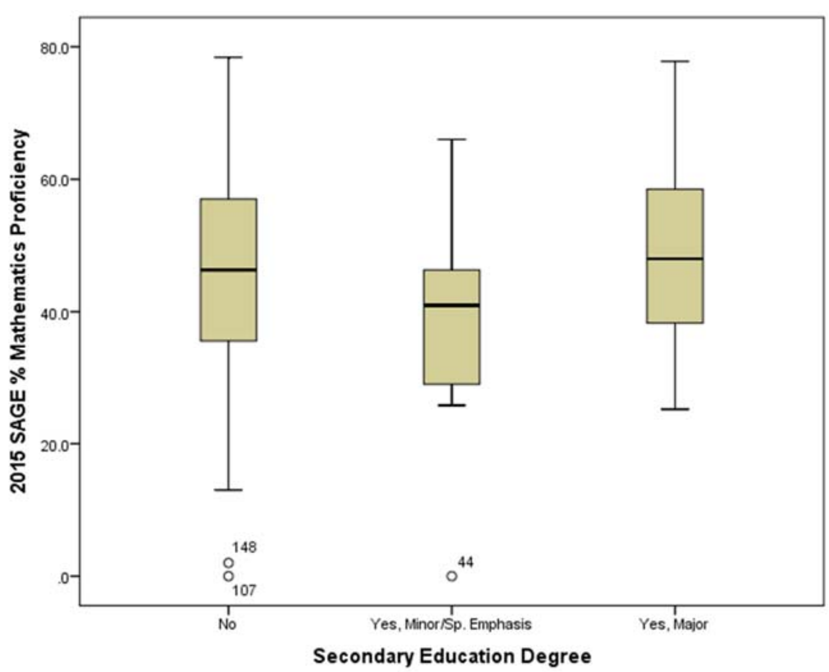

Figure J-223. Boxplot of 2015 SAGE % Mathematics Proficiency for Sec_Ed. This figure illustrates spread of school-wide 2015 SAGE % Mathematics Proficiency scores based on school leaders' ranking of Sec_Ed.

Table J-16

ISAM13: Tests for Normality

Variable		Shapiro-Wilk Statistic	df	Sig.	Skewness	Std. Error	Kurtosis	Std. Error
ISAM13	1							
	2							
	3	.94	8	.620	-.48	.75	-.54	1.48
	4	.98	78	.176	-.34	.27	-.18	.54
	5	.98	57	.565	-.05	.32	-.49	.62

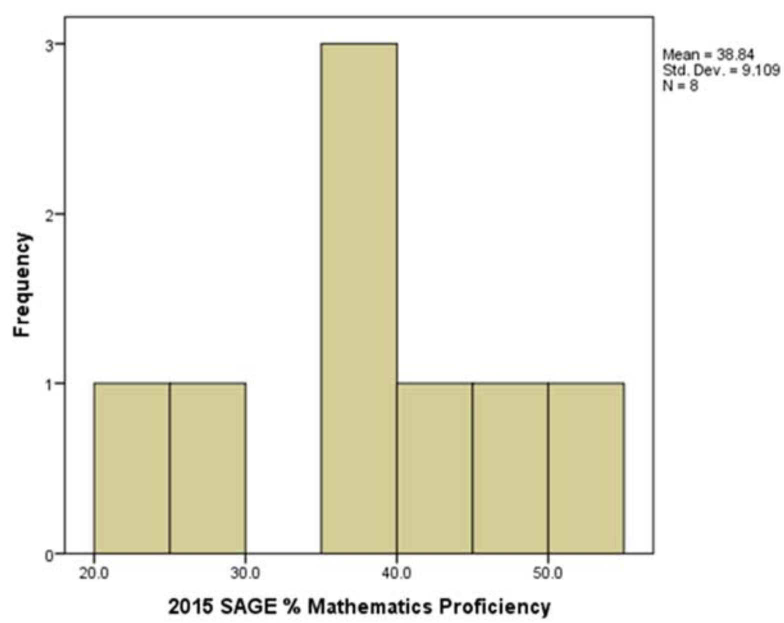

Figure J-224. Frequency by 2015 SAGE % Mathematics Proficiency for ISAM13 = 3. This figure illustrates the number of school leaders who rated ISAM13 at 3 based on their school's school-wide 2015 SAGE % mathematics proficiency.

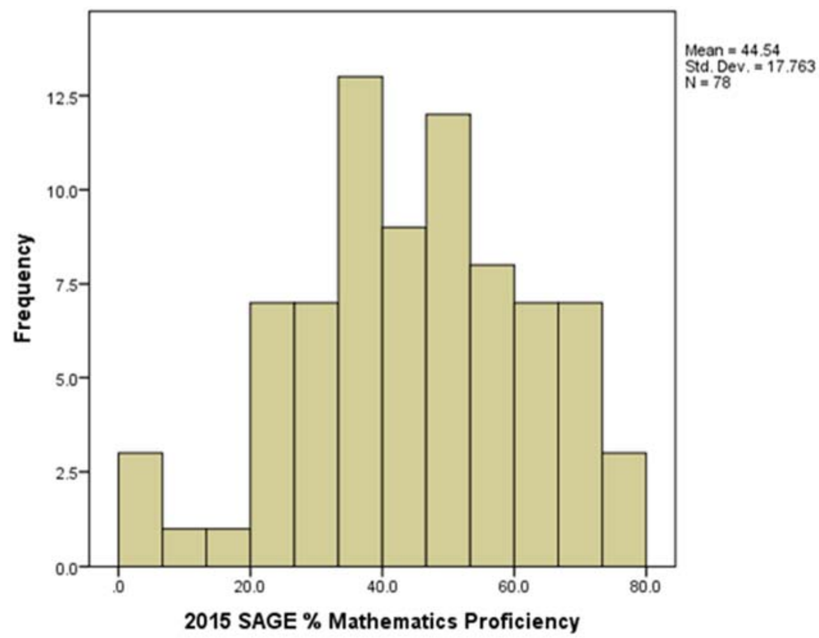

Figure J-225. Frequency by 2015 SAGE % Mathematics Proficiency for ISAM13 = 4. This figure illustrates the number of school leaders who rated ISAM13 at 4 based on their school's school-wide 2015 SAGE % mathematics proficiency.

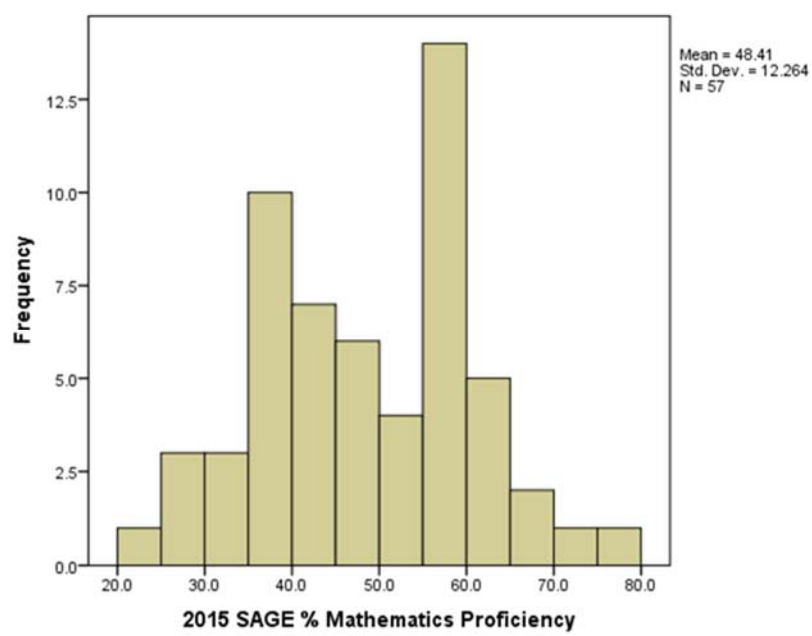

Figure J-226. Frequency by 2015 SAGE % Mathematics Proficiency for ISAM13 = 5. This figure illustrates the number of school leaders who rated ISAM13 at 5 based on their school's school-wide 2015 SAGE % mathematics proficiency.

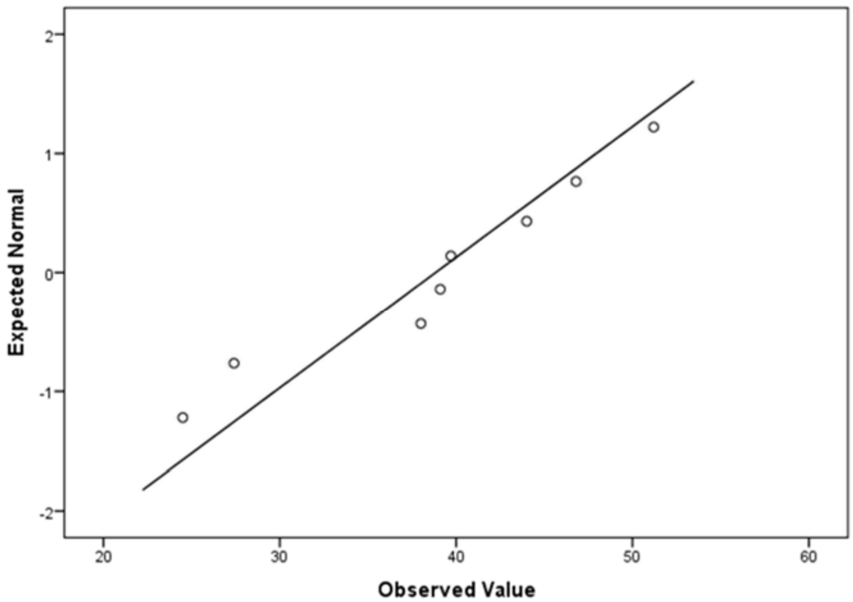

Figure J-227. Normal Q-Q Plot of 2015 SAGE % Mathematics Proficiency for ISAM13 = 3. This figure illustrates the observed value versus the expected normal for school leaders who ranked ISAM13 as 3 based on their school's school-wide 2015 SAGE % mathematics proficiency.

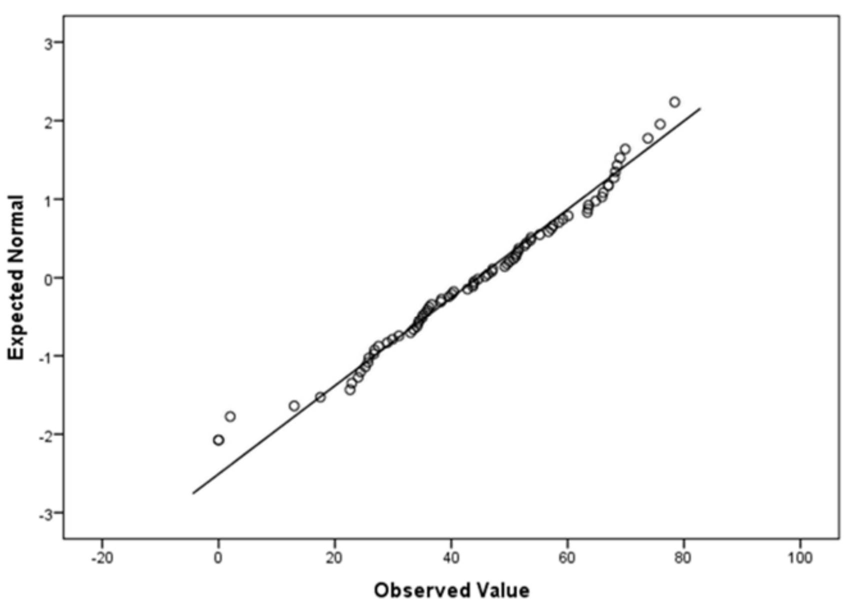

Figure J-228. Normal Q-Q Plot of 2015 SAGE % Mathematics Proficiency for ISAM13 = 4. This figure illustrates the observed value versus the expected normal for school leaders who ranked ISAM13 as 4 based on their school's school-wide 2015 SAGE % mathematics proficiency.

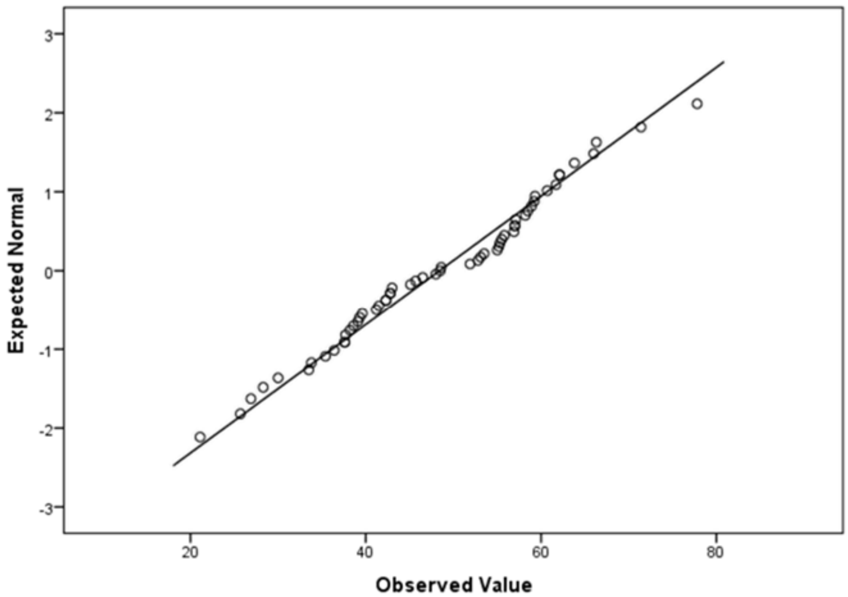

Figure J-229. Normal Q-Q Plot of 2015 SAGE % Mathematics Proficiency for ISAM13 = 5. This figure illustrates the observed value versus the expected normal for school leaders who ranked ISAM13 as 5 based on their school's school-wide 2015 SAGE % mathematics proficiency.

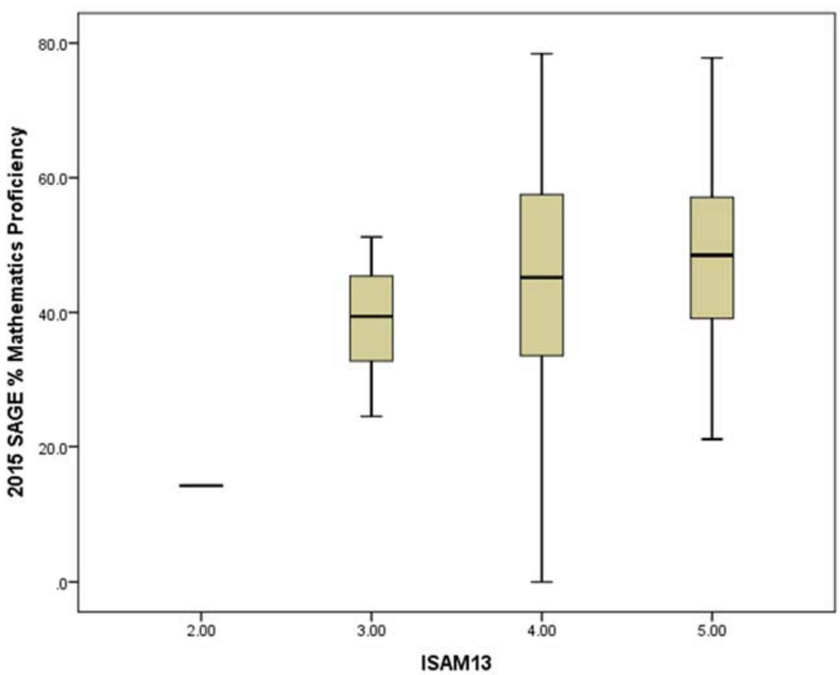

Figure J-230. Boxplot of 2015 SAGE % Mathematics Proficiency for ISAM13. This figure illustrates spread of school-wide 2015 SAGE % Mathematics Proficiency scores based on school leaders' ranking of ISAM13.

Table J-17

MTL62: Tests for Normality

Variable		Shapiro-Wilk Statistic	df	Sig.	Skewness	Std. Error	Kurtosis	Std. Error
MTL62	1							
	2							
	3	.94	16	.336	-.21	.56	-.94	1.09
	4	.98	66	.534	-.09	.30	-.08	.58
	5	.95	5	.725	-.05	.91	1.68	2.00

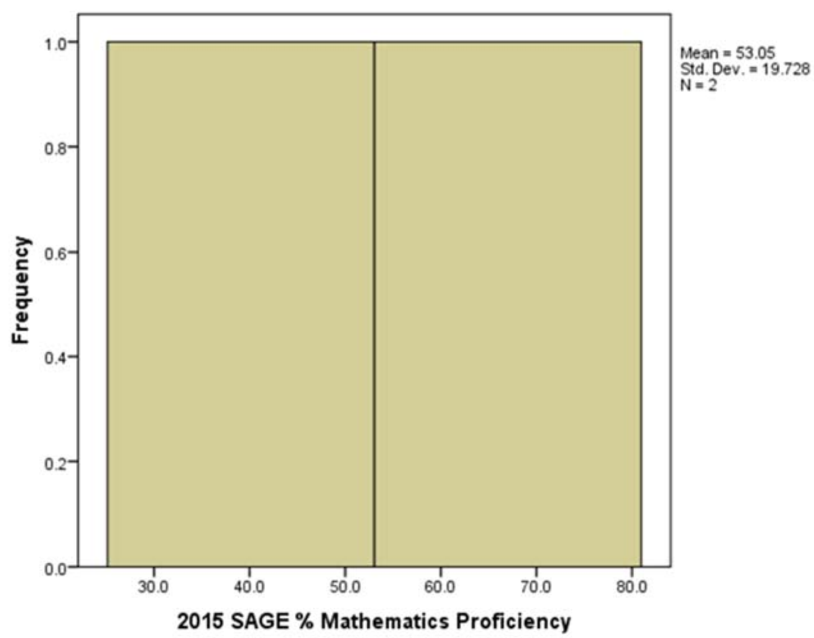

Figure J-231. Frequency by 2015 SAGE % Mathematics Proficiency for MTL62 = 2. This figure illustrates the number of school leaders who rated MTL62 at 2 based on their school's school-wide 2015 SAGE % mathematics proficiency.

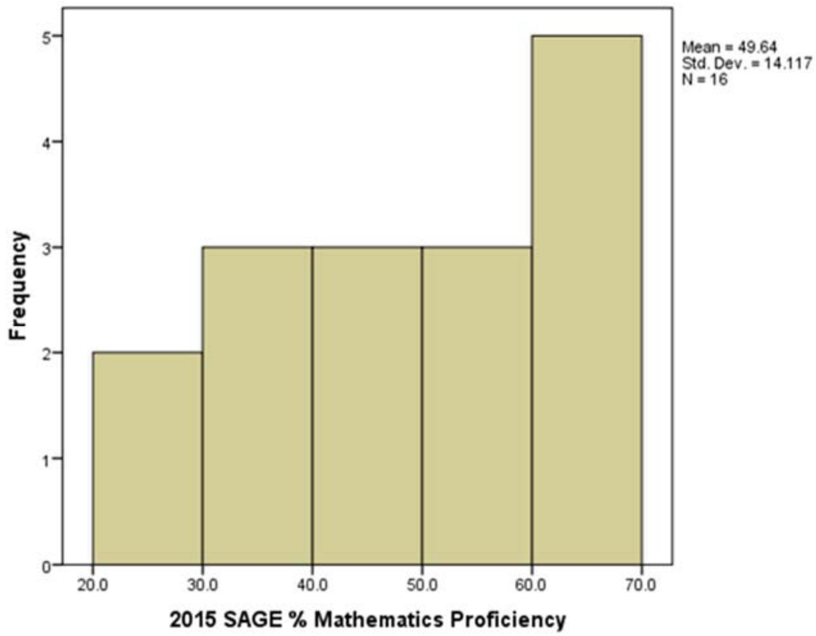

Figure J-232. Frequency by 2015 SAGE % Mathematics Proficiency for MTL62 = 3. This figure illustrates the number of school leaders who rated MTL62 at 3 based on their school's school-wide 2015 SAGE % mathematics proficiency.

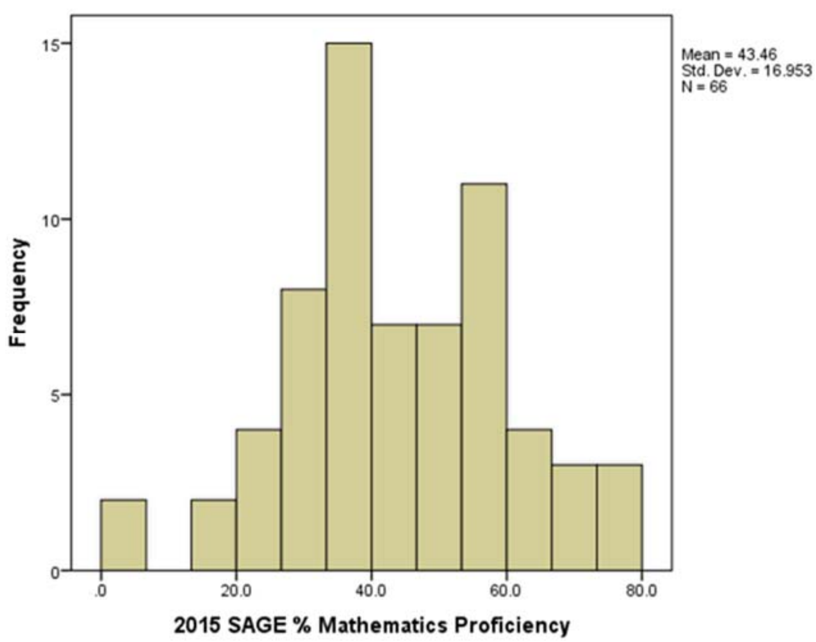

Figure J-233. Frequency by 2015 SAGE % Mathematics Proficiency for MTL62 = 4. This figure illustrates the number of school leaders who rated MTL62 at 4 based on their school's school-wide 2015 SAGE % mathematics proficiency.

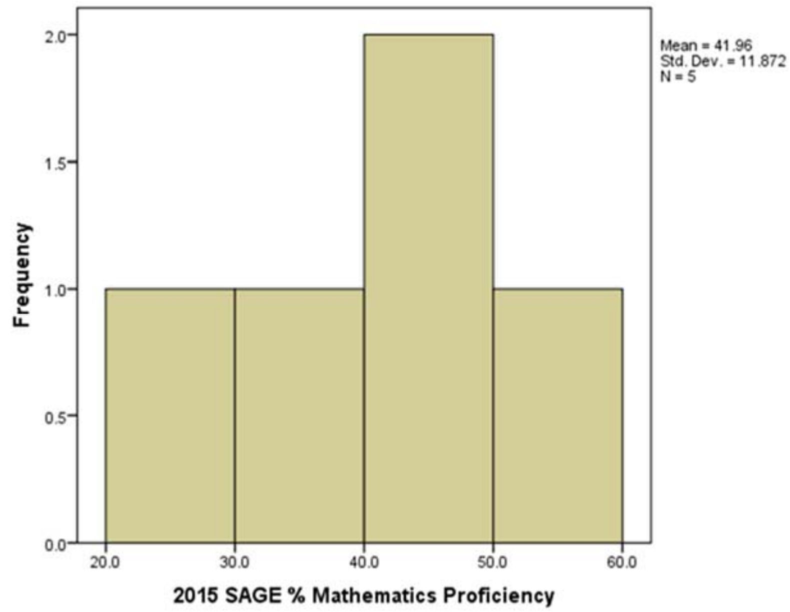

Figure J-234. Frequency by 2015 SAGE % Mathematics Proficiency for MTL62 = 5. This figure illustrates the number of school leaders who rated MTL62 at 5 based on their school's school-wide 2015 SAGE % mathematics proficiency.

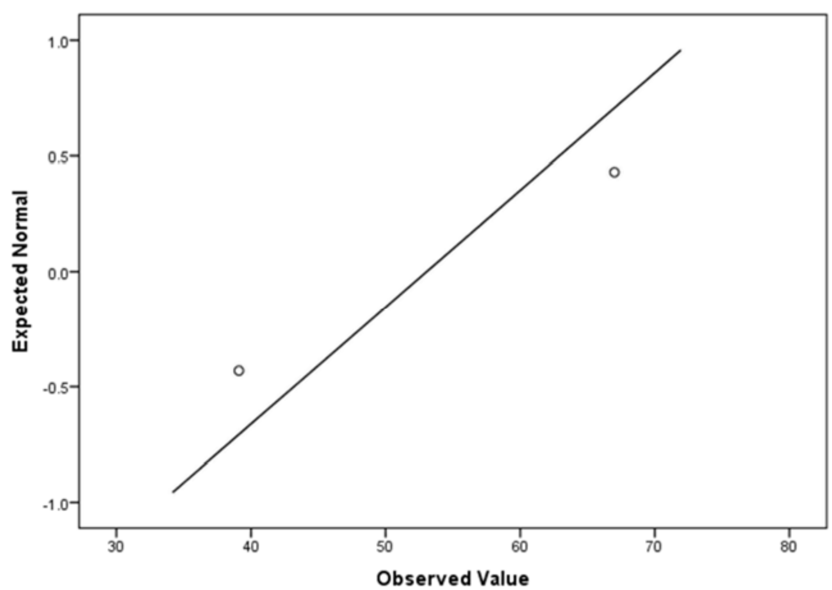

Figure J-235. Normal Q-Q Plot of 2015 SAGE % Mathematics Proficiency for MTL62 = 2. This figure illustrates the observed value versus the expected normal for school leaders who ranked MTL62 as 2 based on their school's school-wide 2015 SAGE % mathematics proficiency.

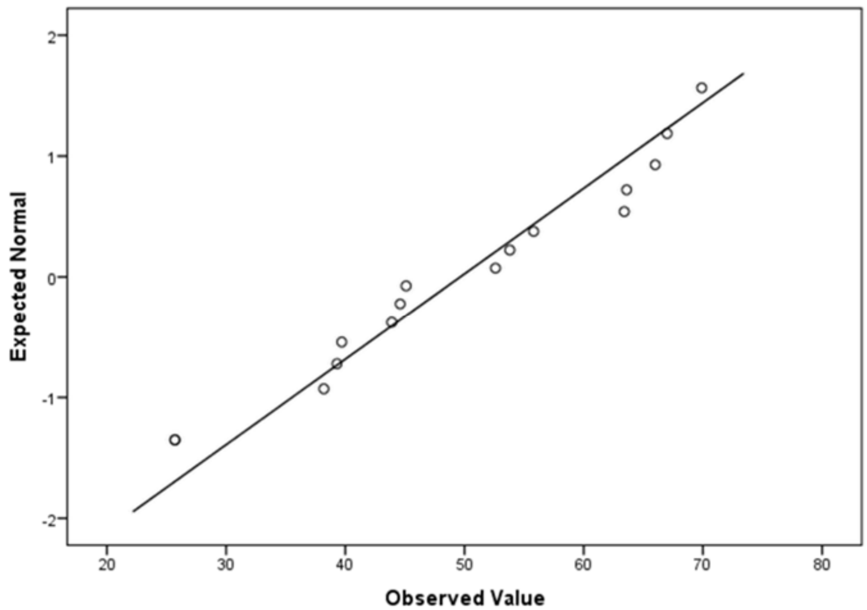

Figure J-236. Normal Q-Q Plot of 2015 SAGE % Mathematics Proficiency for MTL62 = 2. This figure illustrates the observed value versus the expected normal for school leaders who ranked MTL62 as 2 based on their school's school-wide 2015 SAGE % mathematics proficiency.

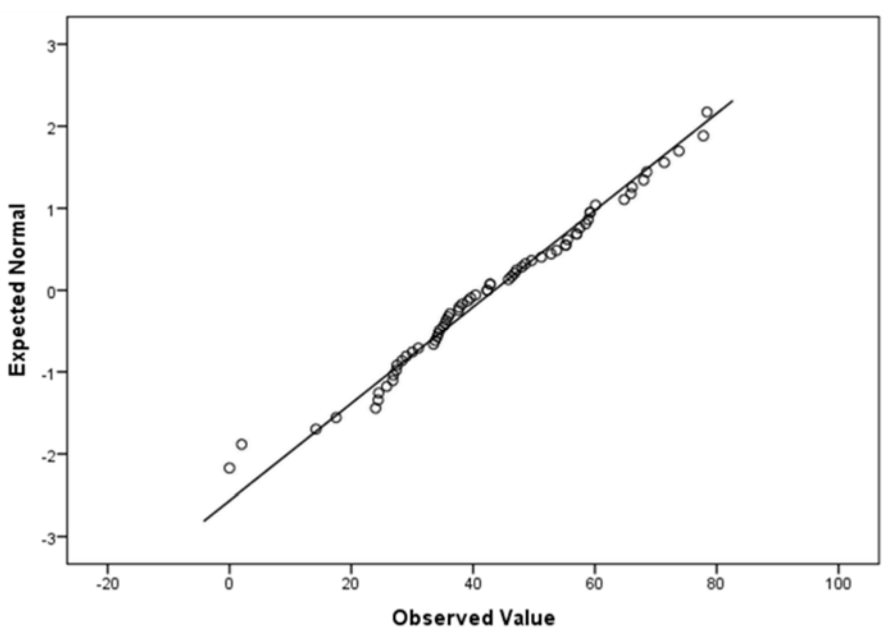

Figure J-237. Normal Q-Q Plot of 2015 SAGE % Mathematics Proficiency for MTL62 = 4. This figure illustrates the observed value versus the expected normal for school leaders who ranked MTL62 as 4 based on their school's school-wide 2015 SAGE % mathematics proficiency.

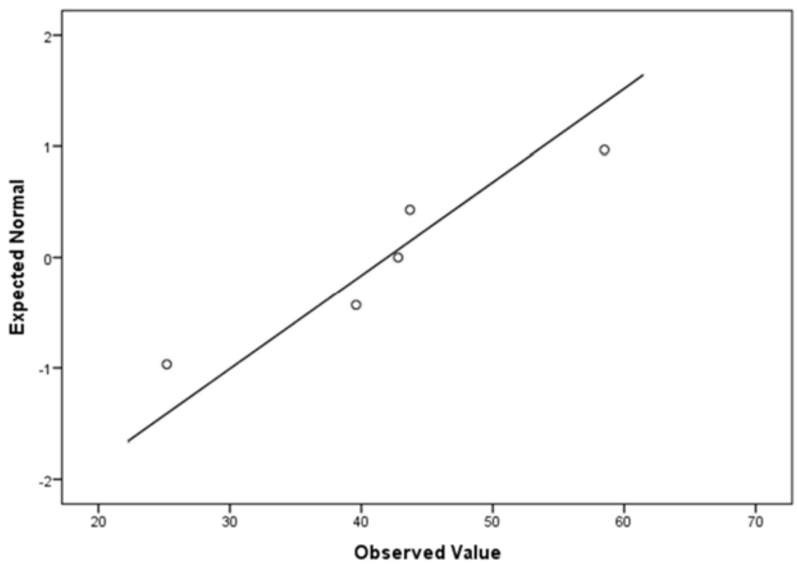

Figure J-238. Normal Q-Q Plot of 2015 SAGE % Mathematics Proficiency for MTL62 = 5. This figure illustrates the observed value versus the expected normal for school leaders who ranked MTL62 as 5 based on their school's school-wide 2015 SAGE % mathematics proficiency.

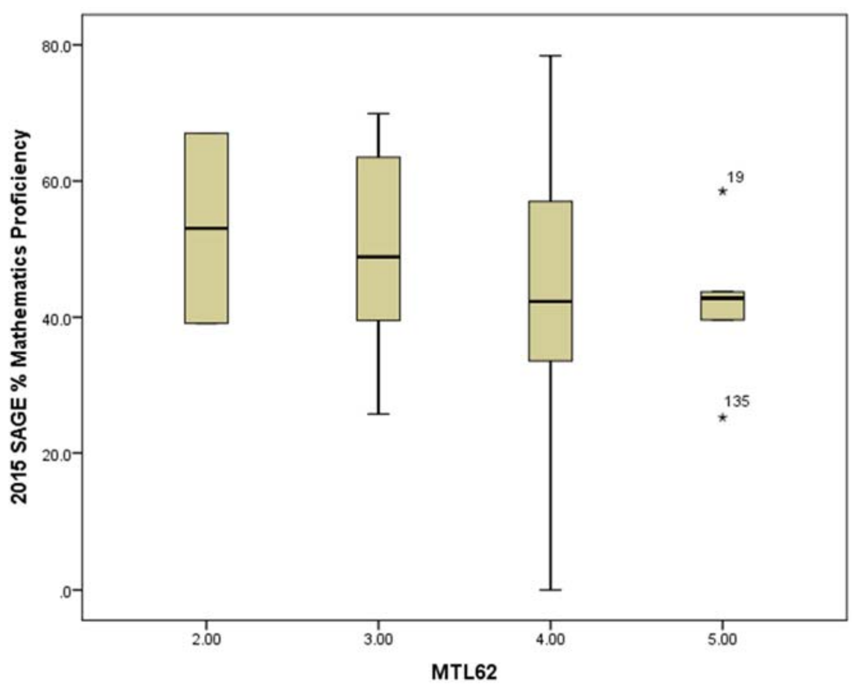

Figure J-239. Boxplot of 2015 SAGE % Mathematics Proficiency for MTL62. This figure illustrates spread of school-wide 2015 SAGE % Mathematics Proficiency scores based on school leaders' ranking of MTL62.

Table J-18

Age: Tests for Normality

		Shapiro-Wilk						
Variable		Statistic	df	Sig.	Skewness	Std. Error	Kurtosis	Std. Error
Age	34							
	35							
	36	1.	3	.914	-.23	1.23		
	37	.98	4	.907	.37	1.01	-1.3	2.62
	38							
	39	.97	4	.85	-.77	1.01	.89	2.62
	40	.93	7	.585	.1	.79	-.58	1.59
	41	.81	5	.096	-1.78	.91	3.65	2.00
	42	.91	7	.418	-.66	.79	-.68	1.59
	43	.9	6	.346	.67	.85	-.89	1.74
	44	.85	5	.196	.63	.91	-2.52	2.00
	45	.9	8	.299	-.59	.75	-.76	1.48
	46	.91	5	.451	.77	.91	-1.01	2.00
	47	.88	9	.141	-.07	.72	-2.06	1.40
	48	.97	7	.884	.03	.79	-1.09	1.59
	49	.87	7	.192	1.03	.79	-.13	1.59
	50	.99	3	.768	-.62	1.23		
	51	1.	4	.980	-.32	1.01	.30	2.62
	52	.87	4	.301	.17	1.01	-4.76	2.62
	53	.89	8	.221	-1.31	.75	3.09	1.48
	54	.99	3	.797	.54	1.23		
	55	.96	3	.631	.95	1.23		
	56	.91	6	.441	-.75	.85	-1.01	1.74
	57	.83	4	.176	1.52	1.01	2.04	2.62
	58	1.	3	.919	.22	1.23		
	59	.97	4	.822	.07	1.01	1.41	2.62
	60	.88	6	.279	.79	.85	-1.13	1.74
	61							
	62	.96	4	.771	.39	1.01	1.52	2.62
	63							
	64	.9	3	.394	-1.41	1.23		
	65	.95	3	.587	1.05	1.23		

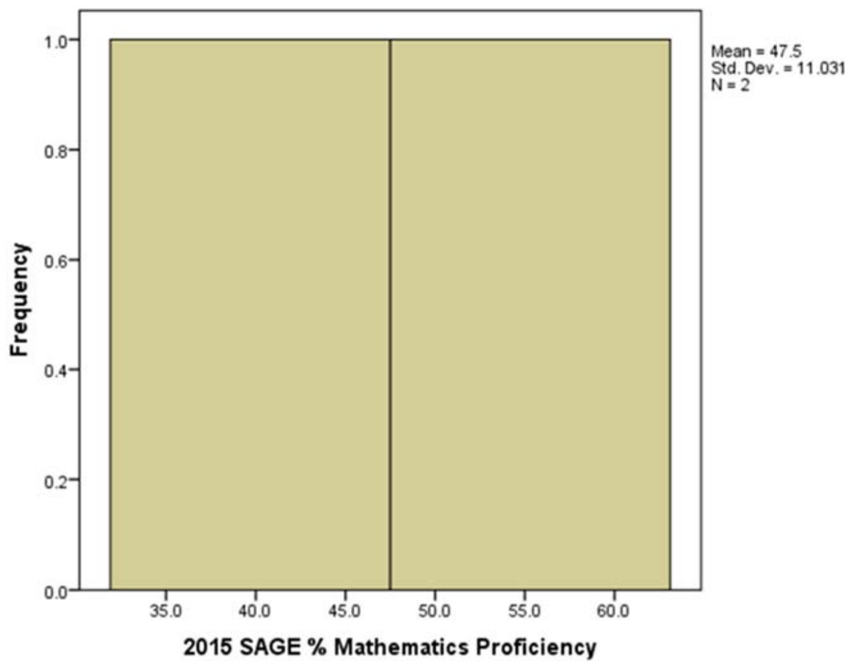

Figure J-240. Frequency by 2015 SAGE % Mathematics Proficiency for Age = 34. This figure illustrates the number of school leaders whose age was 34 based on their school's school-wide 2015 SAGE % mathematics proficiency.

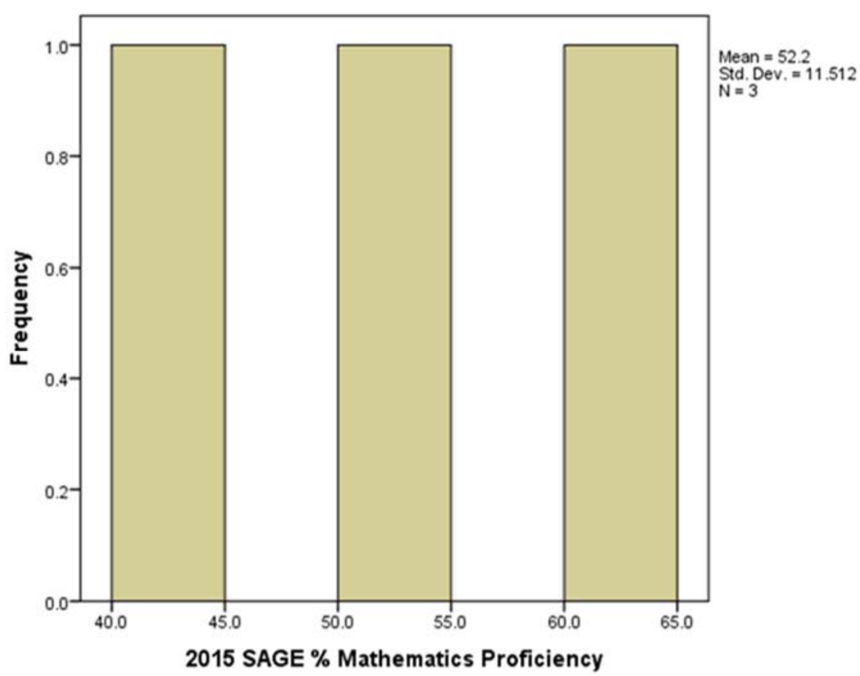

Figure J-241. Frequency by 2015 SAGE % Mathematics Proficiency for Age = 36. This figure illustrates the number of school leaders whose age was 36 based on their school's school-wide 2015 SAGE % mathematics proficiency.

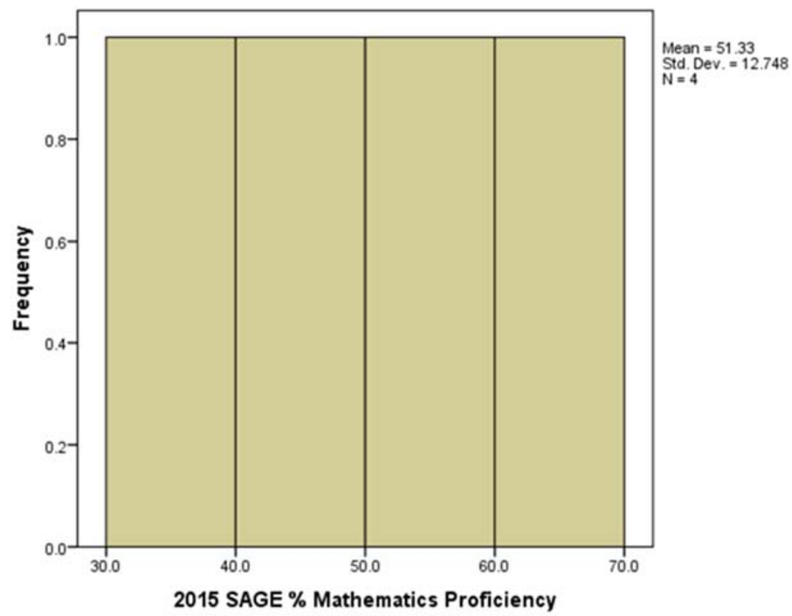

Figure J-242. Frequency by 2015 SAGE % Mathematics Proficiency for Age = 37. This figure illustrates the number of school leaders whose age was 37 based on their school's school-wide 2015 SAGE % mathematics proficiency.

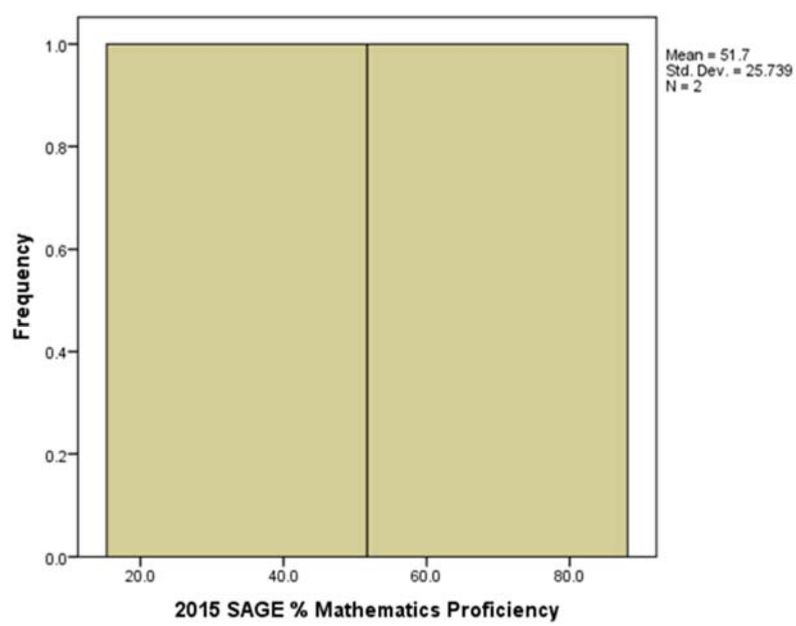

Figure J-243. Frequency by 2015 SAGE % Mathematics Proficiency for Age = 38. This figure illustrates the number of school leaders whose age was 38 based on their school's school-wide 2015 SAGE % mathematics proficiency.

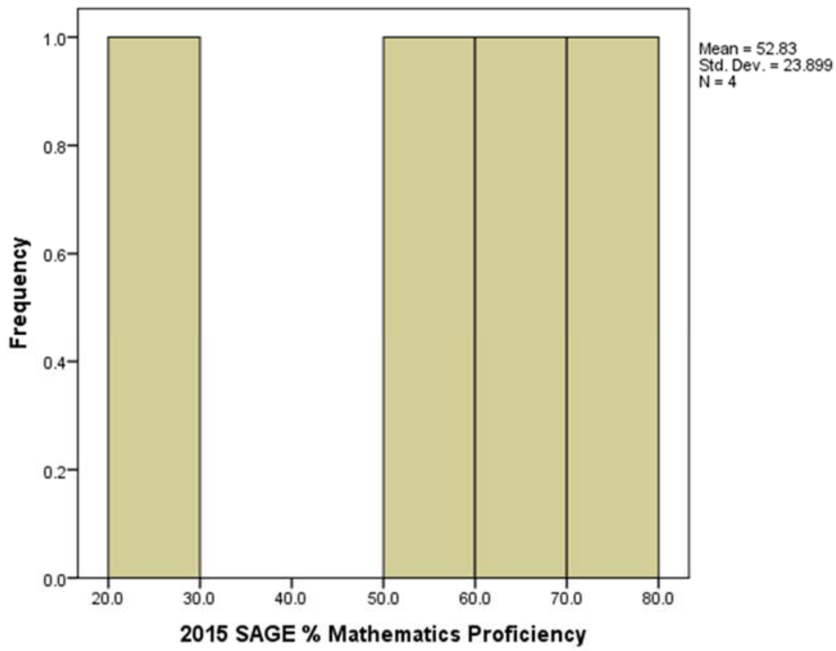

Figure J-244. Frequency by 2015 SAGE % Mathematics Proficiency for Age = 39. This figure illustrates the number of school leaders whose age was 39 based on their school's school-wide 2015 SAGE % mathematics proficiency.

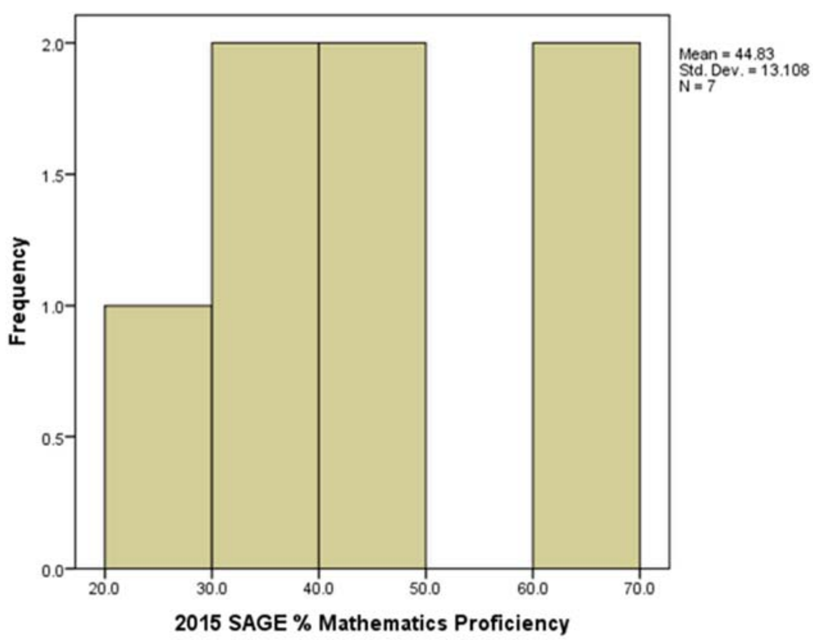

Figure J-245. Frequency by 2015 SAGE % Mathematics Proficiency for Age = 40. This figure illustrates the number of school leaders whose age was 40 based on their school's school-wide 2015 SAGE % mathematics proficiency.

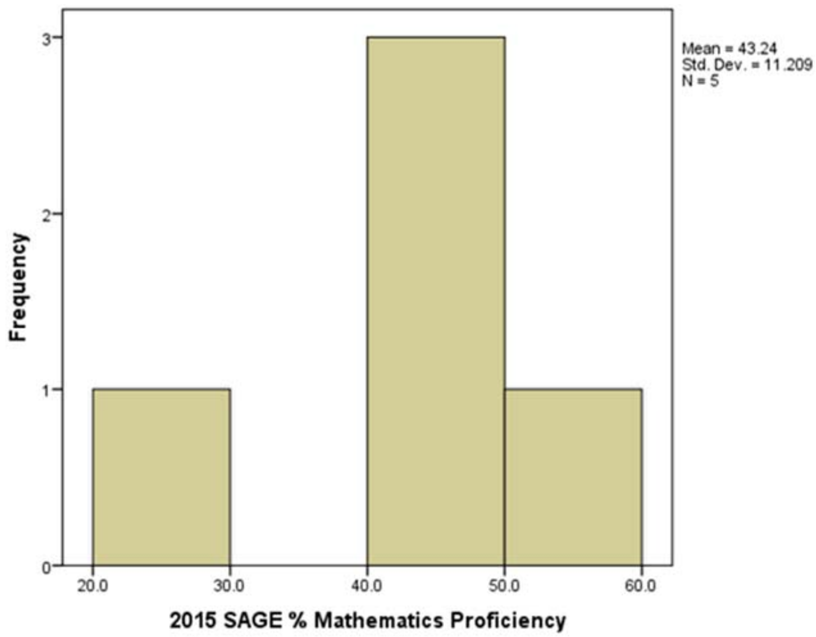

Figure J-246. Frequency by 2015 SAGE % Mathematics Proficiency for Age = 41. This figure illustrates the number of school leaders whose age was 41 based on their school's school-wide 2015 SAGE % mathematics proficiency.

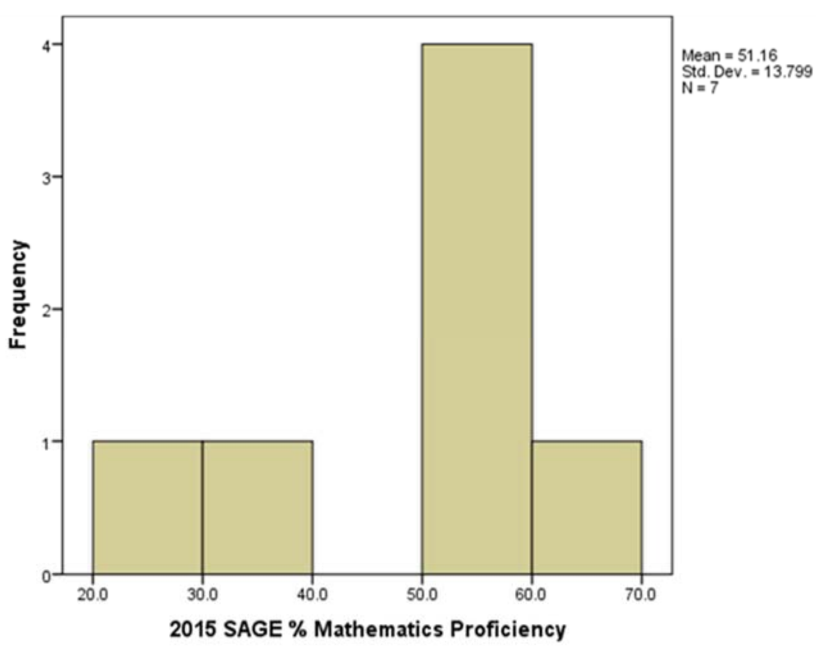

Figure J-247. Frequency by 2015 SAGE % Mathematics Proficiency for Age = 42. This figure illustrates the number of school leaders whose age was 42 based on their school's school-wide 2015 SAGE % mathematics proficiency.

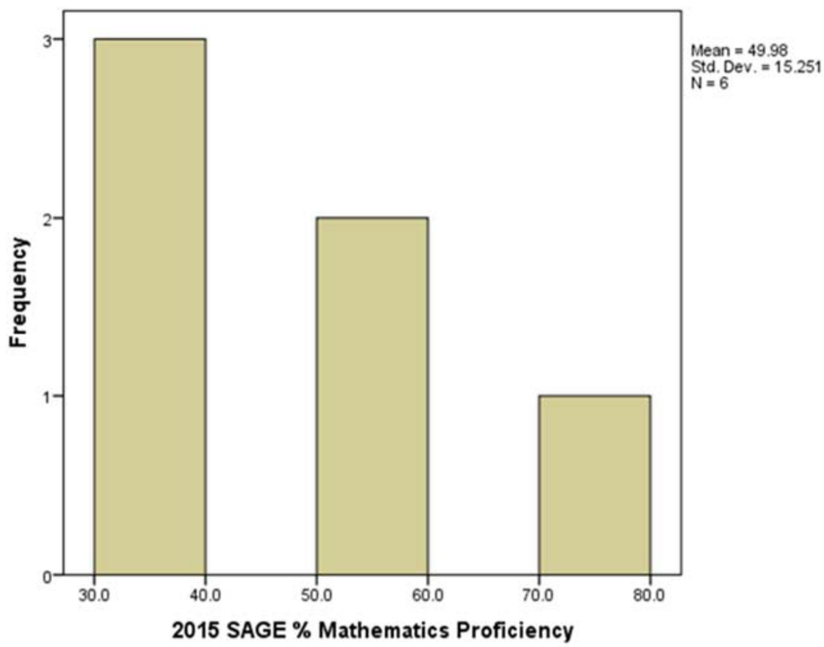

Figure J-248. Frequency by 2015 SAGE % Mathematics Proficiency for Age = 43. This figure illustrates the number of school leaders whose age was 43 based on their school's school-wide 2015 SAGE % mathematics proficiency.

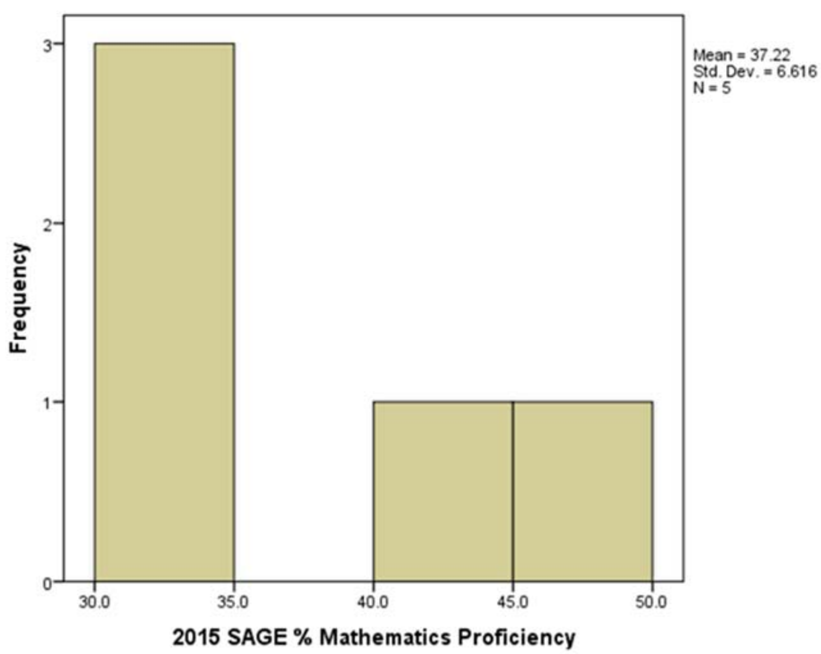

Figure J-249. Frequency by 2015 SAGE % Mathematics Proficiency for Age = 44. This figure illustrates the number of school leaders whose age was 44 based on their school's school-wide 2015 SAGE % mathematics proficiency.

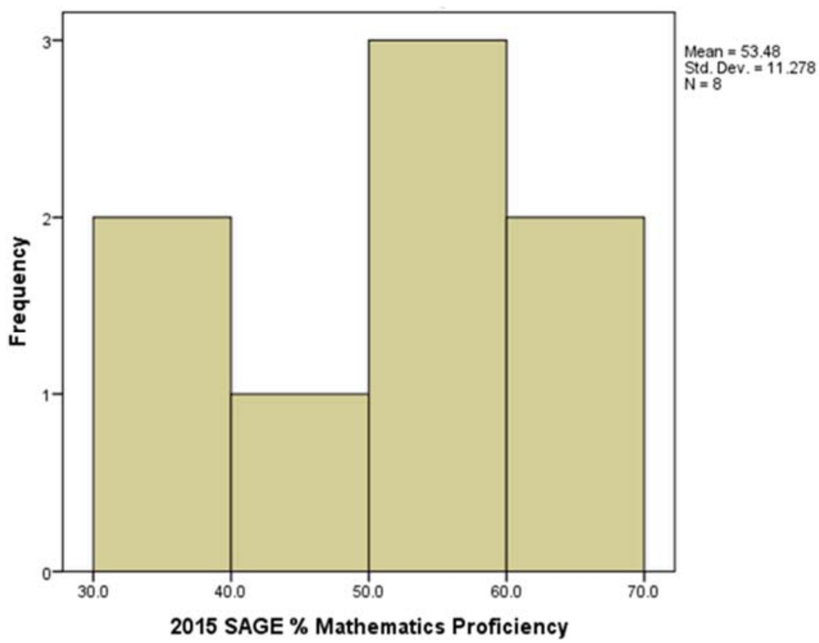

Figure J-250. Frequency by 2015 SAGE % Mathematics Proficiency for Age = 45. This figure illustrates the number of school leaders whose age was 45 based on their school's school-wide 2015 SAGE % mathematics proficiency.

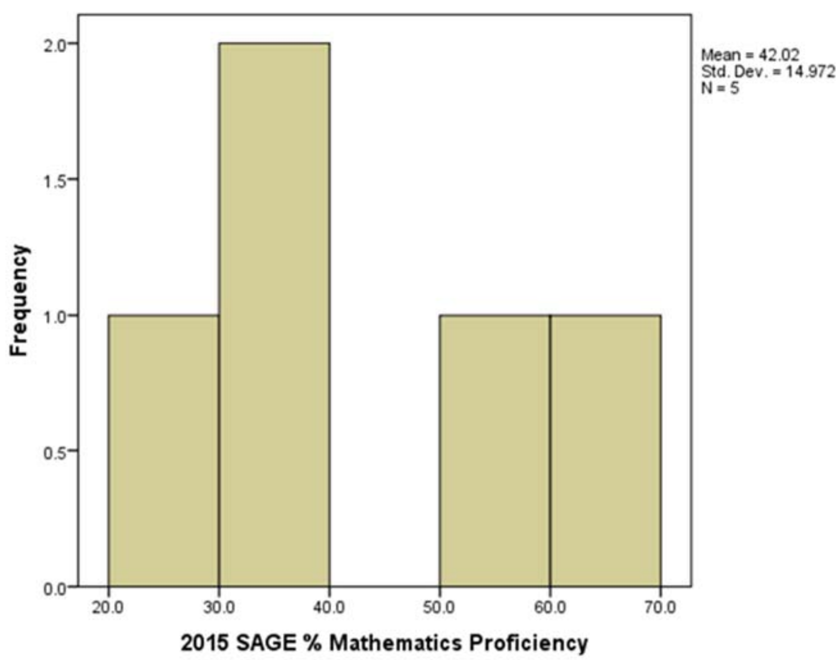

Figure J-251. Frequency by 2015 SAGE % Mathematics Proficiency for Age = 46. This figure illustrates the number of school leaders whose age was 46 based on their school's school-wide 2015 SAGE % mathematics proficiency.

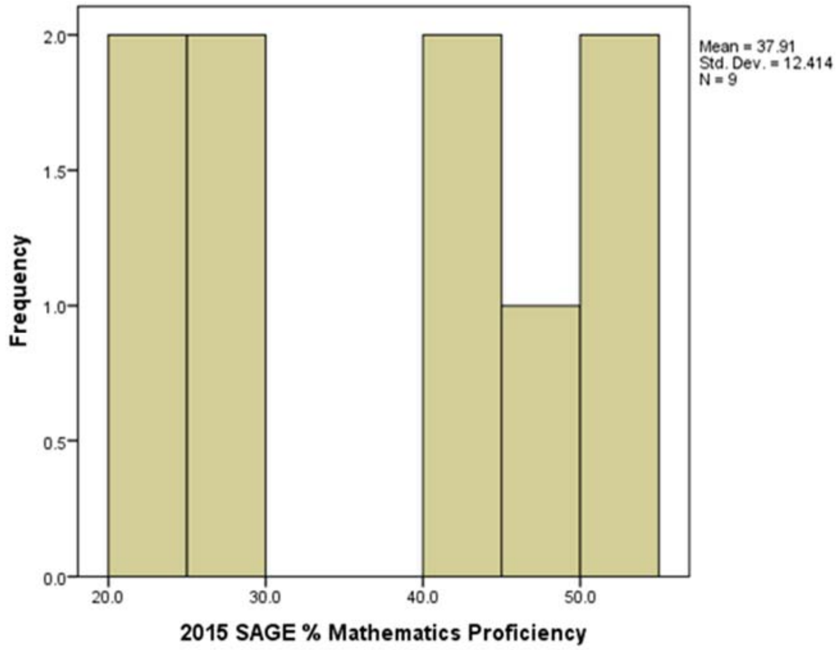

Figure J-252. Frequency by 2015 SAGE % Mathematics Proficiency for Age = 47. This figure illustrates the number of school leaders whose age was 47 based on their school's school-wide 2015 SAGE % mathematics proficiency.

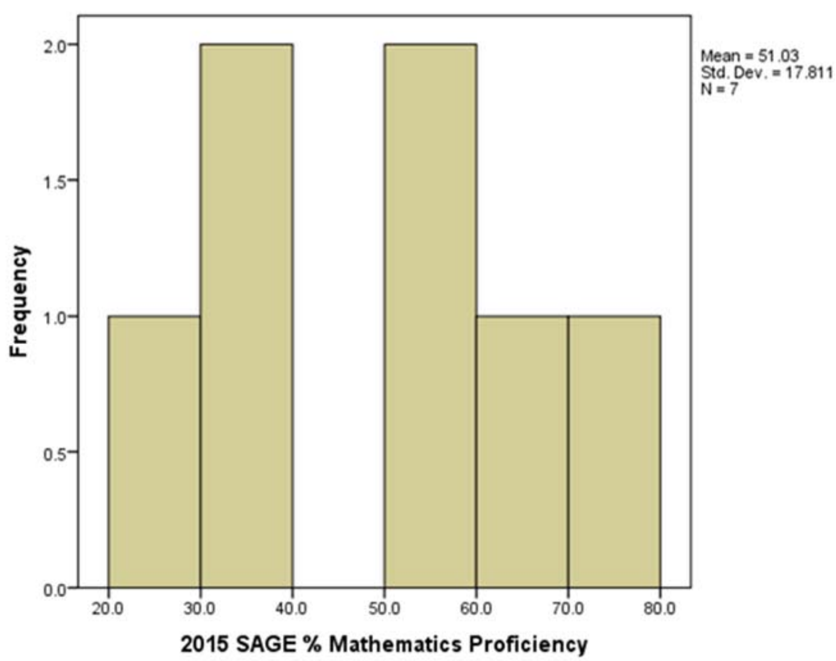

Figure J-253. Frequency by 2015 SAGE % Mathematics Proficiency for Age = 48. This figure illustrates the number of school leaders whose age was 48 based on their school's school-wide 2015 SAGE % mathematics proficiency.

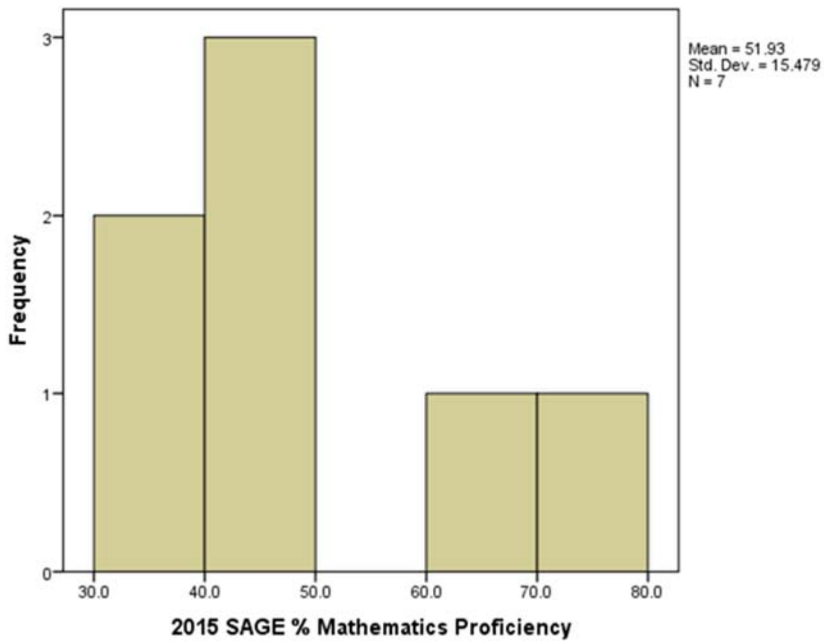

Figure J-254. Frequency by 2015 SAGE % Mathematics Proficiency for Age = 49. This figure illustrates the number of school leaders whose age was 49 based on their school's school-wide 2015 SAGE % mathematics proficiency.

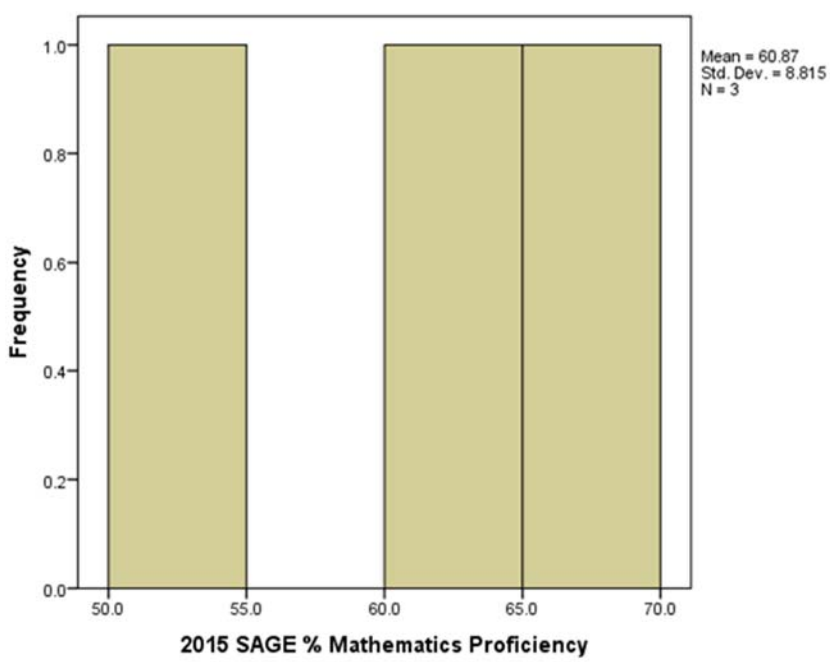

Figure J-255. Frequency by 2015 SAGE % Mathematics Proficiency for Age = 50. This figure illustrates the number of school leaders whose age was 50 based on their school's school-wide 2015 SAGE % mathematics proficiency.

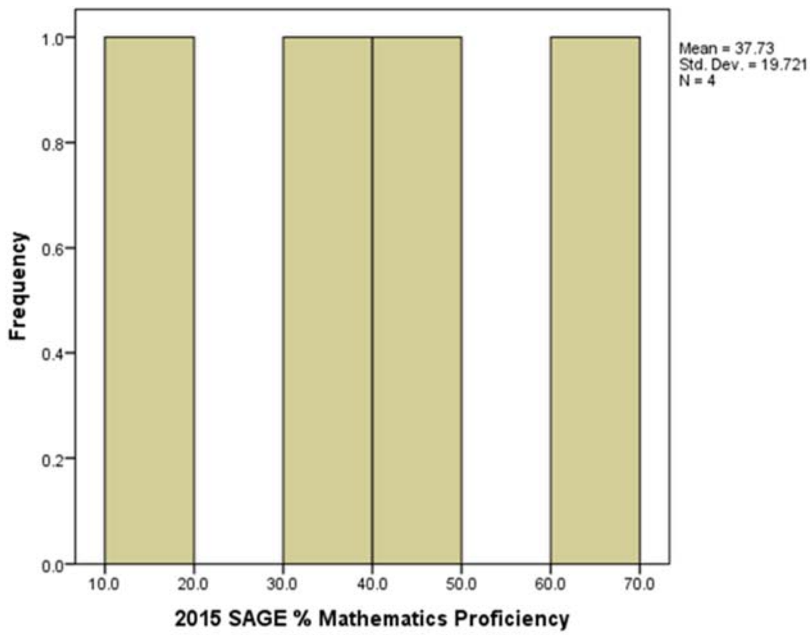

Figure J-256. Frequency by 2015 SAGE % Mathematics Proficiency for Age = 51. This figure illustrates the number of school leaders whose age was 51 based on their school's school-wide 2015 SAGE % mathematics proficiency.

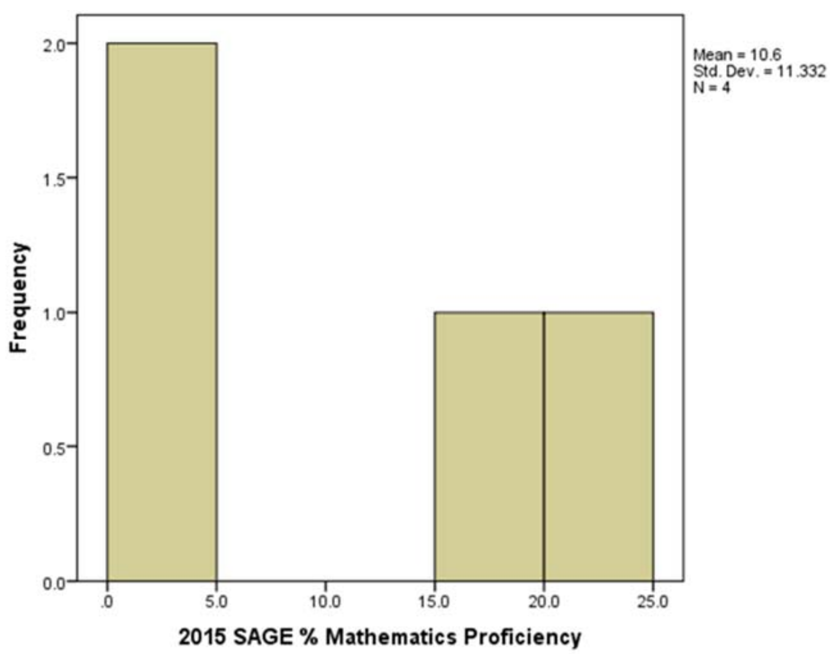

Figure J-257. Frequency by 2015 SAGE % Mathematics Proficiency for Age = 52. This figure illustrates the number of school leaders whose age was 52 based on their school's school-wide 2015 SAGE % mathematics proficiency.

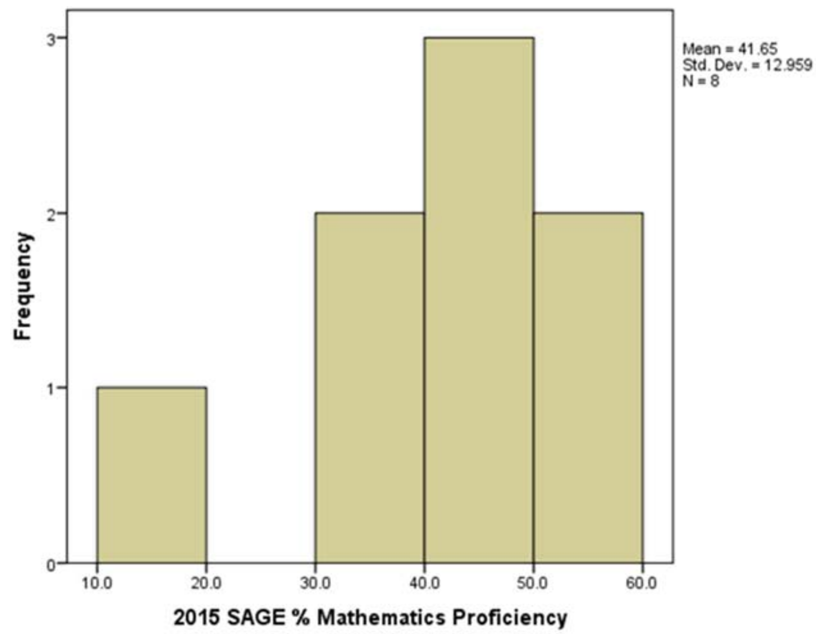

Figure J-258. Frequency by 2015 SAGE % Mathematics Proficiency for Age = 53. This figure illustrates the number of school leaders whose age was 53 based on their school's school-wide 2015 SAGE % mathematics proficiency.

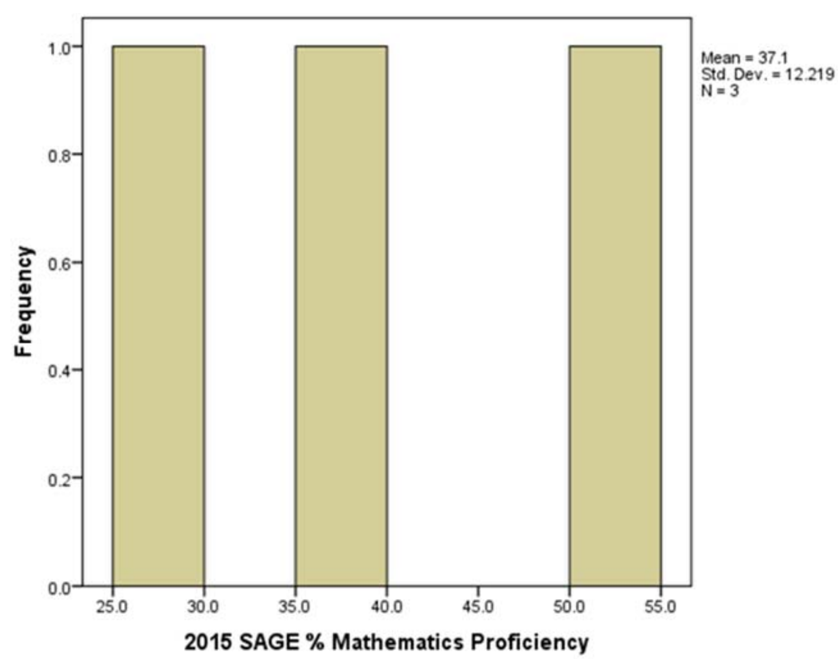

Figure J-259. Frequency by 2015 SAGE % Mathematics Proficiency for Age = 54. This figure illustrates the number of school leaders whose age was 54 based on their school's school-wide 2015 SAGE % mathematics proficiency.

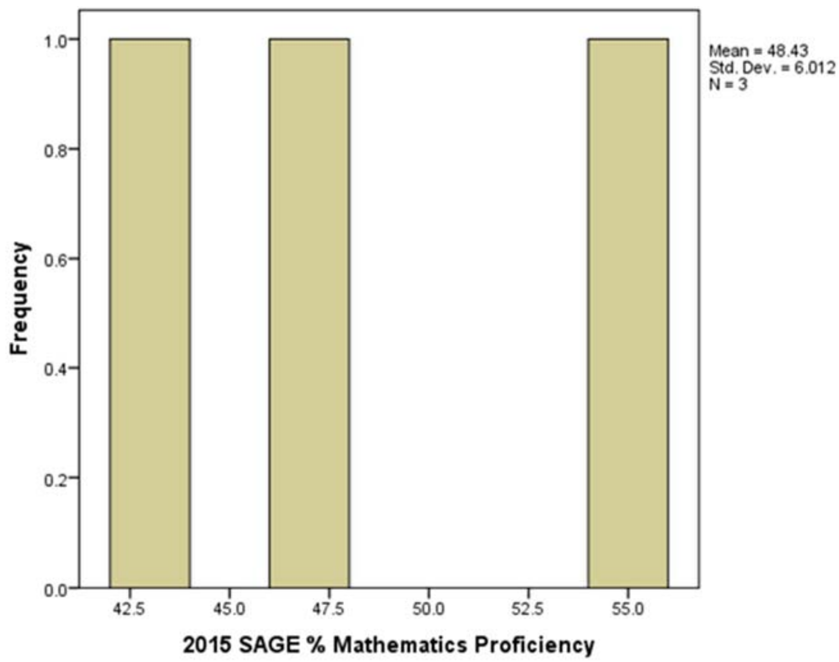

Figure J-260. Frequency by 2015 SAGE % Mathematics Proficiency for Age = 55. This figure illustrates the number of school leaders whose age was 55 based on their school's school-wide 2015 SAGE % mathematics proficiency.

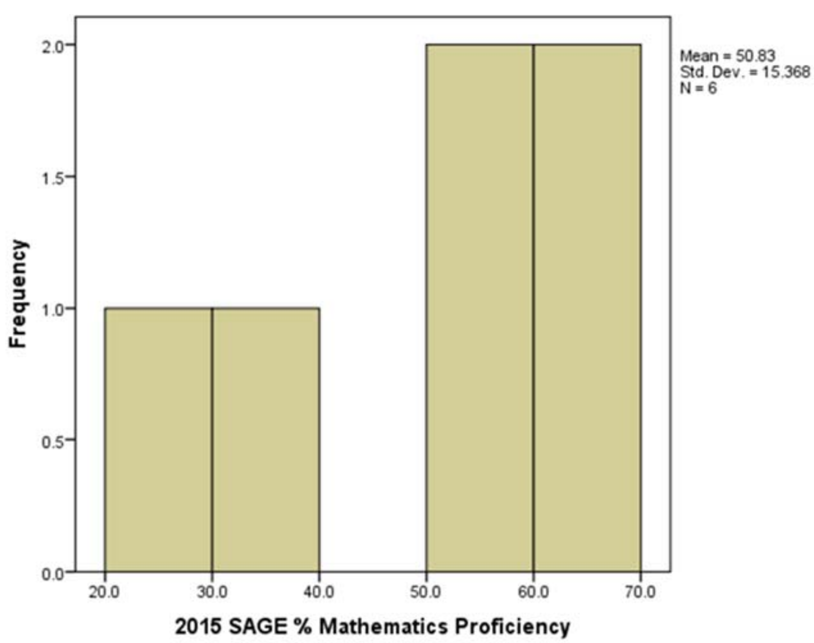

Figure J-261. Frequency by 2015 SAGE % Mathematics Proficiency for Age = 56. This figure illustrates the number of school leaders whose age was 56 based on their school's school-wide 2015 SAGE % mathematics proficiency.

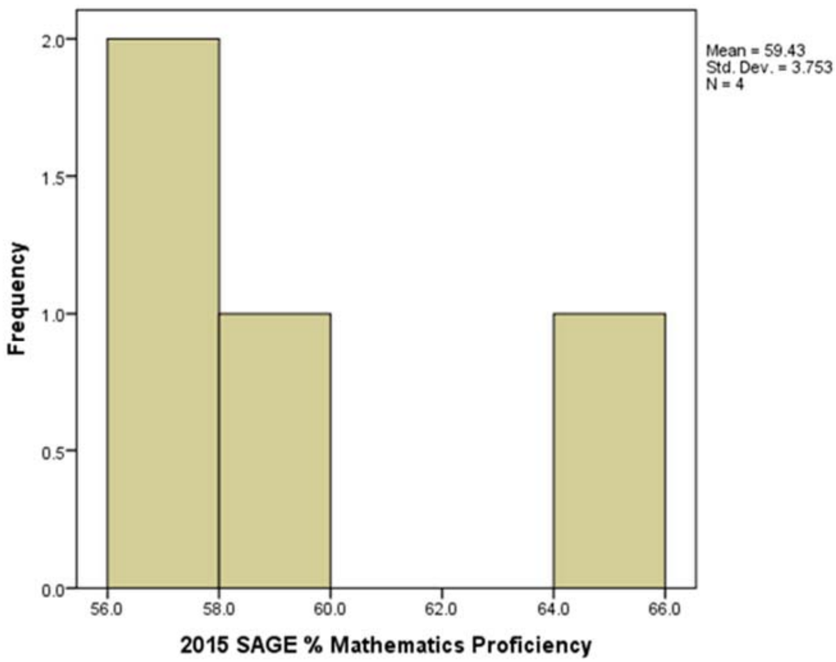

Figure J-262. Frequency by 2015 SAGE % Mathematics Proficiency for Age = 57. This figure illustrates the number of school leaders whose age was 57 based on their school's school-wide 2015 SAGE % mathematics proficiency.

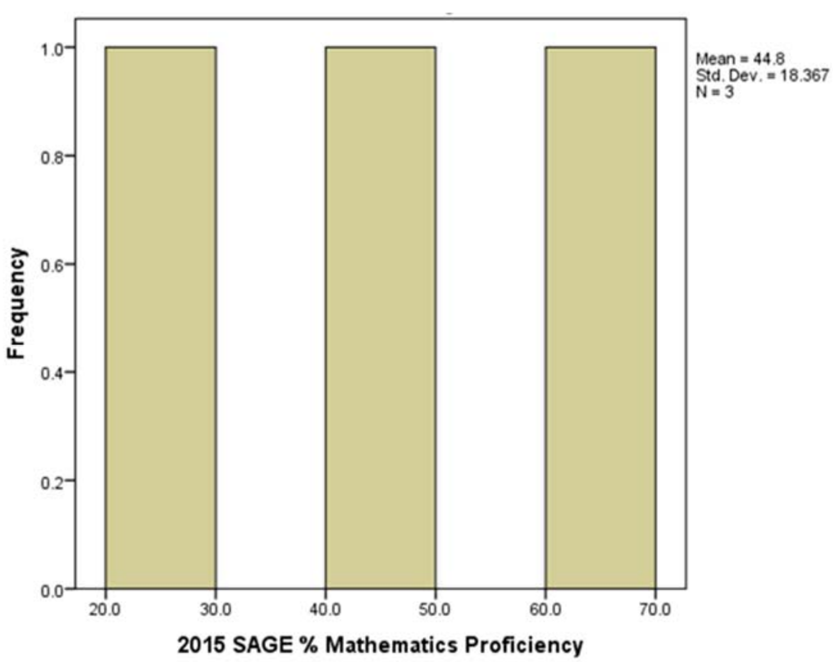

Figure J-263. Frequency by 2015 SAGE % Mathematics Proficiency for Age = 58. This figure illustrates the number of school leaders whose age was 58 based on their school's school-wide 2015 SAGE % mathematics proficiency.

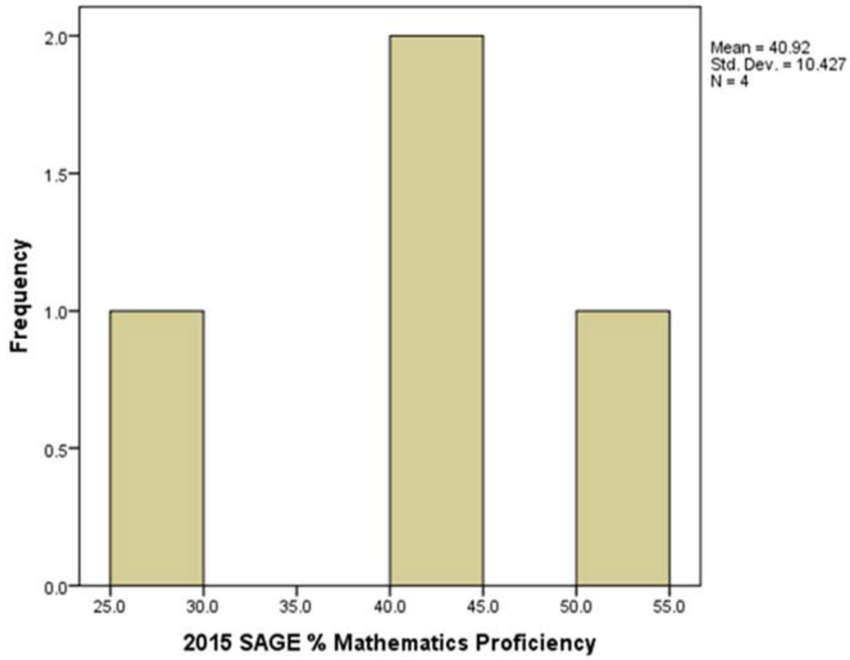

Figure J-264. Frequency by 2015 SAGE % Mathematics Proficiency for Age = 59. This figure illustrates the number of school leaders whose age was 59 based on their school's school-wide 2015 SAGE % mathematics proficiency.

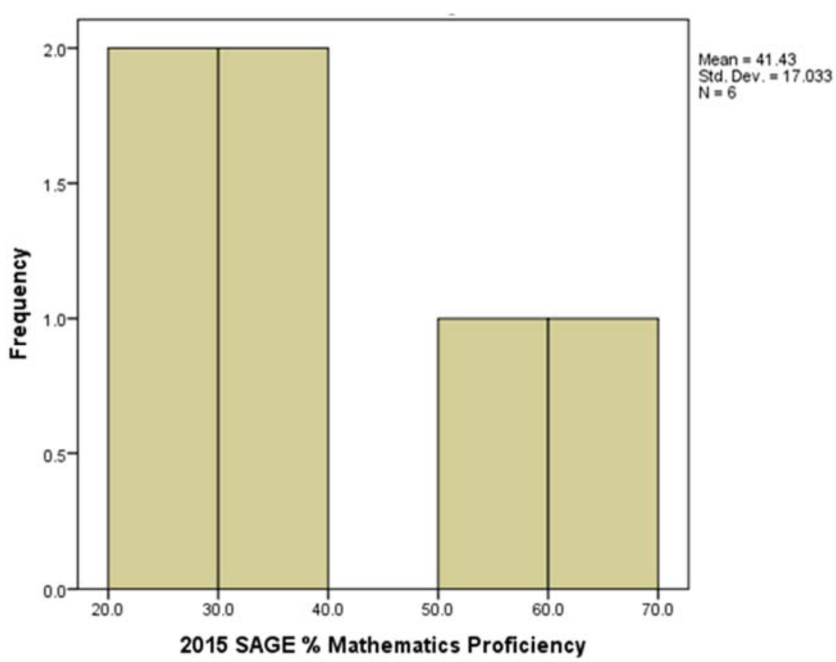

Figure J-265. Frequency by 2015 SAGE % Mathematics Proficiency for Age = 60. This figure illustrates the number of school leaders whose age was 60 based on their school's school-wide 2015 SAGE % mathematics proficiency.

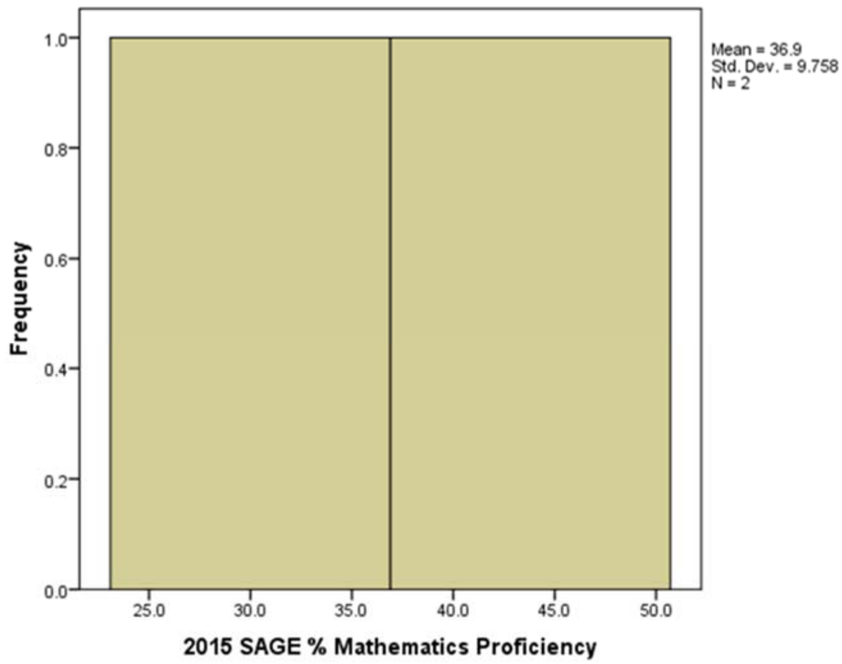

Figure J-266. Frequency by 2015 SAGE % Mathematics Proficiency for Age = 61. This figure illustrates the number of school leaders whose age was 61 based on their school's school-wide 2015 SAGE % mathematics proficiency.

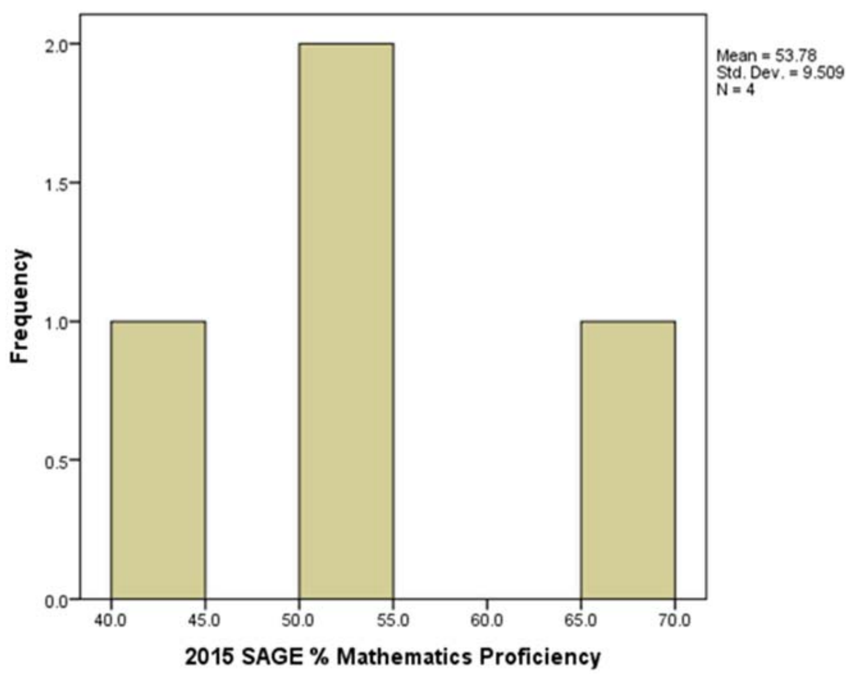

Figure J-267. Frequency by 2015 SAGE % Mathematics Proficiency for Age = 62. This figure illustrates the number of school leaders whose age was 362 based on their school's school-wide 2015 SAGE % mathematics proficiency.

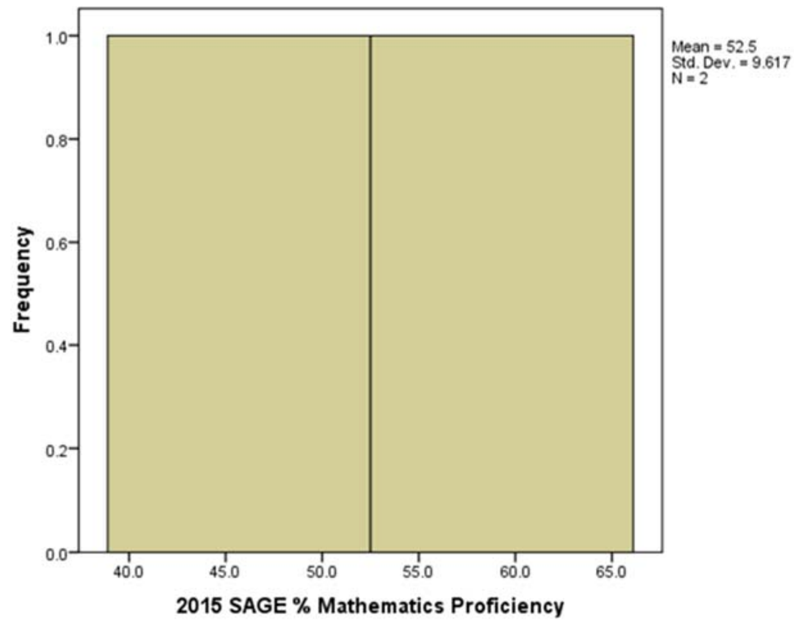

Figure J-268. Frequency by 2015 SAGE % Mathematics Proficiency for Age = 63. This figure illustrates the number of school leaders whose age was 63 based on their school's school-wide 2015 SAGE % mathematics proficiency.

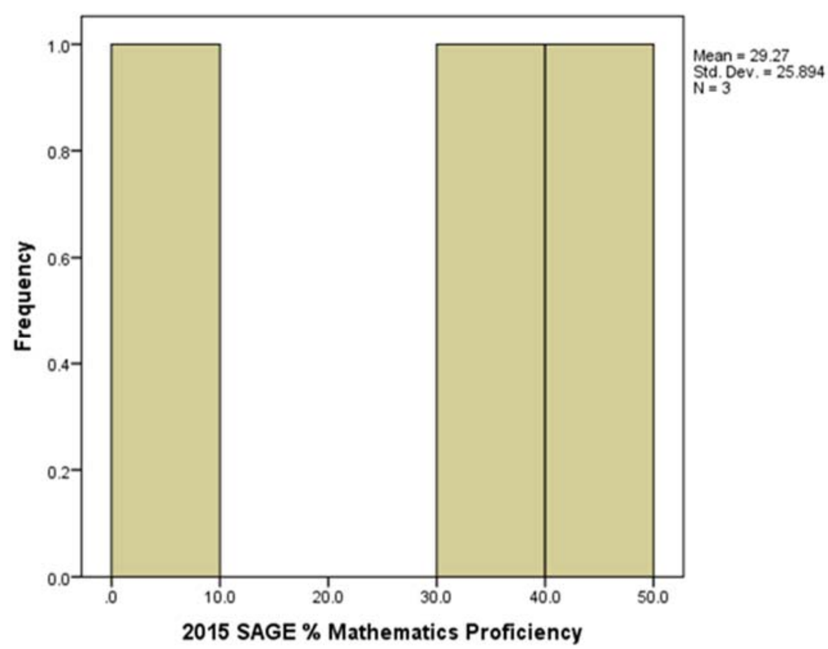

Figure J-269. Frequency by 2015 SAGE % Mathematics Proficiency for Age = 64. This figure illustrates the number of school leaders whose age was 64 based on their school's school-wide 2015 SAGE % mathematics proficiency.

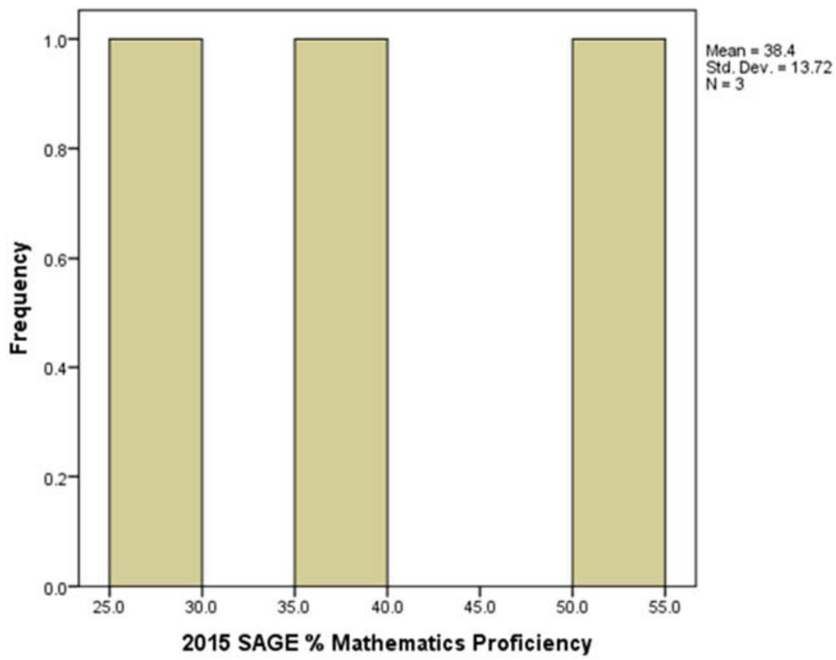

Figure J-270. Frequency by 2015 SAGE % Mathematics Proficiency for Age = 65. This figure illustrates the number of school leaders whose age was 65 based on their school's school-wide 2015 SAGE % mathematics proficiency.

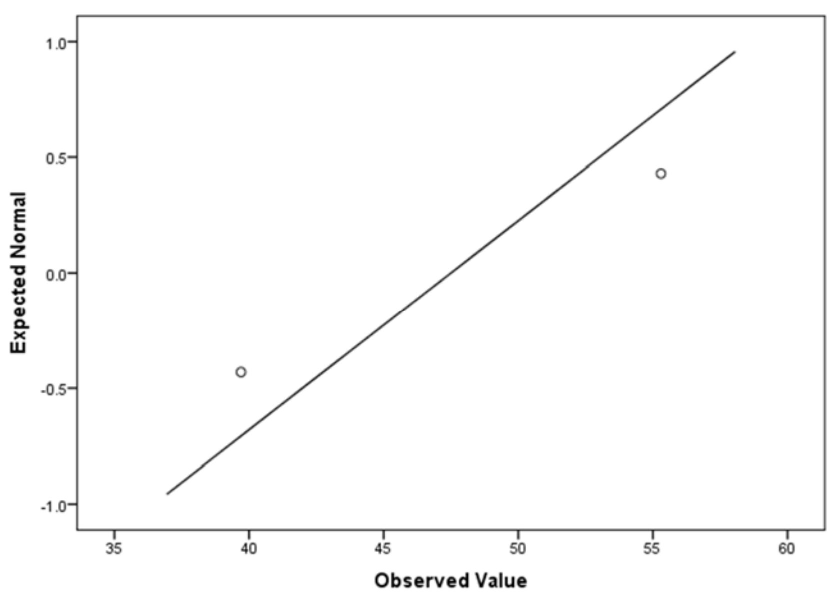

Figure J-271. Normal Q-Q Plot of 2015 SAGE % Mathematics Proficiency for Age = 34. This figure illustrates the observed value versus the expected normal for school leaders whose age was 34 based on their school's school-wide 2015 SAGE % mathematics proficiency.

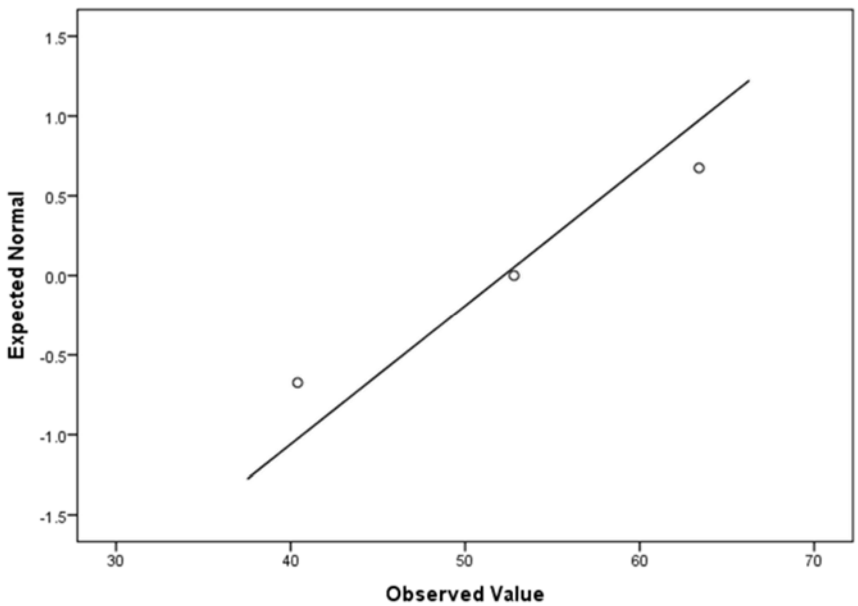

Figure J-272. Normal Q-Q Plot of 2015 SAGE % Mathematics Proficiency for Age = 36. This figure illustrates the observed value versus the expected normal for school leaders whose age was 36 based on their school's school-wide 2015 SAGE % mathematics proficiency.

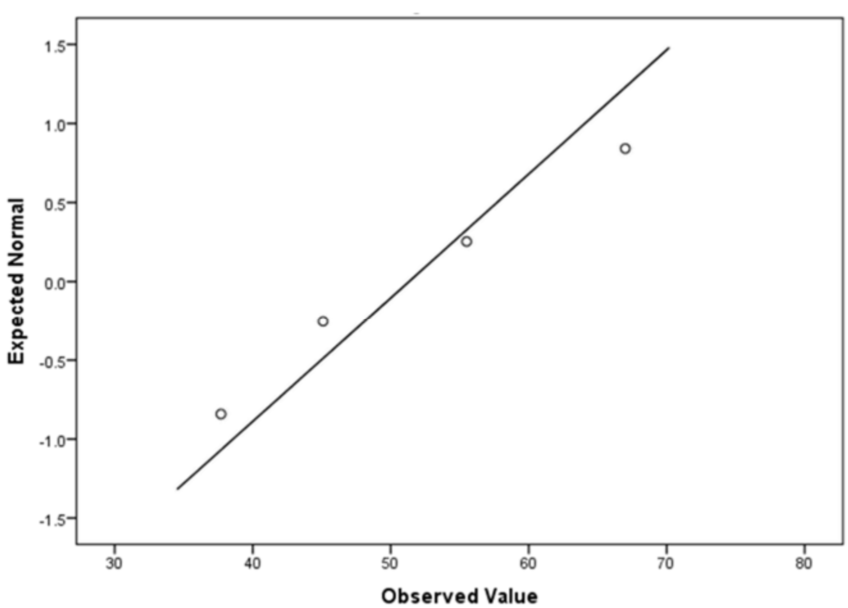

Figure J-273. Normal Q-Q Plot of 2015 SAGE % Mathematics Proficiency for Age = 37. This figure illustrates the observed value versus the expected normal for school leaders whose age was 37 based on their school's school-wide 2015 SAGE % mathematics proficiency.

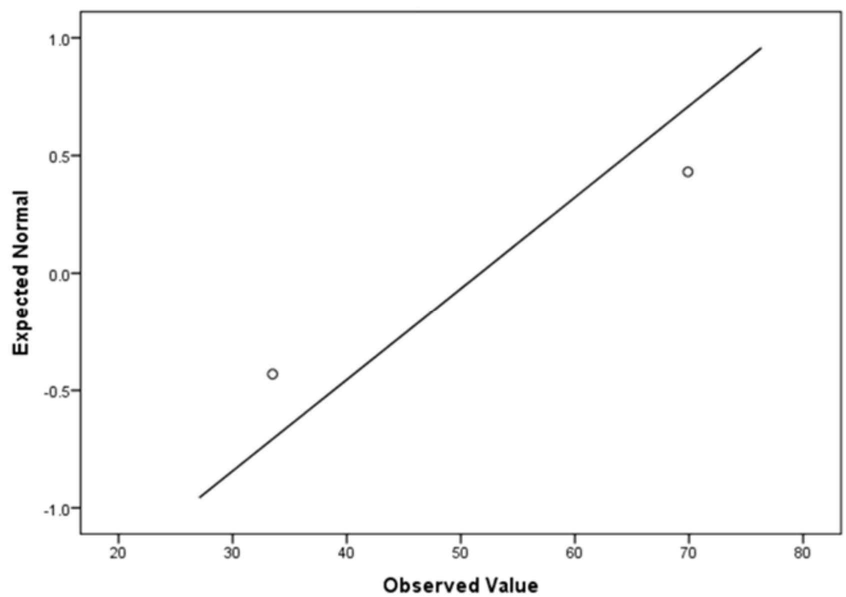

Figure J-274. Normal Q-Q Plot of 2015 SAGE % Mathematics Proficiency for Age = 38. This figure illustrates the observed value versus the expected normal for school leaders whose age was 38 based on their school's school-wide 2015 SAGE % mathematics proficiency.

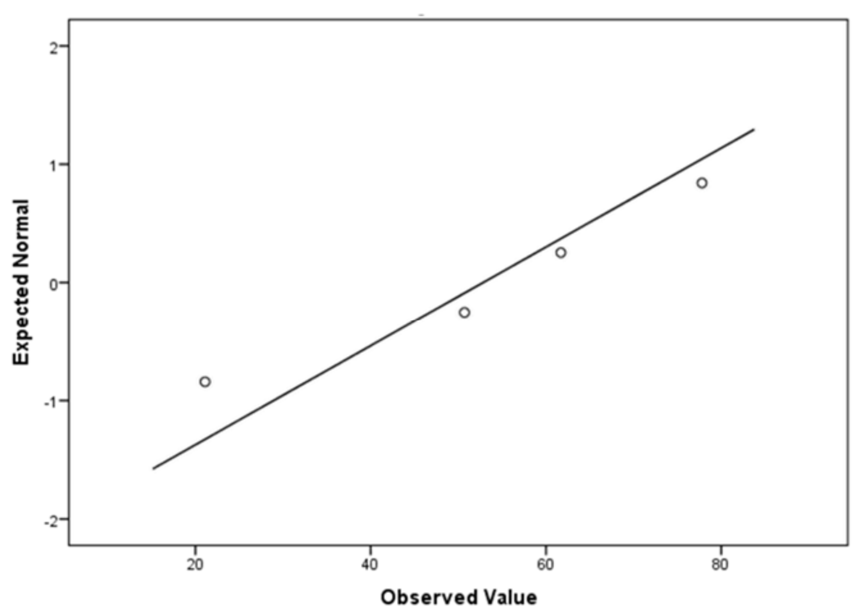

Figure J-275. Normal Q-Q Plot of 2015 SAGE % Mathematics Proficiency for Age = 39. This figure illustrates the observed value versus the expected normal for school leaders whose age was 39 based on their school's school-wide 2015 SAGE % mathematics proficiency.

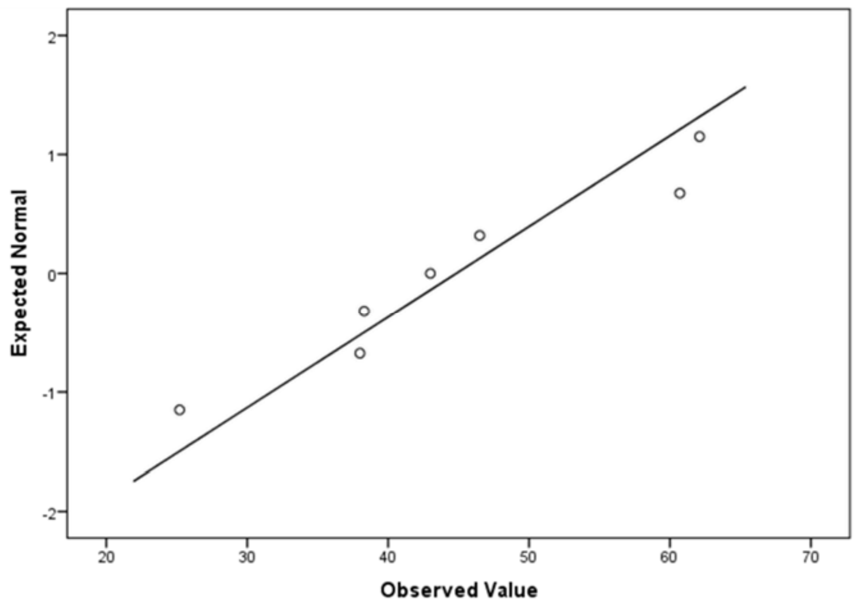

Figure J-276. Normal Q-Q Plot of 2015 SAGE % Mathematics Proficiency for Age = 40. This figure illustrates the observed value versus the expected normal for school leaders whose age was 40 based on their school's school-wide 2015 SAGE % mathematics proficiency.

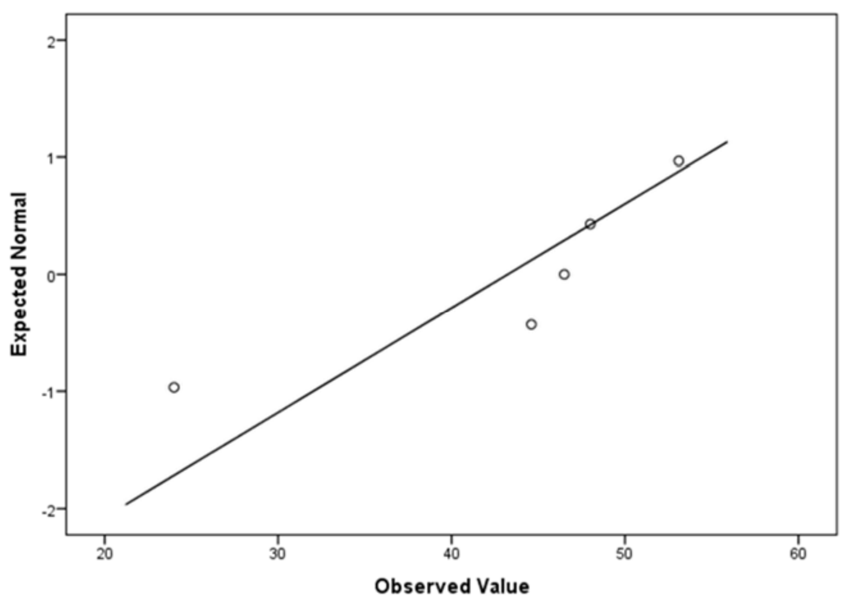

Figure J-277. Normal Q-Q Plot of 2015 SAGE % Mathematics Proficiency for Age = 41. This figure illustrates the observed value versus the expected normal for school leaders whose age was 41 based on their school's school-wide 2015 SAGE % mathematics proficiency.

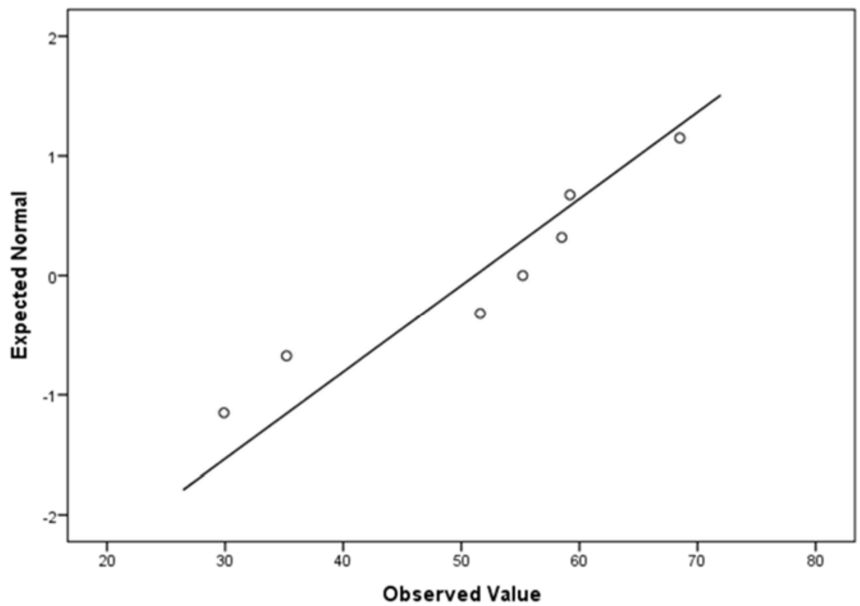

Figure J-278. Normal Q-Q Plot of 2015 SAGE % Mathematics Proficiency for Age = 42. This figure illustrates the observed value versus the expected normal for school leaders whose age was 42 based on their school's school-wide 2015 SAGE % mathematics proficiency.

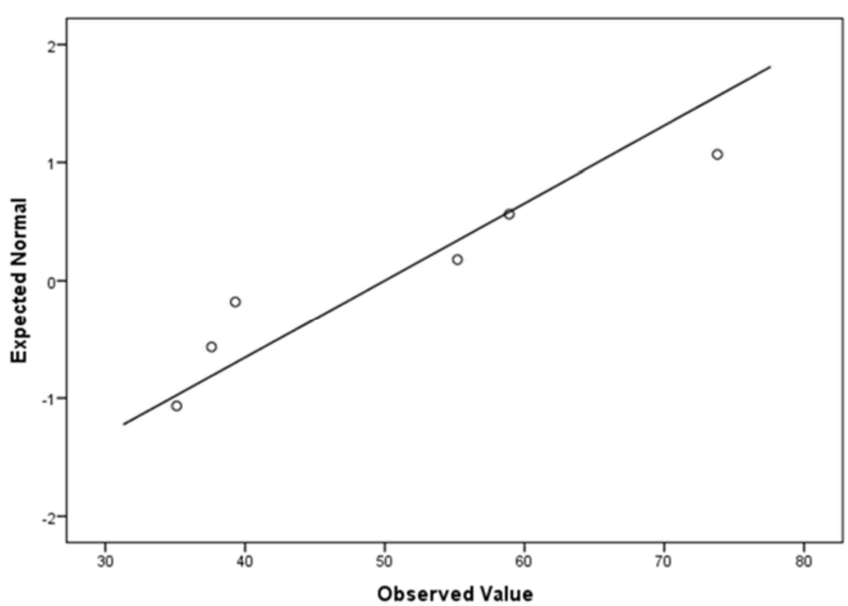

Figure J-279. Normal Q-Q Plot of 2015 SAGE % Mathematics Proficiency for Age = 43. This figure illustrates the observed value versus the expected normal for school leaders whose age was 43 based on their school's school-wide 2015 SAGE % mathematics proficiency.

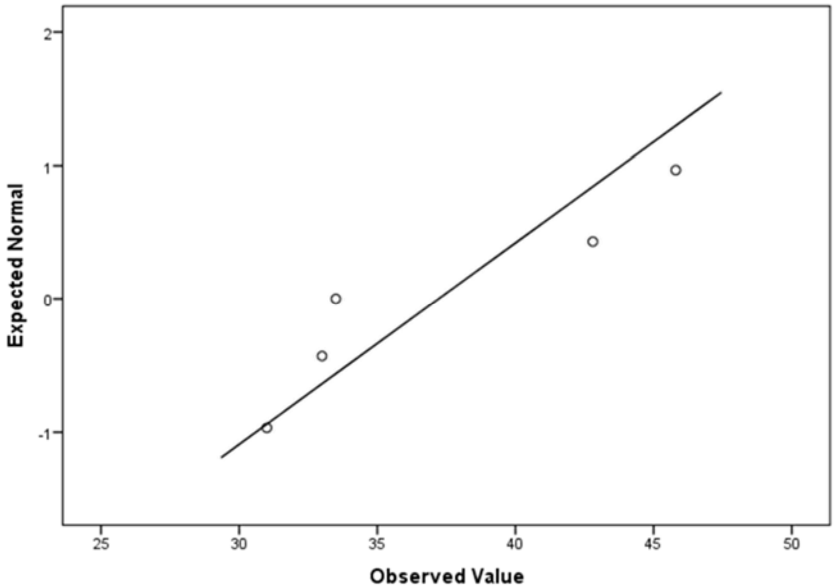

Figure J-280. Normal Q-Q Plot of 2015 SAGE % Mathematics Proficiency for Age = 44. This figure illustrates the observed value versus the expected normal for school leaders whose age was 44 based on their school's school-wide 2015 SAGE % mathematics proficiency.

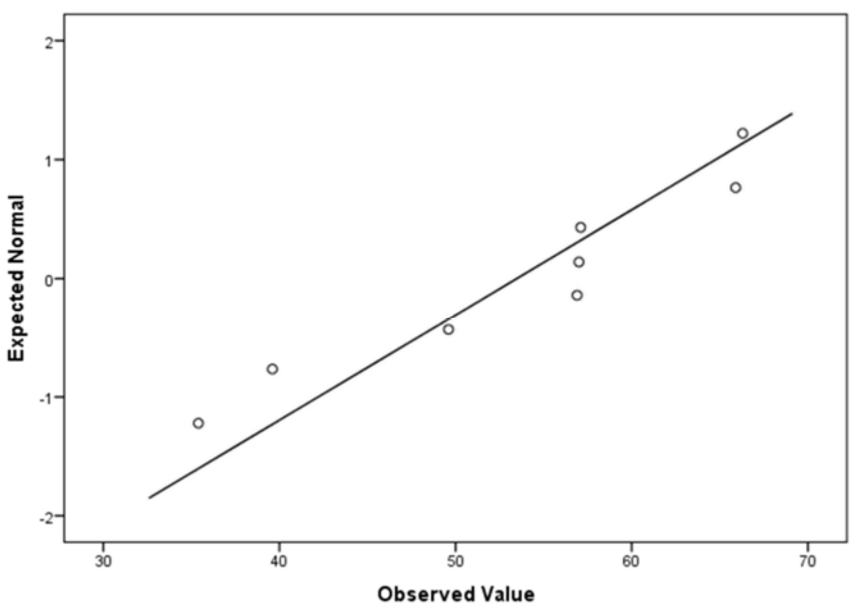

Figure J-281. Normal Q-Q Plot of 2015 SAGE % Mathematics Proficiency for Age = 45. This figure illustrates the observed value versus the expected normal for school leaders whose age was 45 based on their school's school-wide 2015 SAGE % mathematics proficiency.

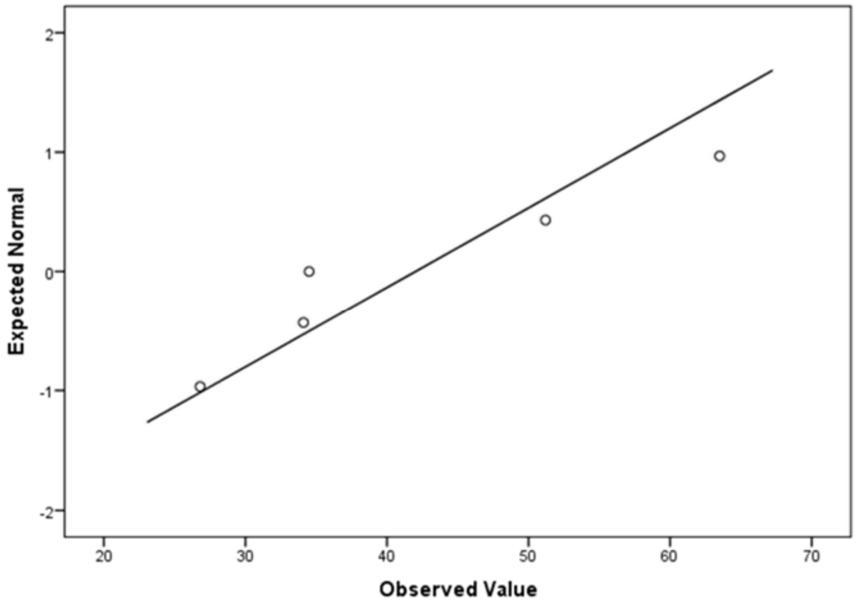

Figure J-282. Normal Q-Q Plot of 2015 SAGE % Mathematics Proficiency for Age = 46. This figure illustrates the observed value versus the expected normal for school leaders whose age was 46 based on their school's school-wide 2015 SAGE % mathematics proficiency.

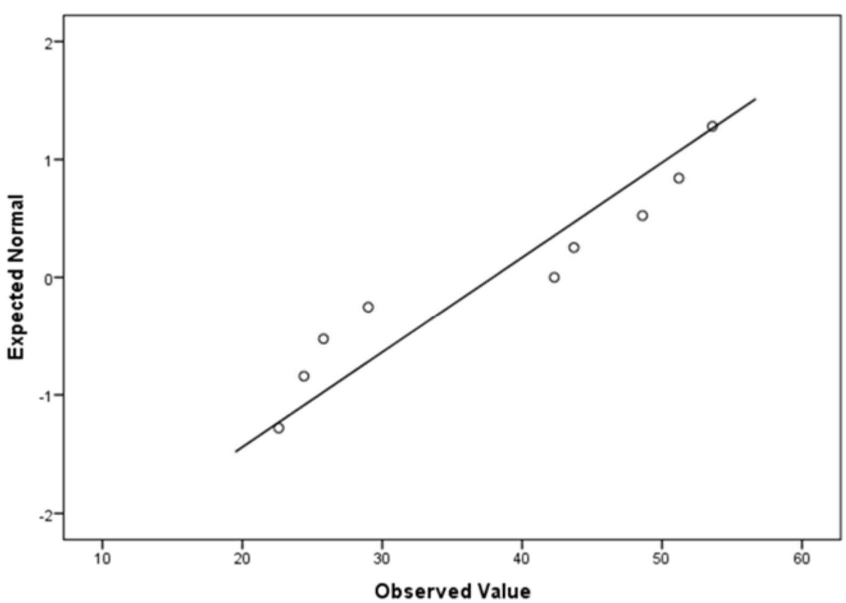

Figure J-283. Normal Q-Q Plot of 2015 SAGE % Mathematics Proficiency for Age = 47. This figure illustrates the observed value versus the expected normal for school leaders whose age was 47 based on their school's school-wide 2015 SAGE % mathematics proficiency.

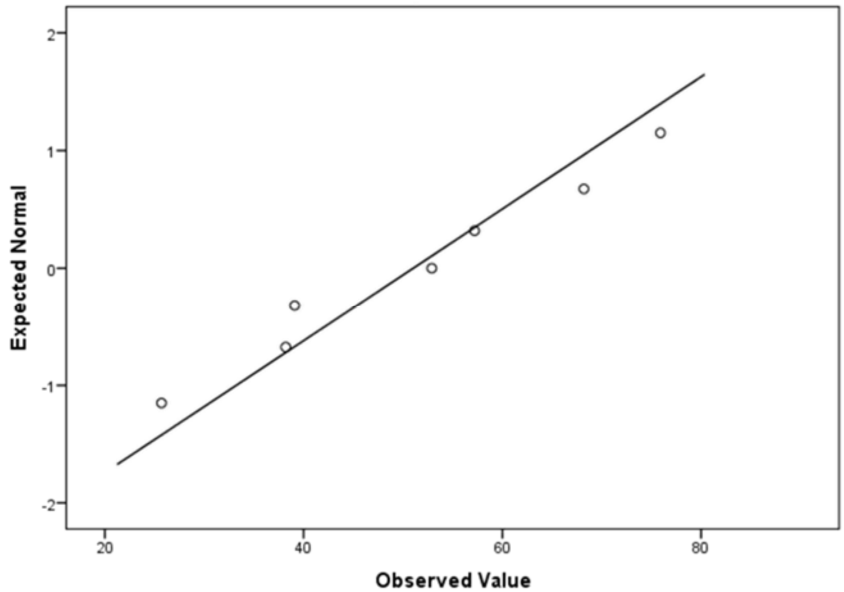

Figure J-284. Normal Q-Q Plot of 2015 SAGE % Mathematics Proficiency for Age = 48. This figure illustrates the observed value versus the expected normal for school leaders whose age was 48 based on their school's school-wide 2015 SAGE % mathematics proficiency.

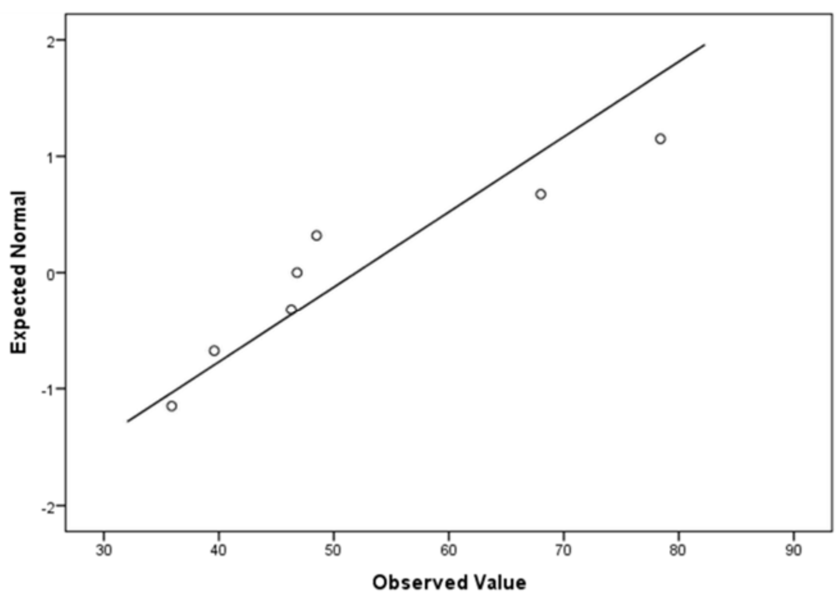

Figure J-285. Normal Q-Q Plot of 2015 SAGE % Mathematics Proficiency for Age = 49. This figure illustrates the observed value versus the expected normal for school leaders whose age was 49 based on their school's school-wide 2015 SAGE % mathematics proficiency.

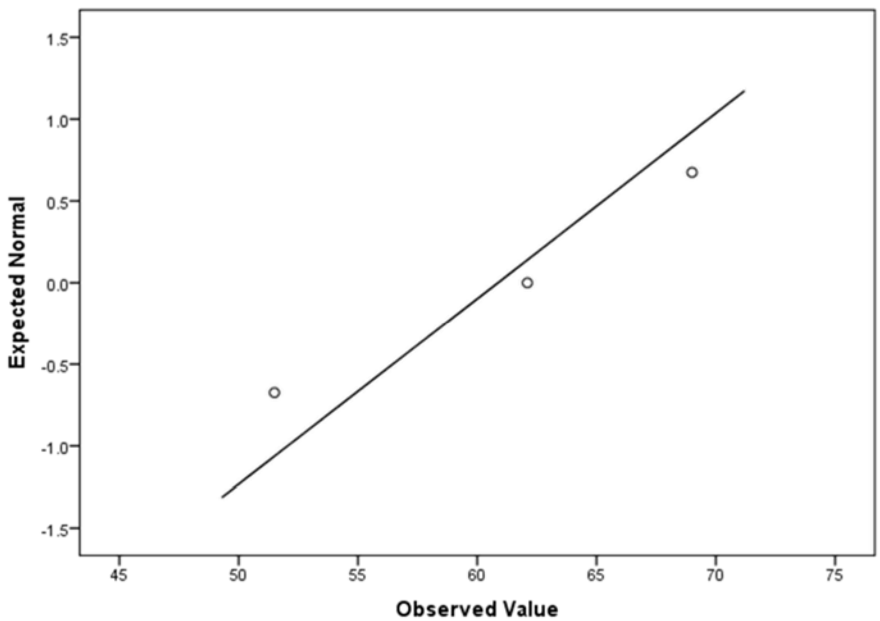

Figure J-286. Normal Q-Q Plot of 2015 SAGE % Mathematics Proficiency for Age = 50. This figure illustrates the observed value versus the expected normal for school leaders whose age was 50 based on their school's school-wide 2015 SAGE % mathematics proficiency.

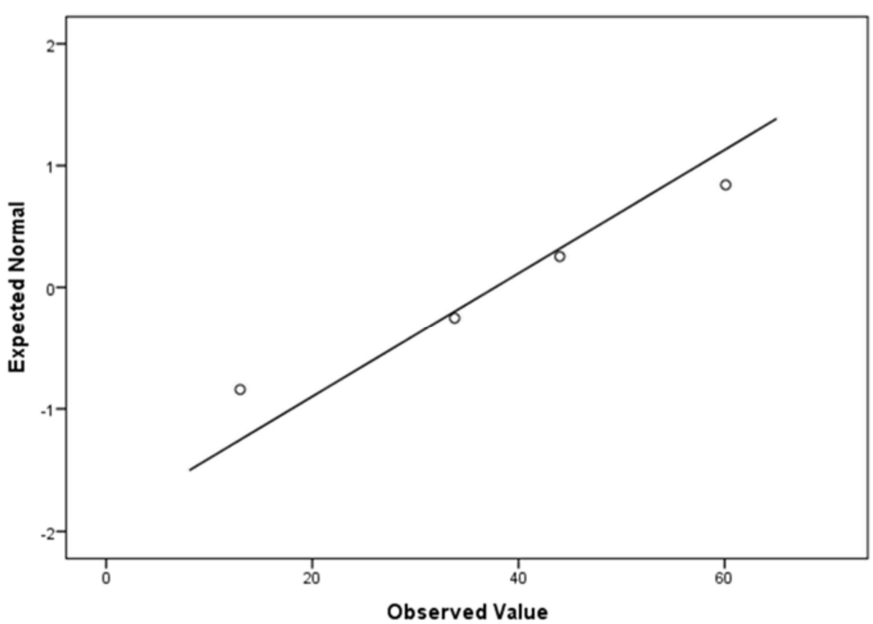

Figure J-287. Normal Q-Q Plot of 2015 SAGE % Mathematics Proficiency for Age = 51. This figure illustrates the observed value versus the expected normal for school leaders whose age was 51 based on their school's school-wide 2015 SAGE % mathematics proficiency.

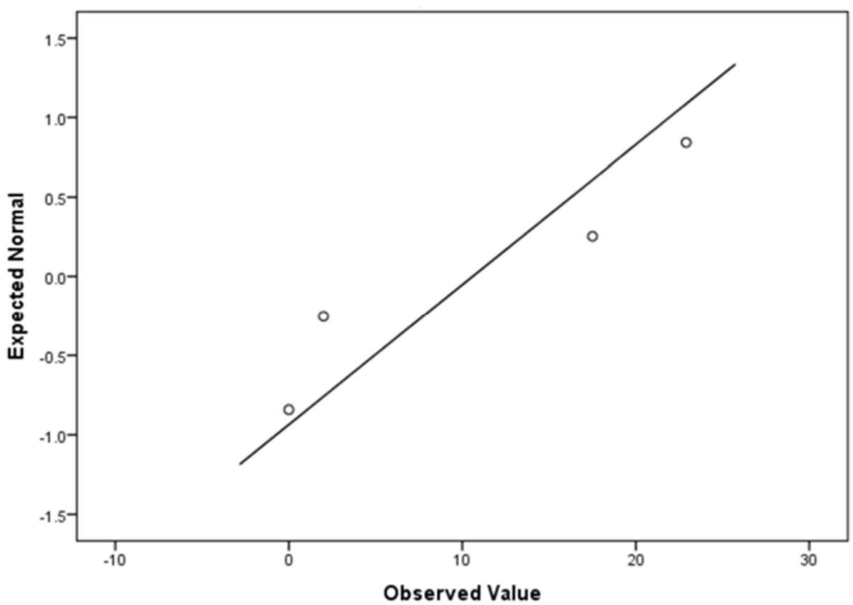

Figure J-288. Normal Q-Q Plot of 2015 SAGE % Mathematics Proficiency for Age = 52. This figure illustrates the observed value versus the expected normal for school leaders whose age was 52 based on their school's school-wide 2015 SAGE % mathematics proficiency.

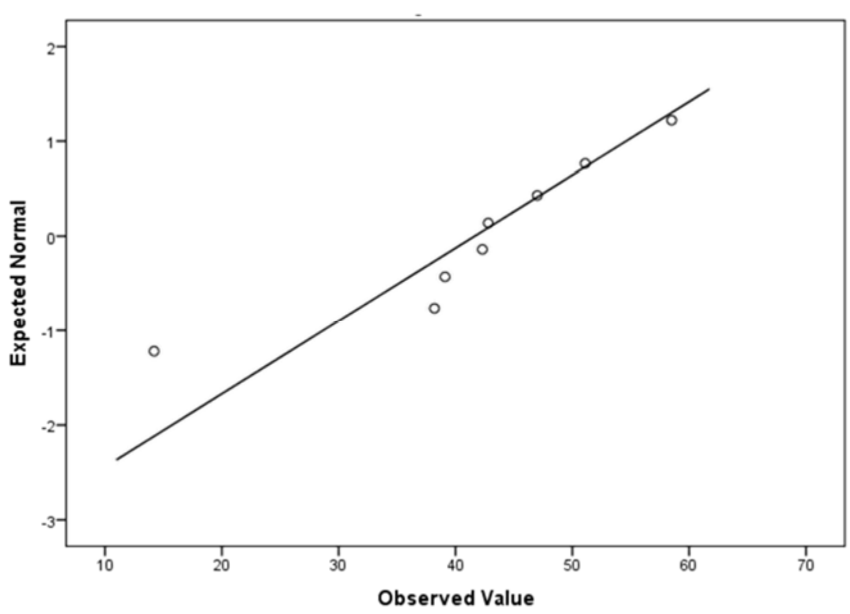

Figure J-289. Normal Q-Q Plot of 2015 SAGE % Mathematics Proficiency for Age = 53. This figure illustrates the observed value versus the expected normal for school leaders whose age was 53 based on their school's school-wide 2015 SAGE % mathematics proficiency.

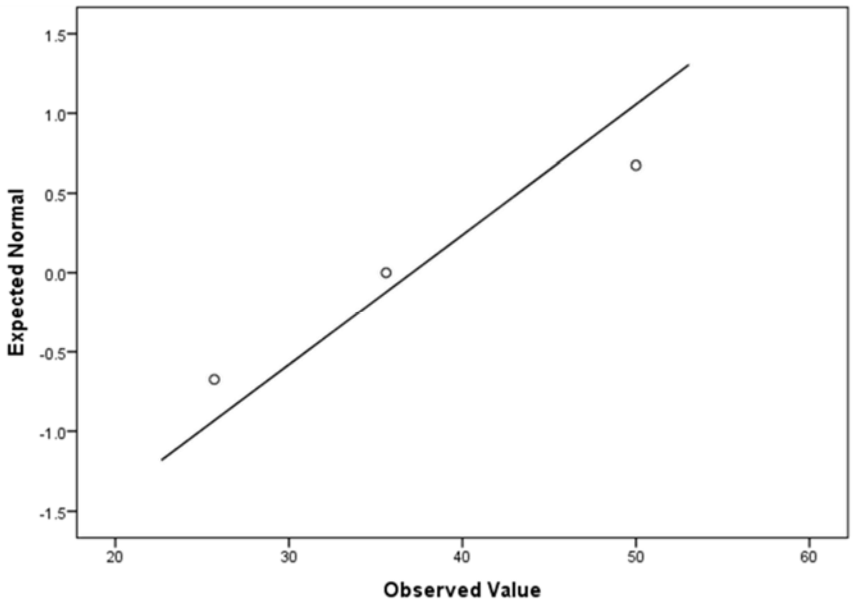

Figure J-290. Normal Q-Q Plot of 2015 SAGE % Mathematics Proficiency for Age = 54. This figure illustrates the observed value versus the expected normal for school leaders whose age was 54 based on their school's school-wide 2015 SAGE % mathematics proficiency.

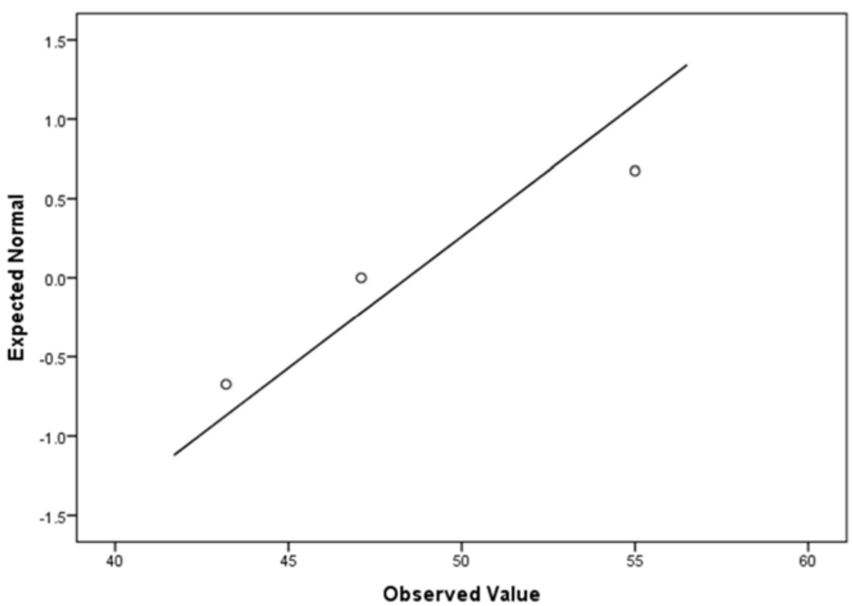

Figure J-291. Normal Q-Q Plot of 2015 SAGE % Mathematics Proficiency for Age = 55. This figure illustrates the observed value versus the expected normal for school leaders whose age was 55 based on their school's school-wide 2015 SAGE % mathematics proficiency.

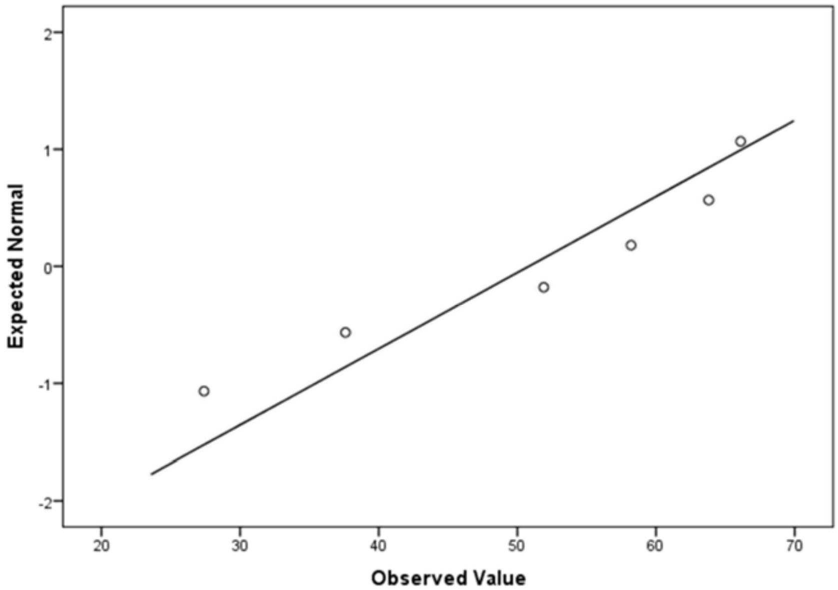

Figure J-292. Normal Q-Q Plot of 2015 SAGE % Mathematics Proficiency for Age = 56. This figure illustrates the observed value versus the expected normal for school leaders whose age was 56 based on their school's school-wide 2015 SAGE % mathematics proficiency.

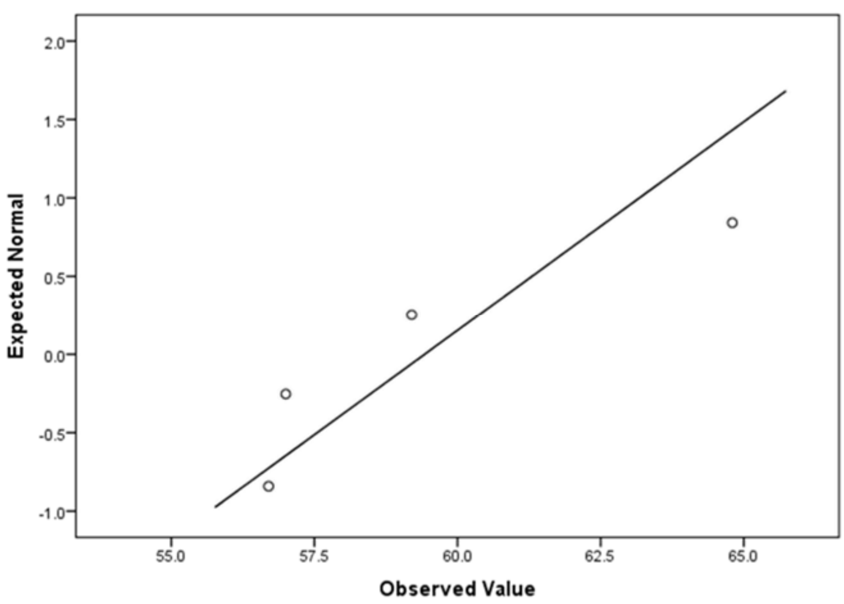

Figure J-293. Normal Q-Q Plot of 2015 SAGE % Mathematics Proficiency for Age = 57. This figure illustrates the observed value versus the expected normal for school leaders whose age was 57 based on their school's school-wide 2015 SAGE % mathematics proficiency.

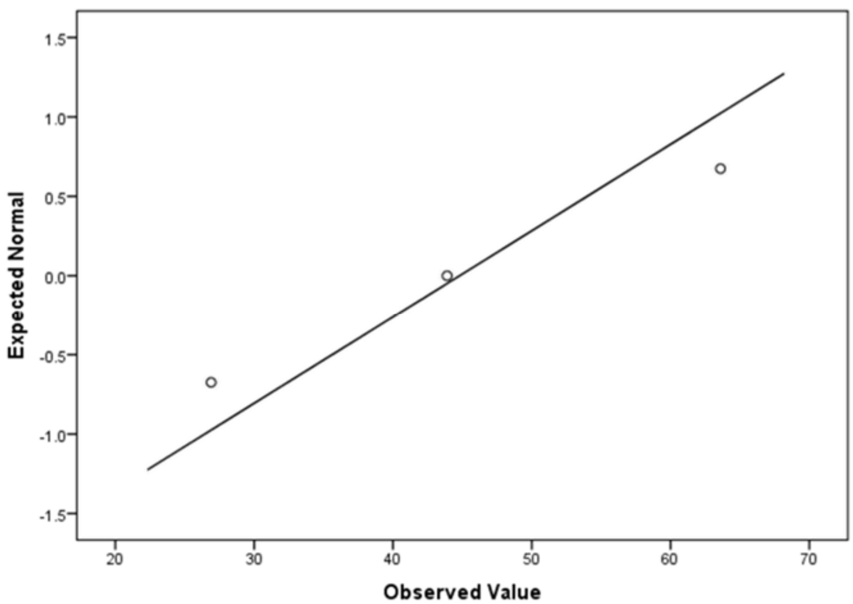

Figure J-294. Normal Q-Q Plot of 2015 SAGE % Mathematics Proficiency for Age = 58. This figure illustrates the observed value versus the expected normal for school leaders whose age was 58 based on their school's school-wide 2015 SAGE % mathematics proficiency.

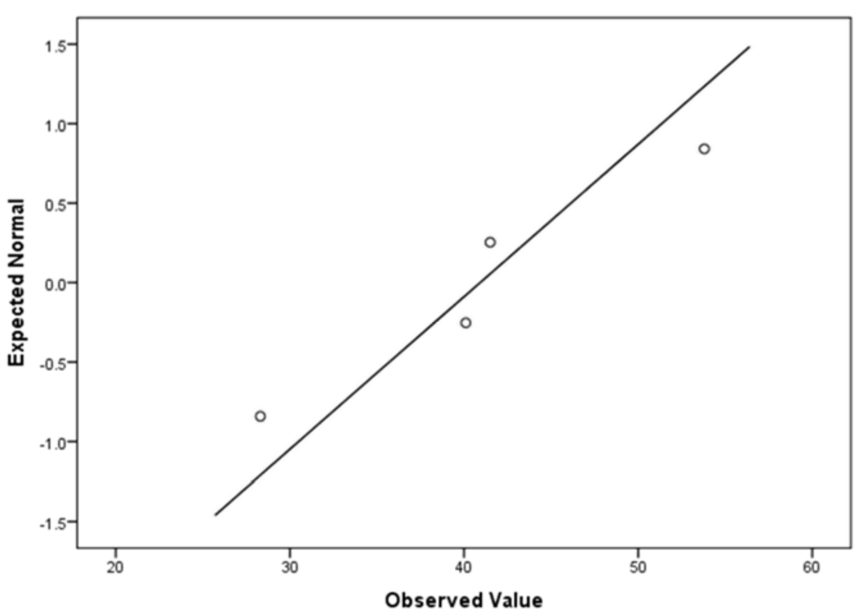

Figure J-295. Normal Q-Q Plot of 2015 SAGE % Mathematics Proficiency for Age = 59. This figure illustrates the observed value versus the expected normal for school leaders whose age was 59 based on their school's school-wide 2015 SAGE % mathematics proficiency.

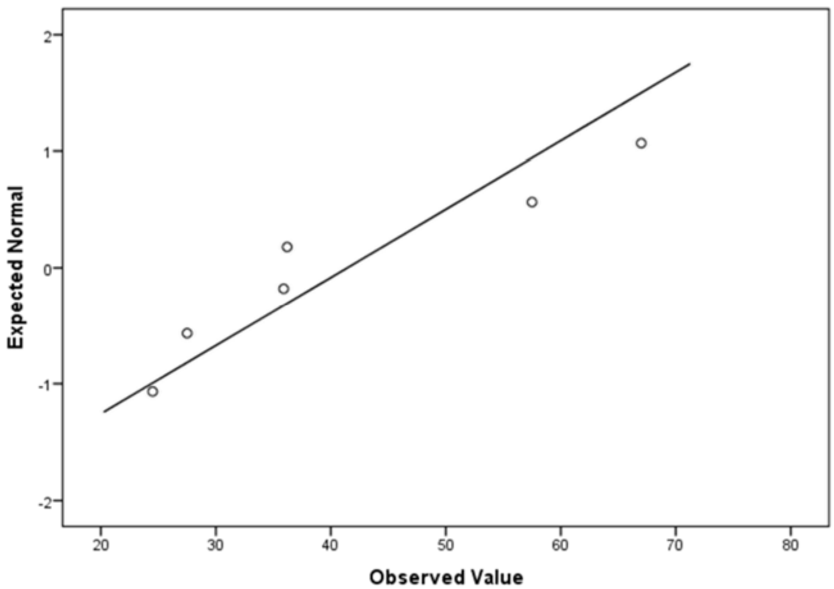

Figure J-296. Normal Q-Q Plot of 2015 SAGE % Mathematics Proficiency for Age = 60. This figure illustrates the observed value versus the expected normal for school leaders whose age was 60 based on their school's school-wide 2015 SAGE % mathematics proficiency.

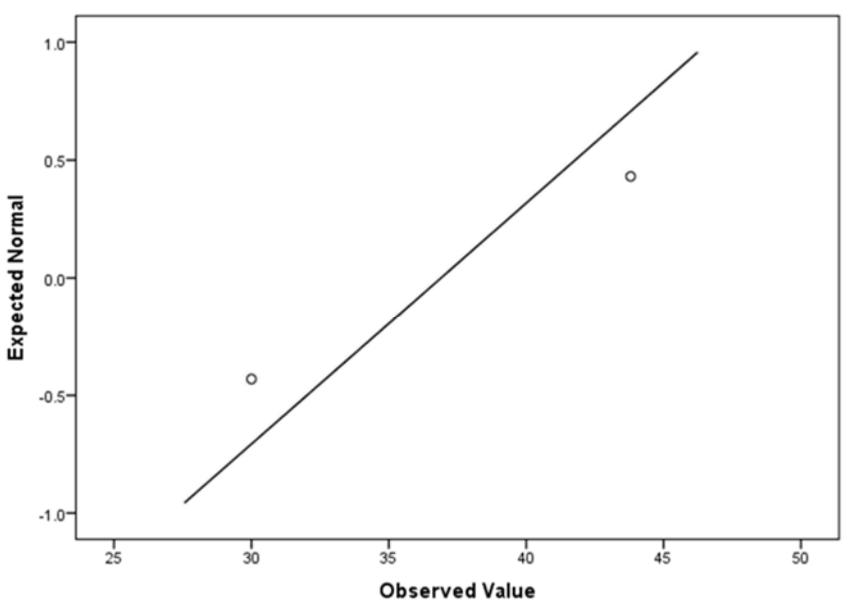

Figure J-297. Normal Q-Q Plot of 2015 SAGE % Mathematics Proficiency for Age = 61. This figure illustrates the observed value versus the expected normal for school leaders whose age was 61 based on their school's school-wide 2015 SAGE % mathematics proficiency.

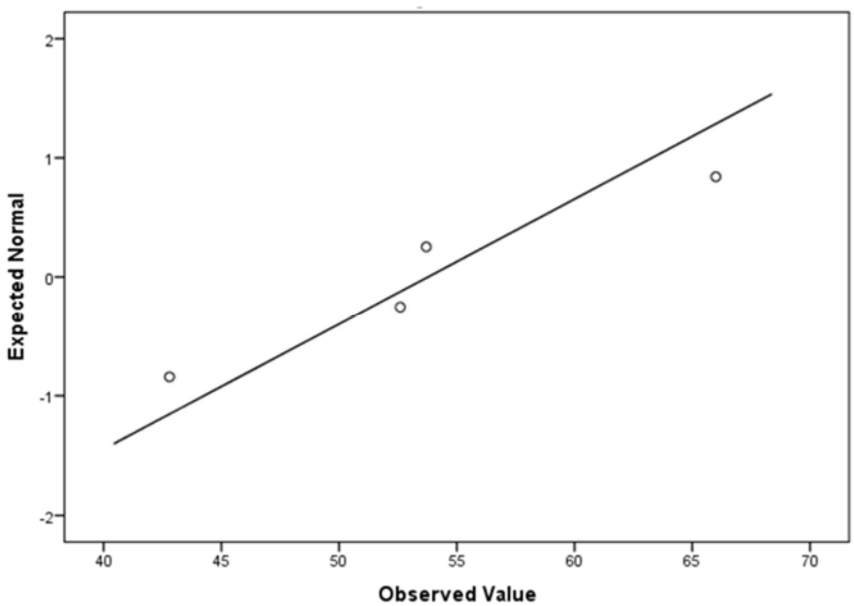

Figure J-298. Normal Q-Q Plot of 2015 SAGE % Mathematics Proficiency for Age = 62. This figure illustrates the observed value versus the expected normal for school leaders whose age was 62 based on their school's school-wide 2015 SAGE % mathematics proficiency.

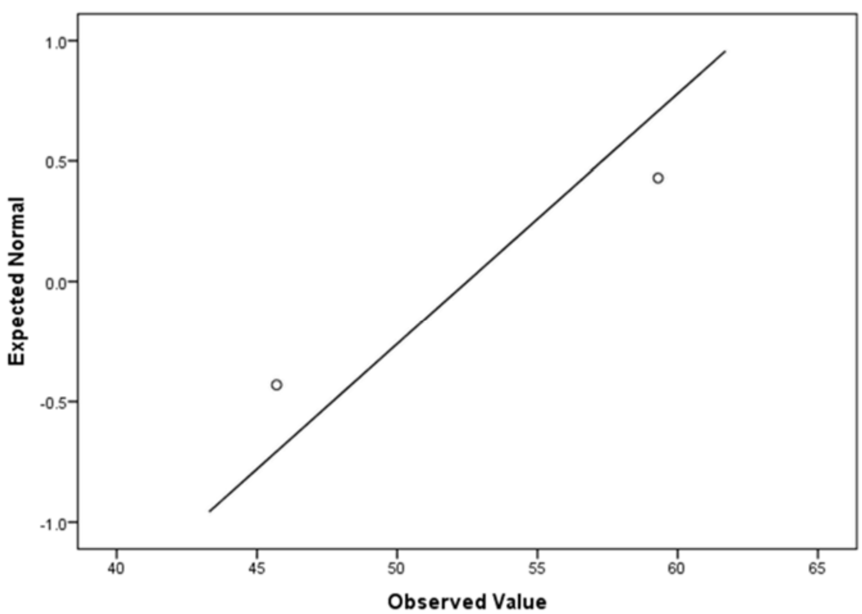

Figure J-299. Normal Q-Q Plot of 2015 SAGE % Mathematics Proficiency for Age = 63. This figure illustrates the observed value versus the expected normal for school leaders whose age was 63 based on their school's school-wide 2015 SAGE % mathematics proficiency.

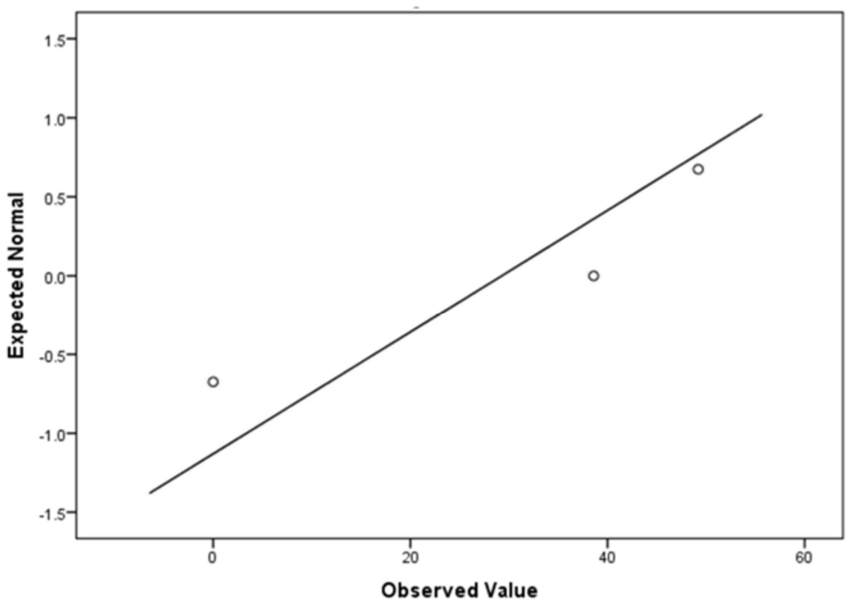

Figure J-300. Normal Q-Q Plot of 2015 SAGE % Mathematics Proficiency for Age = 64. This figure illustrates the observed value versus the expected normal for school leaders whose age was 64 based on their school's school-wide 2015 SAGE % mathematics proficiency.

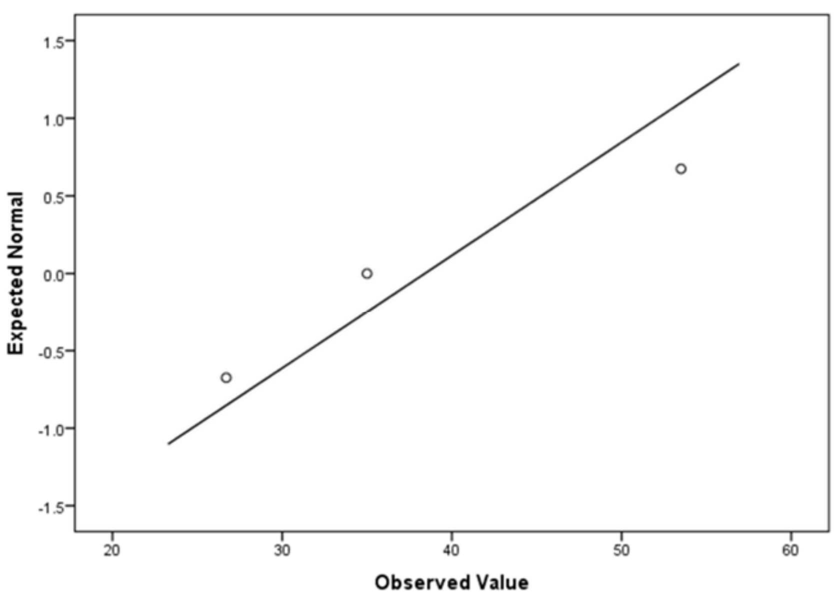

Figure J-301. Normal Q-Q Plot of 2015 SAGE % Mathematics Proficiency for Age = 65. This figure illustrates the observed value versus the expected normal for school leaders whose age was 65 based on their school's school-wide 2015 SAGE % mathematics proficiency.

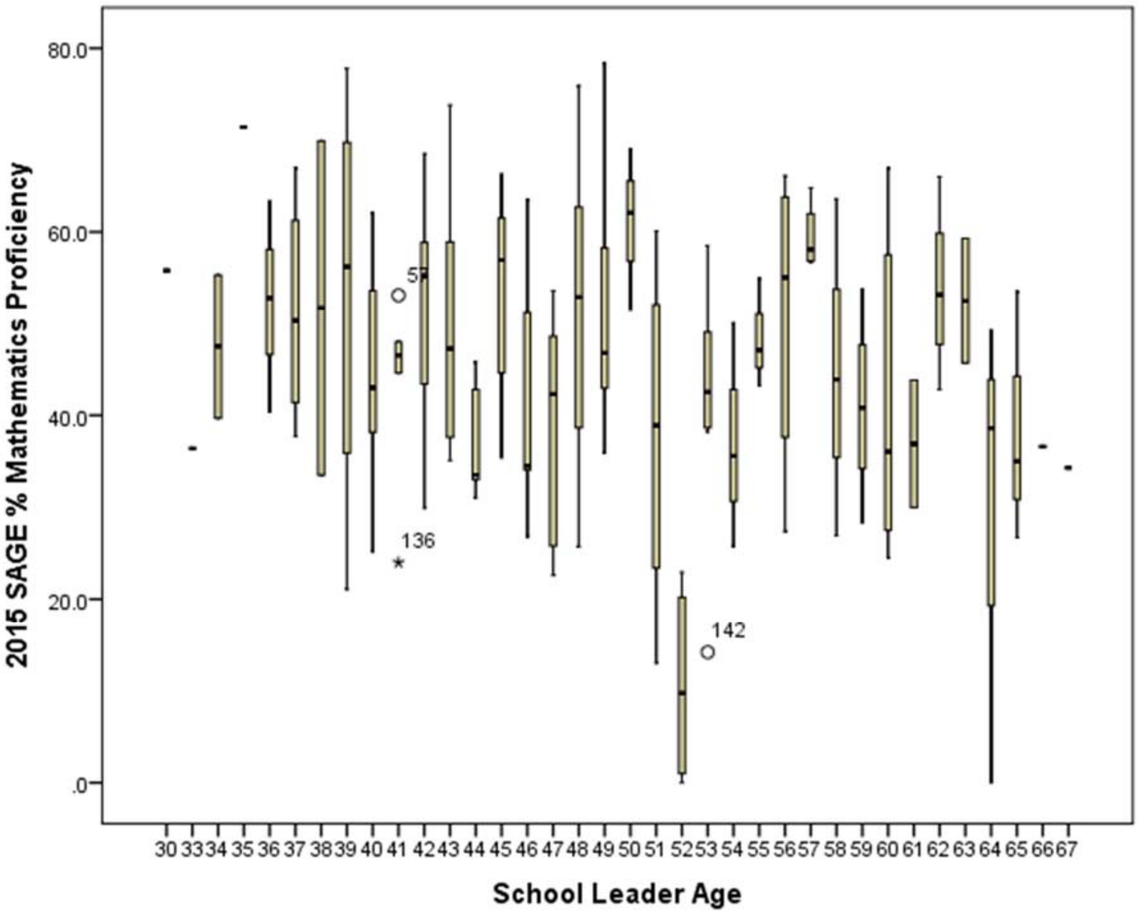

Figure J-302. Boxplot of 2015 SAGE % Mathematics Proficiency for Age. This figure illustrates spread of school-wide 2015 SAGE % Mathematics Proficiency scores based on school leaders' age.

Table J-19

MTL55: Tests for Normality

Variable		Shapiro-Wilk Statistic	df	Sig.	Skewness	Std. Error	Kurtosis	Std. Error
MTL55	1							
	2							
	3	.94	13	.460	-.38	.62	-.67	1.19
	4	.97	58	.235	.05	.31	-.24	.62
	5	.93	19	.203	-.27	.52	-1.07	1.01

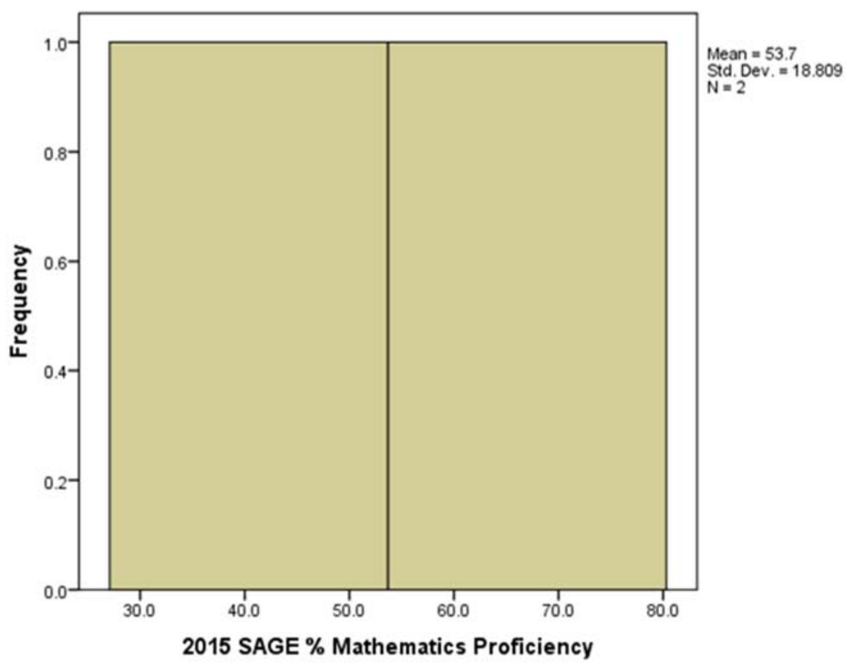

Figure J-303. Frequency by 2015 SAGE % Mathematics Proficiency for MTL55 = 2. This figure illustrates the number of school leaders who ranked MTL55 at 2 based on their school's school-wide 2015 SAGE % mathematics proficiency.

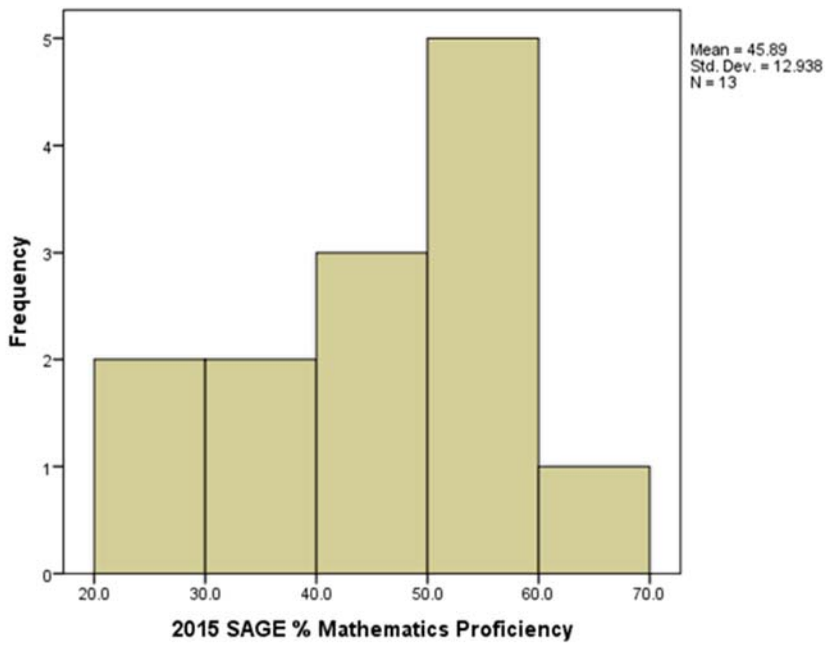

Figure J-304. Frequency by 2015 SAGE % Mathematics Proficiency for MTL55 = 3. This figure illustrates the number of school leaders who ranked MTL55 at 3 based on their school's school-wide 2015 SAGE % mathematics proficiency.

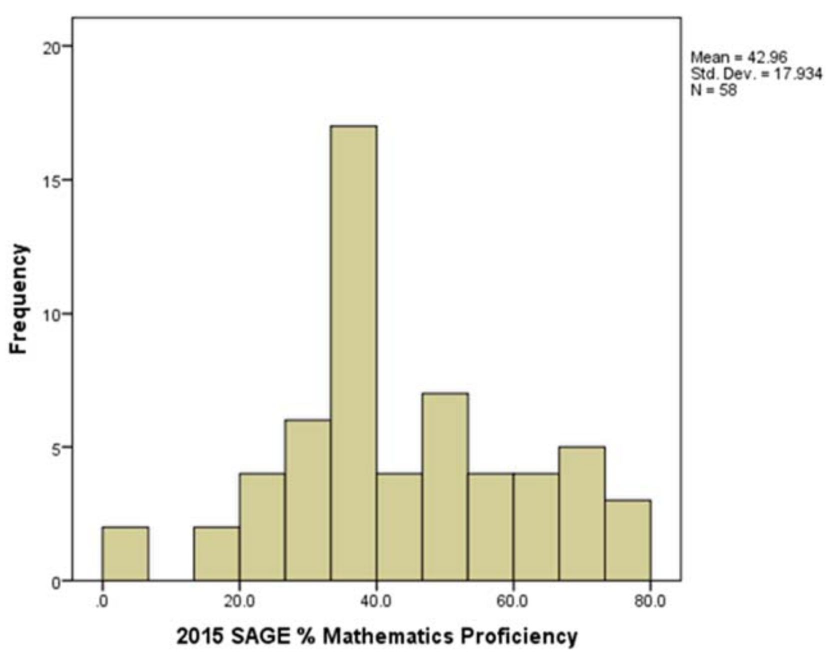

Figure J-305. Frequency by 2015 SAGE % Mathematics Proficiency for MTL55 = 4. This figure illustrates the number of school leaders who ranked MTL55 at 4 based on their school's school-wide 2015 SAGE % mathematics proficiency.

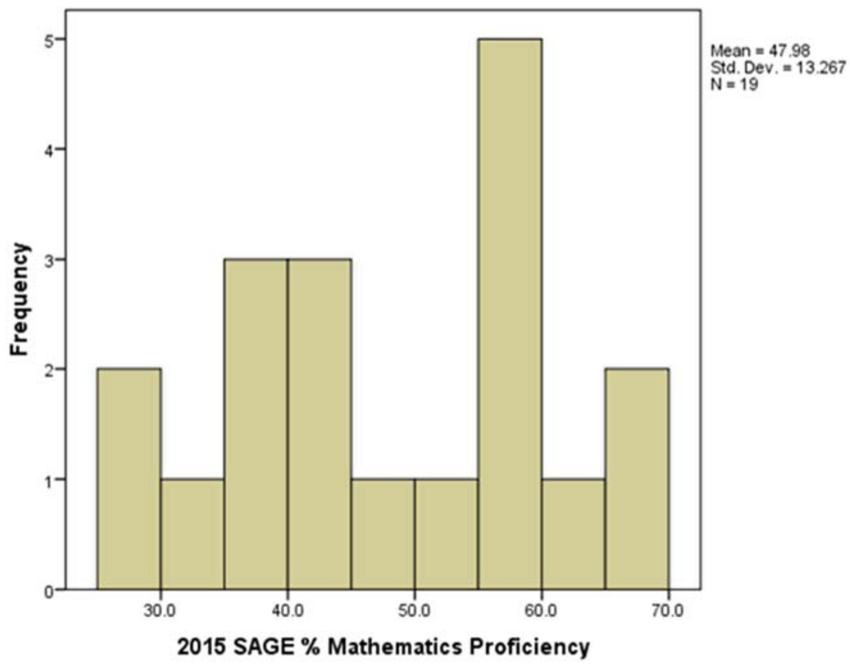

Figure J-306. Frequency by 2015 SAGE % Mathematics Proficiency for MTL55 = 5. This figure illustrates the number of school leaders who ranked MTL55 at 5 based on their school's school-wide 2015 SAGE % mathematics proficiency.

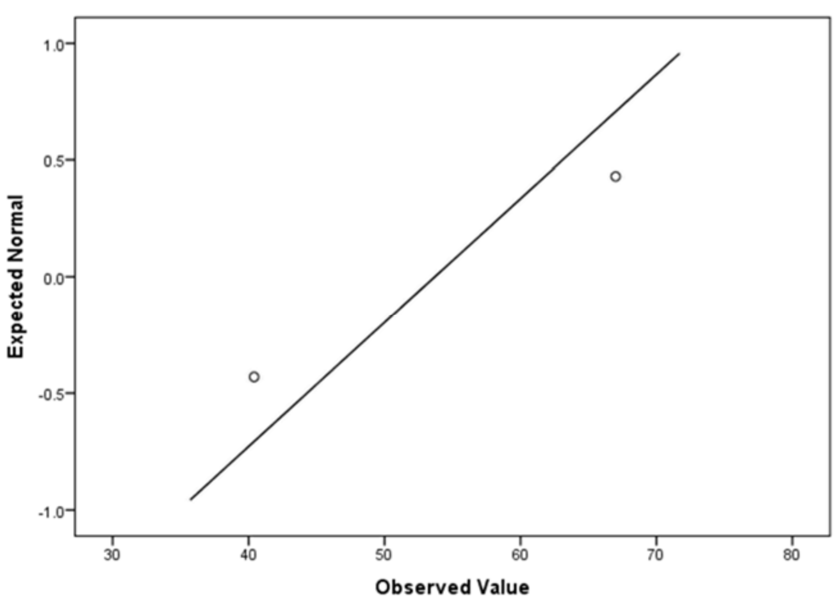

Figure J-307. Normal Q-Q Plot of 2015 SAGE % Mathematics Proficiency for MTL55 = 2. This figure illustrates the observed value versus the expected normal for school leaders who ranked MTL55 at 2 based on their school's school-wide 2015 SAGE % mathematics proficiency.

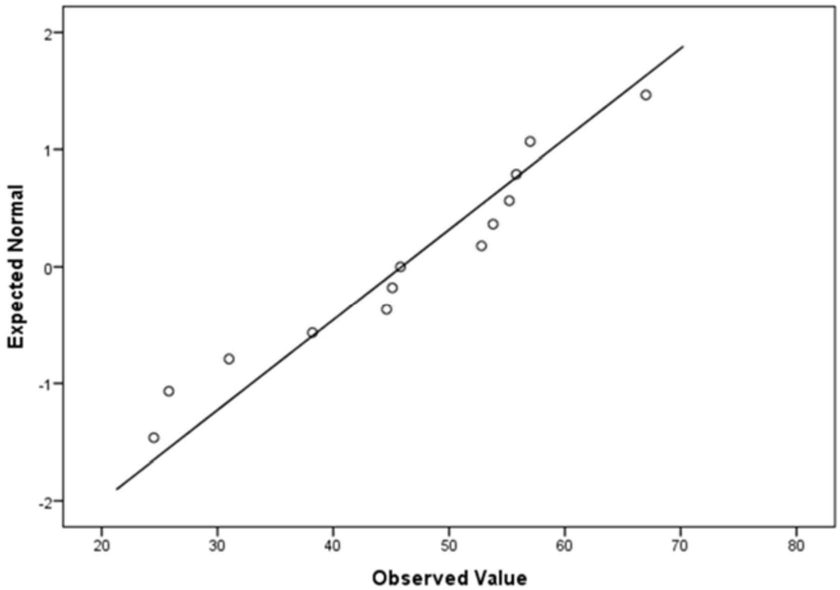

Figure J-308. Normal Q-Q Plot of 2015 SAGE % Mathematics Proficiency for MTL55 = 3. This figure illustrates the observed value versus the expected normal for school leaders who ranked MTL55 at 3 based on their school's school-wide 2015 SAGE % mathematics proficiency.

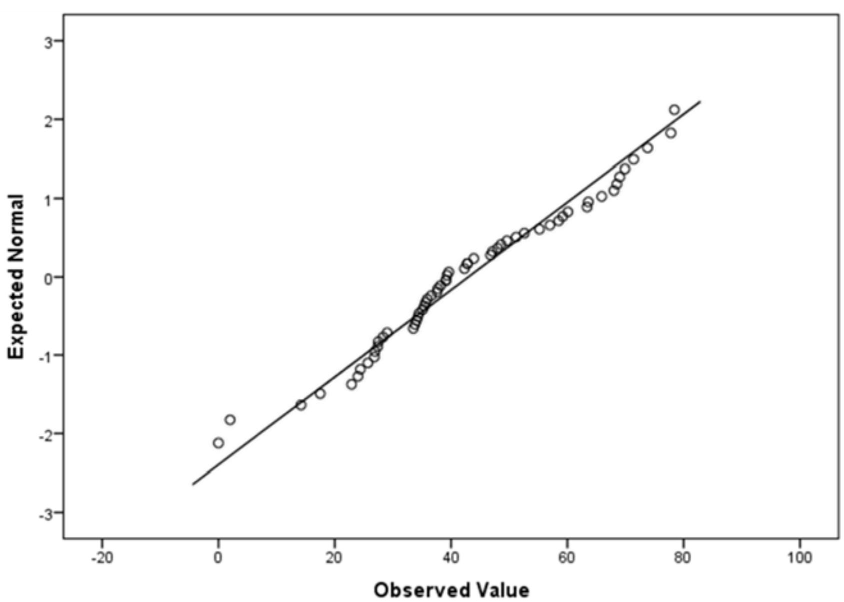

Figure J-309. Normal Q-Q Plot of 2015 SAGE % Mathematics Proficiency for MTL55 = 4. This figure illustrates the observed value versus the expected normal for school leaders who ranked MTL55 at 4 based on their school's school-wide 2015 SAGE % mathematics proficiency.

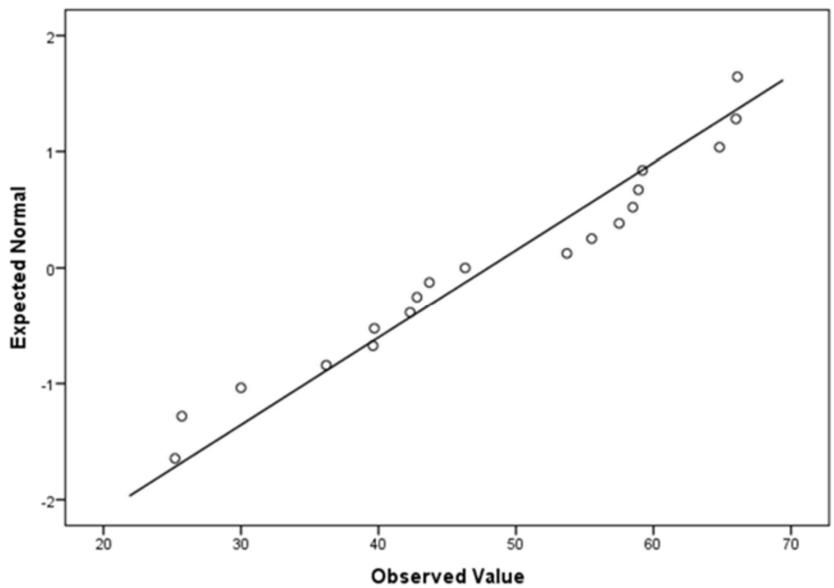

Figure J-310. Normal Q-Q Plot of 2015 SAGE % Mathematics Proficiency for MTL55 = 5. This figure illustrates the observed value versus the expected normal for school leaders who ranked MTL55 at 5 based on their school's school-wide 2015 SAGE % mathematics proficiency.

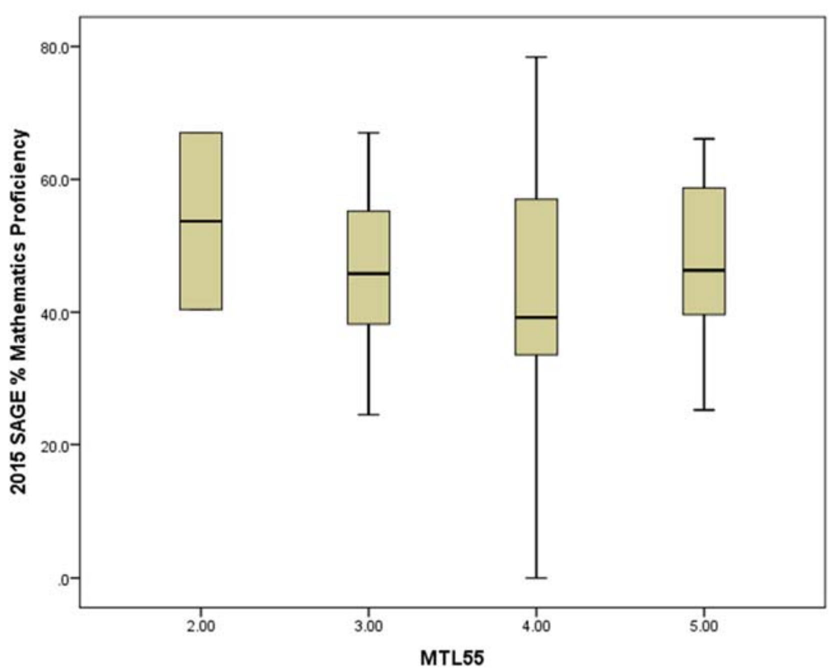

Figure J-311. Boxplot of 2015 SAGE % Mathematics Proficiency for MTL55. This figure illustrates spread of school-wide 2015 SAGE % Mathematics Proficiency scores based on school leaders' ranking of MTL55.

Table J-20

Gr_T_2: Tests for Normality

		Shapiro-Wilk						
Variable		Statistic	*df*	Sig.	Skewness	Std. Error	Kurtosis	Std. Error
Gr_T_2	Yes	.90	22	.029	-.98	.49	1.73	.95
	No	.99	127	.542	-.18	.22	-.36	.43

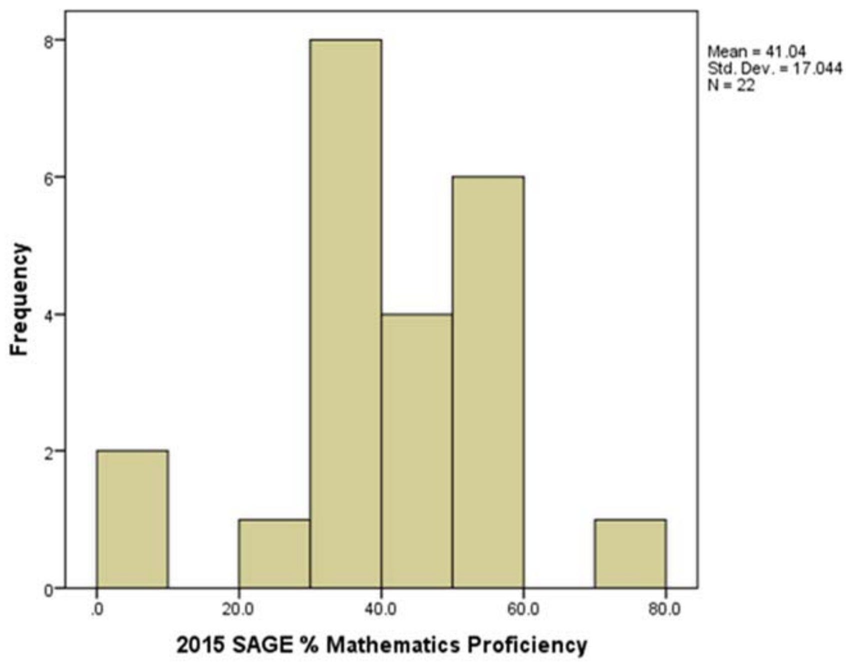

Figure J-312. Frequency by 2015 SAGE % Mathematics Proficiency for Gr_T_2 = Yes. This figure illustrates the number of school leaders who ranked Gr_T_2 at Yes based on their school's school-wide 2015 SAGE % mathematics proficiency.

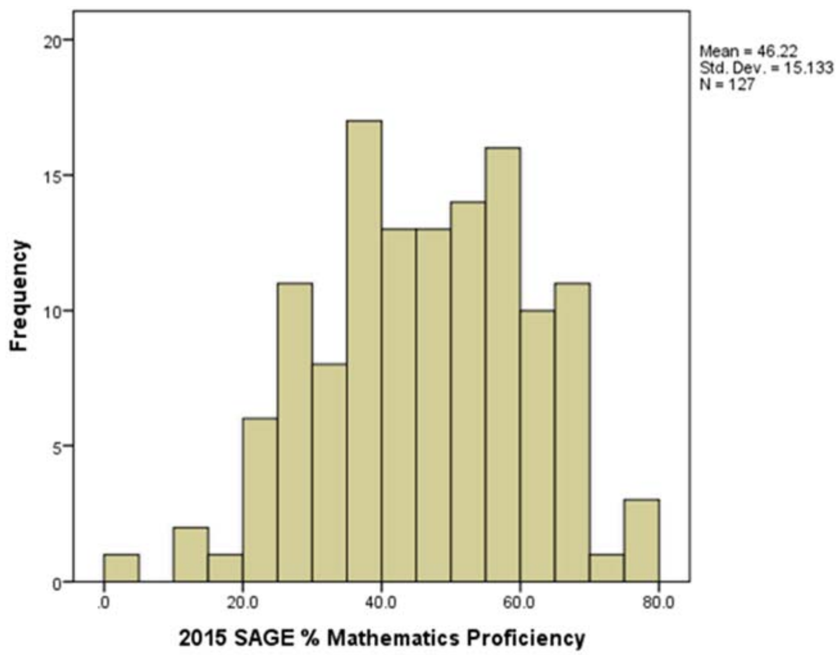

Figure J-313. Frequency by 2015 SAGE % Mathematics Proficiency for Gr_T_2 = No. This figure illustrates the number of school leaders who ranked Gr_T_2 at No based on their school's school-wide 2015 SAGE % mathematics proficiency.

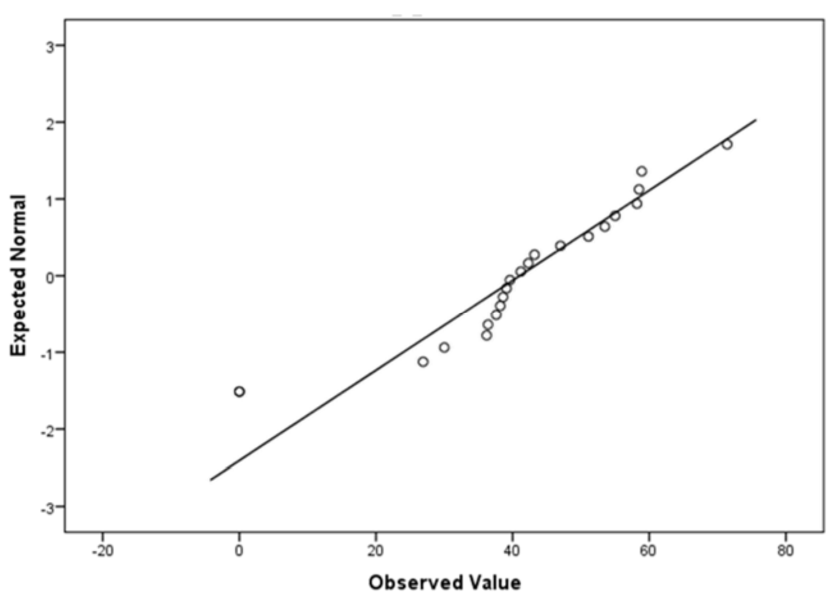

Figure J-314. Normal Q-Q Plot of 2015 SAGE % Mathematics Proficiency for Gr_T_2 = Yes. This figure illustrates the observed value versus the expected normal for school leaders who ranked Gr_T_2 at Yes based on their school's school-wide 2015 SAGE % mathematics proficiency.

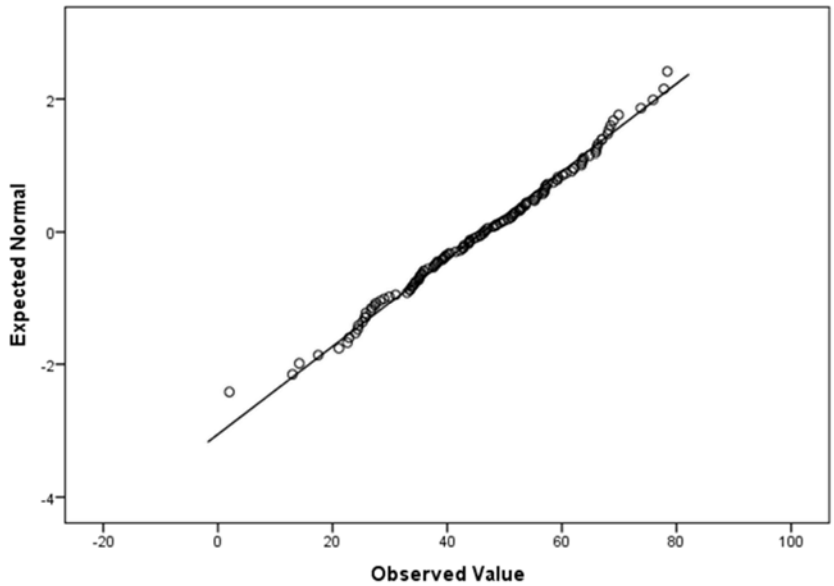

Figure J-315. Normal Q-Q Plot of 2015 SAGE % Mathematics Proficiency for Gr_T_2 = No. This figure illustrates the observed value versus the expected normal for school leaders who ranked Gr_T_2 at No based on their school's school-wide 2015 SAGE % mathematics proficiency.

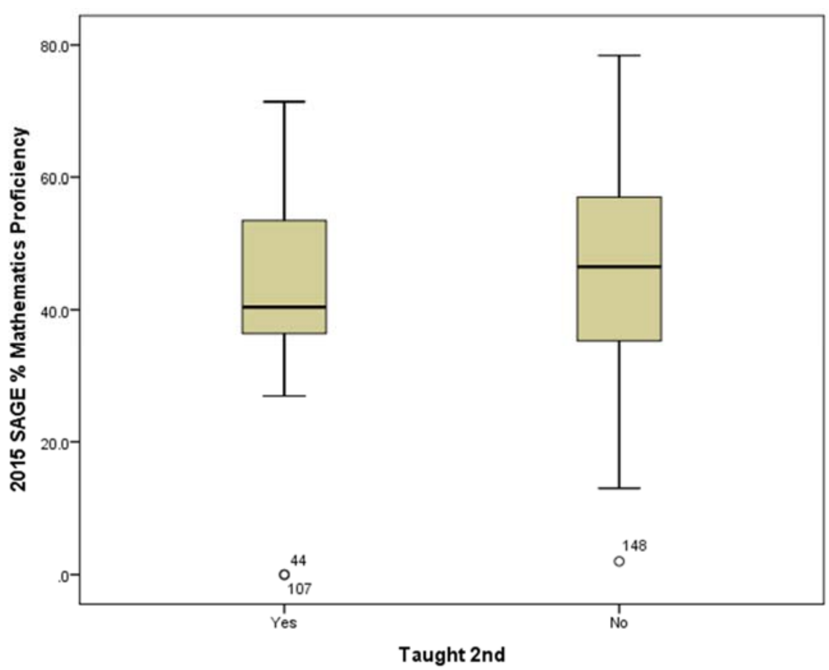

Figure J-316. Boxplot of 2015 SAGE % Mathematics Proficiency for Gr_T_2. This figure illustrates spread of school-wide 2015 SAGE % Mathematics Proficiency scores based on school leaders' teaching or not teaching 2nd grade.

Table J-21

Sub_T_Elec: Tests for Normality

Variable		Shapiro-Wilk Statistic	*df*	Sig.	Skewness	Std. Error	Kurtosis	Std. Error
Sub_T_Elec	Yes	.94	5	.681	-1.05	.91	1.36	2.00
	No	.99	144	.238	-.30	.20	.06	.40

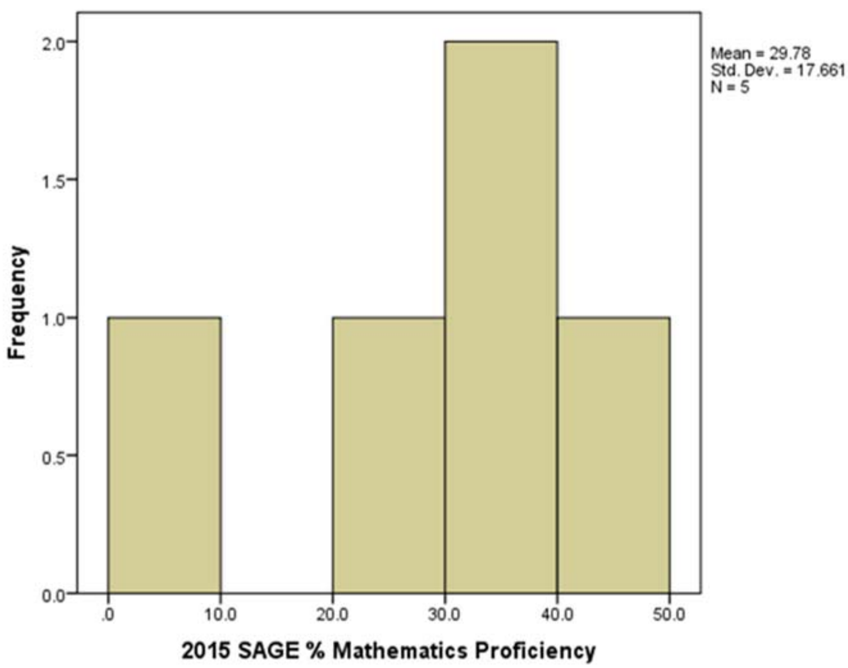

Figure J-317. Frequency by 2015 SAGE % Mathematics Proficiency for Sub_T_Elec = Yes. This figure illustrates the number of school leaders who ranked Sub_T_Elec at Yes based on their school's school-wide 2015 SAGE % mathematics proficiency.

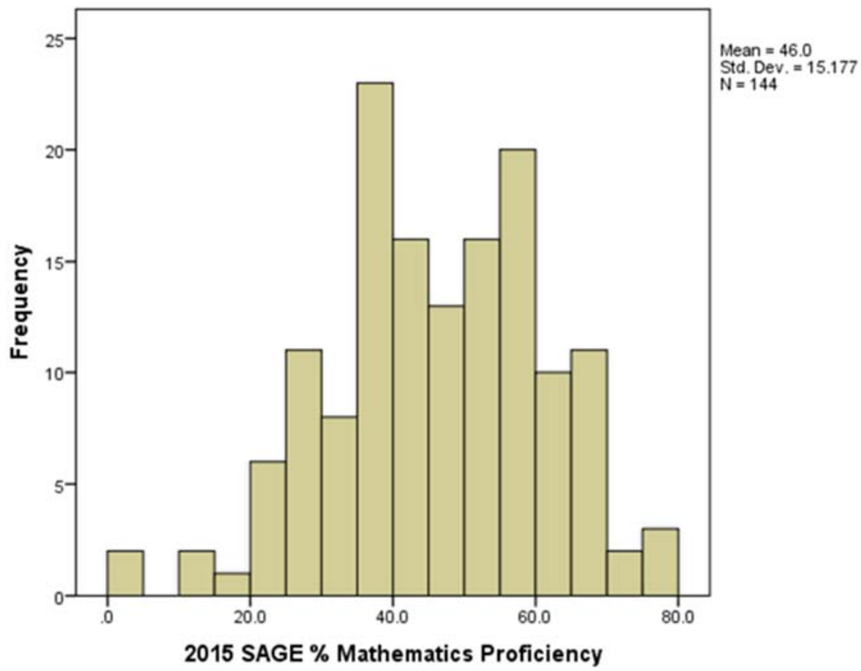

Figure J-318. Frequency by 2015 SAGE % Mathematics Proficiency for Sub_T_Elec = No. This figure illustrates the number of school leaders who ranked Sub_T_Elec at No based on their school's school-wide 2015 SAGE % mathematics proficiency.

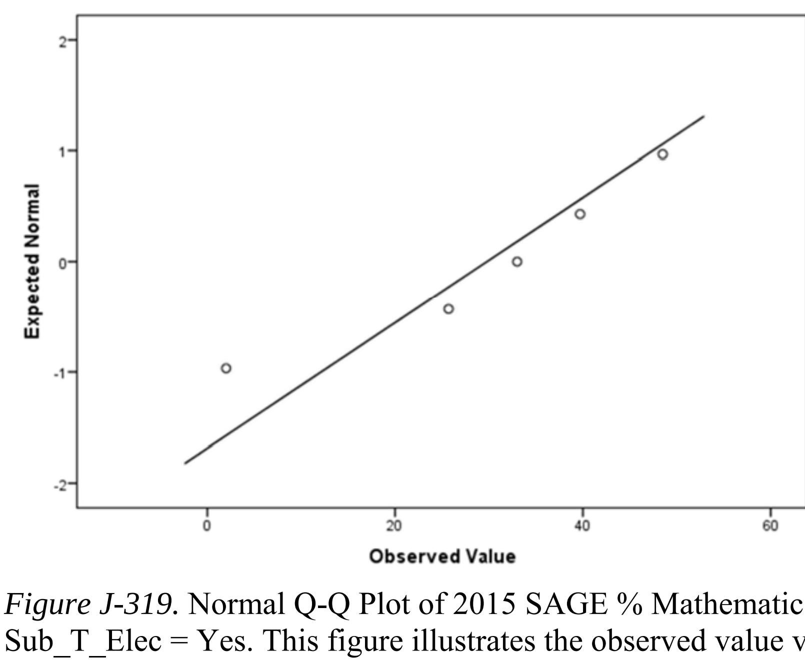

Figure J-319. Normal Q-Q Plot of 2015 SAGE % Mathematics Proficiency for Sub_T_Elec = Yes. This figure illustrates the observed value versus the expected normal for school leaders who ranked Sub_T_Elec at Yes based on their school's school-wide 2015 SAGE % mathematics proficiency.

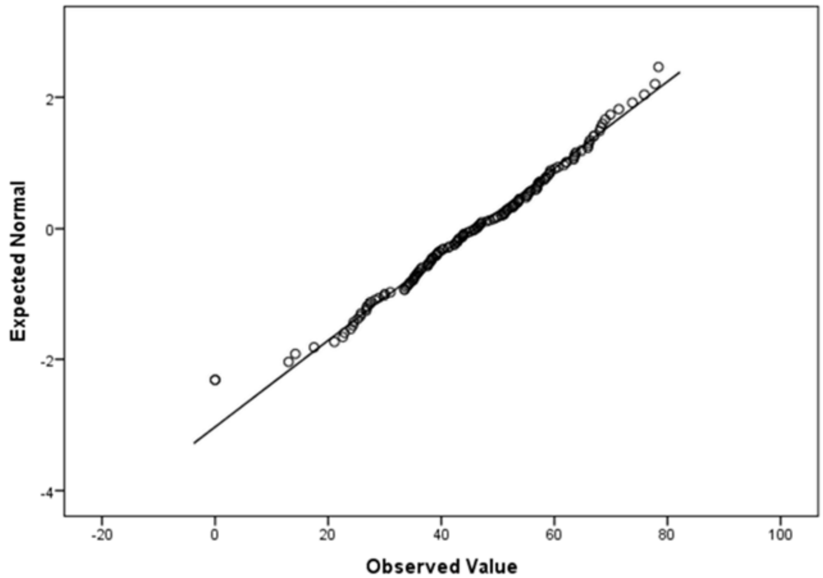

Figure J-320. Normal Q-Q Plot of 2015 SAGE % Mathematics Proficiency for Sub_T_Elec = No. This figure illustrates the observed value versus the expected normal for school leaders who ranked Sub_T_Elec at No based on their school's school-wide 2015 SAGE % mathematics proficiency.

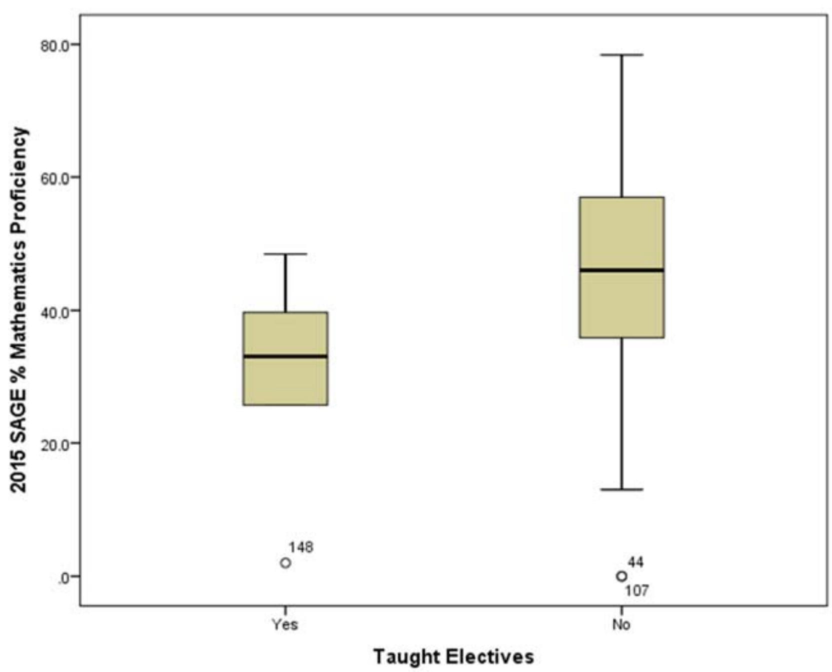

Figure J-321. Boxplot of 2015 SAGE % Mathematics Proficiency for Sub_T_Elec. This figure illustrates spread of school-wide 2015 SAGE % Mathematics Proficiency scores based on school leaders' teaching or not teaching an elective subject.

Table J-22

Other_Math: Tests for Normality

Variable		Shapiro-Wilk Statistic	*df*	Sig.	Skewness	Std. Error	Kurtosis	Std. Error
Other_ Math	No	.99	140	.120	-.36	.21	.13	.41
	Yes, Minor/ Special Emph.	.99	8	.985	-.32	.75	.07	1.48

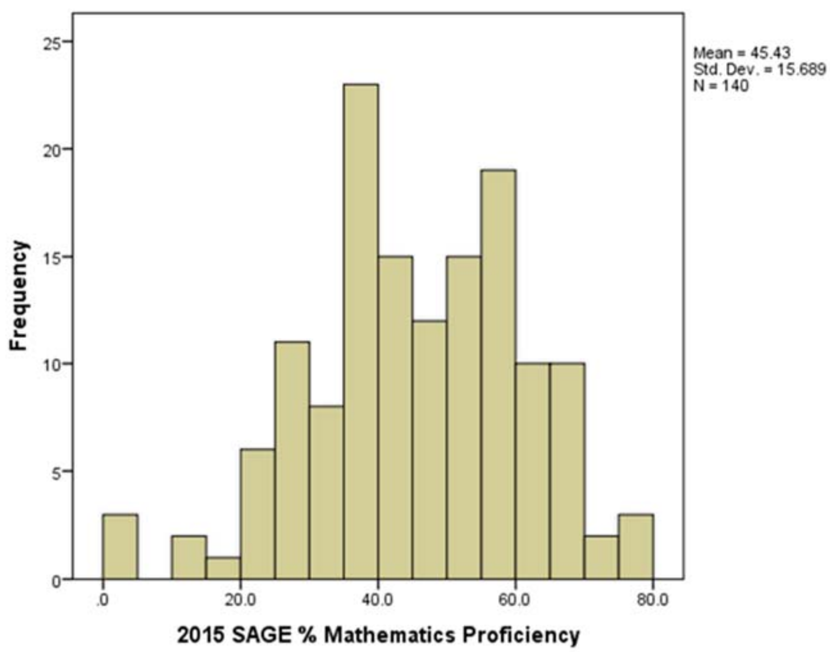

Figure J-322. Frequency by 2015 SAGE % Mathematics Proficiency for Other_Math = No. This figure illustrates the number of school leaders who ranked Math_Other at No based on their school's school-wide 2015 SAGE % mathematics proficiency.

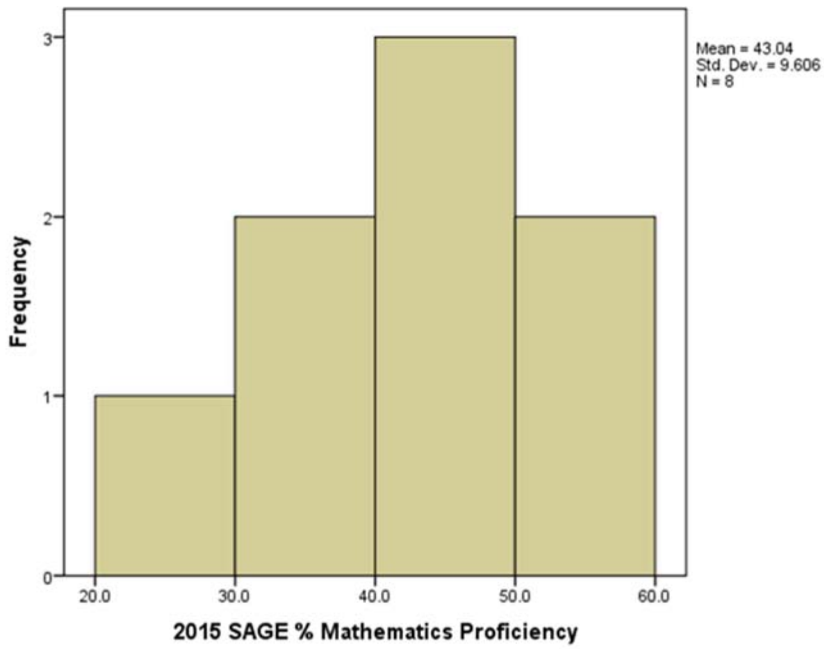

Figure J-323. Frequency by 2015 SAGE % Mathematics Proficiency for Other_Math = Yes, Minor/Sp.Emphasis. This figure illustrates the number of school leaders who ranked Math_Other at Yes, Minor/Sp. Emphasis based on their school's school-wide 2015 SAGE % mathematics proficiency.

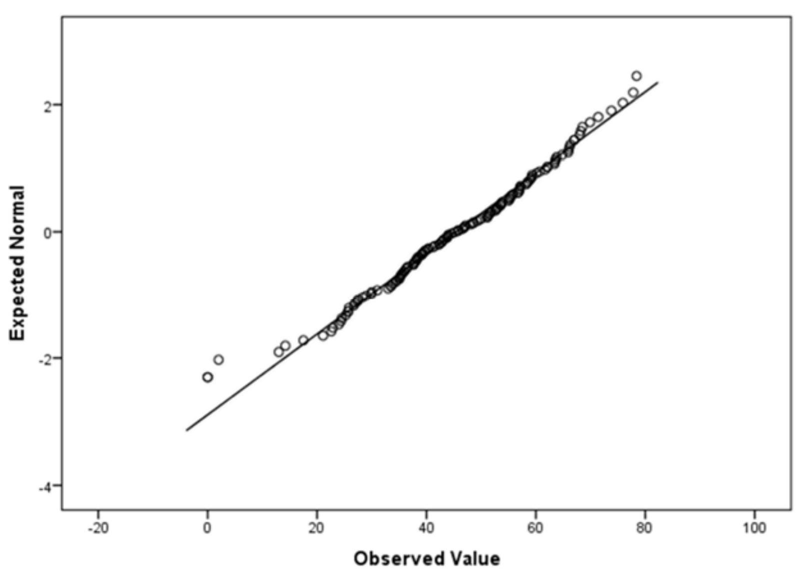

Figure J-324. Normal Q-Q Plot of 2015 SAGE % Mathematics Proficiency for Sub_T_Elec = No. This figure illustrates the observed value versus the expected normal for school leaders who ranked Sub_T_Elec at No based on their school's school-wide 2015 SAGE % mathematics proficiency.

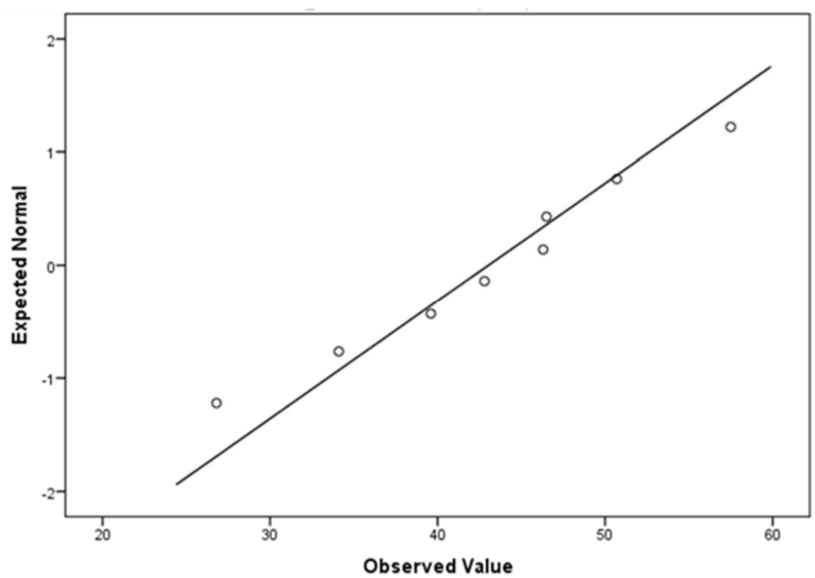

Figure J-325. Normal Q-Q Plot of 2015 SAGE % Mathematics Proficiency for Sub_T_Elec = Yes, Minor/Sp.Emphasis. This figure illustrates the observed value versus the expected normal for school leaders who ranked Sub_T_Elec at Yes, Minor/Sp.Emphasis based on their school's school-wide 2015 SAGE % mathematics proficiency.

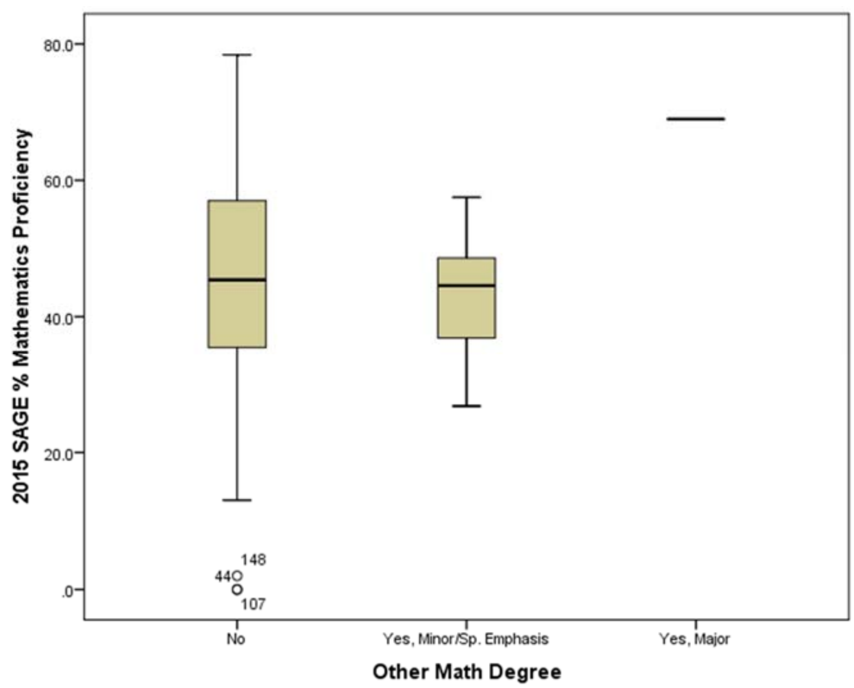

Figure J-326. Boxplot of 2015 SAGE % Mathematics Proficiency for Other_Math. This figure illustrates spread of school-wide 2015 SAGE % Mathematics Proficiency scores based on school leaders' having or not having another math degree.

Table J-23

Inf_State_Leg2: Tests for Normality

		Shapiro-Wilk						
Variable		Statistic	*df*	Sig.	Skewness	Std. Error	Kurtosis	Std. Error
Inf_State_Leg2	1	.94	21	.176	-.84	.50	1.00	.97
	2	.97	33	.517	-.42	.41	.86	.80
	3	.95	37	.125	-.74	.39	1.13	.76
	4	.98	32	.882	.02	.41	-.52	.81
	5	.97	17	.747	.42	.55	.06	1.06
	6	.93	9	.456	-.34	.72	-1.1	1.4

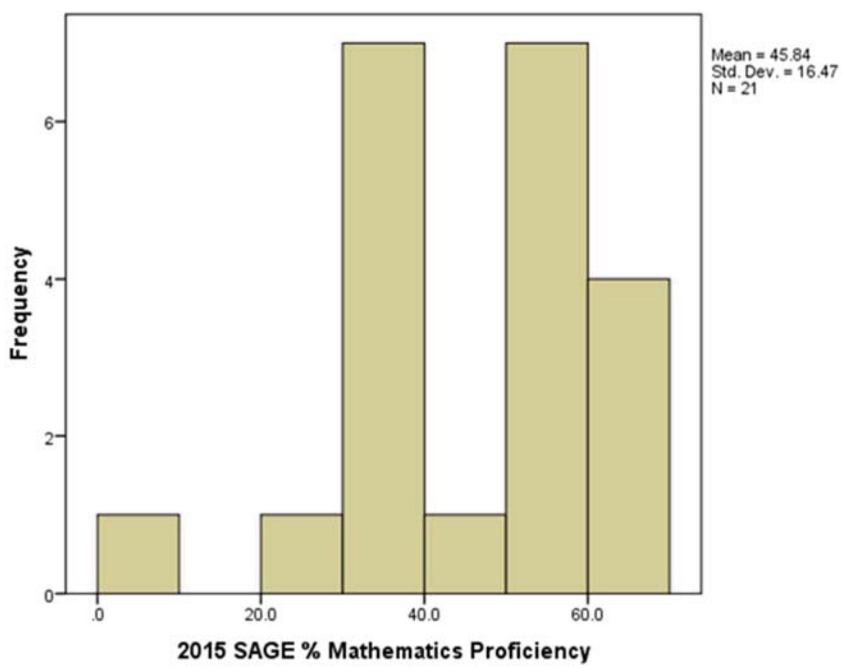

Figure J-327. Frequency by 2015 SAGE % Mathematics Proficiency for Inf_State_Leg2 = 1. This figure illustrates the number of school leaders who ranked Inf_State_Leg2 at 1 based on their school's school-wide 2015 SAGE % mathematics proficiency.

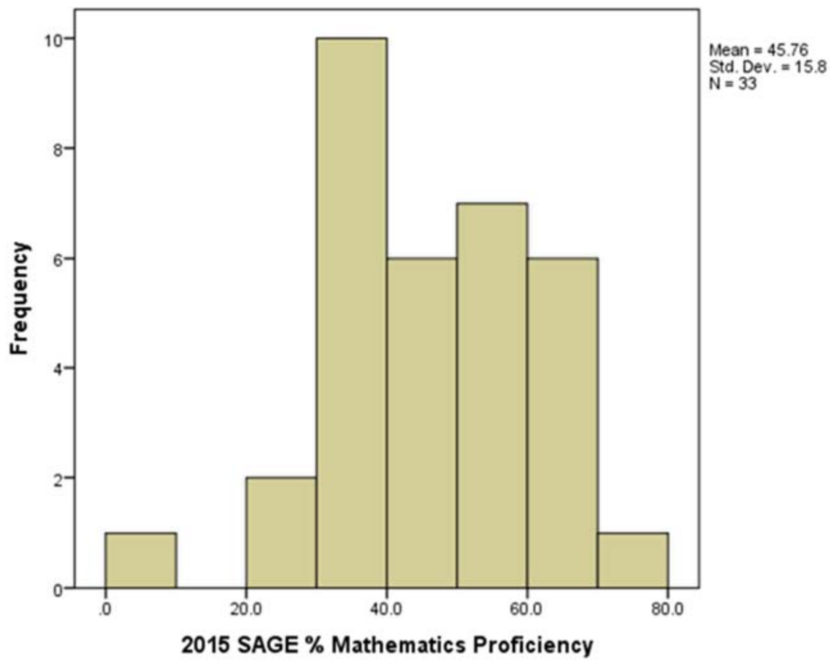

Figure J-328. Frequency by 2015 SAGE % Mathematics Proficiency for Inf_State_Leg2 = 2. This figure illustrates the number of school leaders who ranked Inf_State_Leg2 at 2 based on their school's school-wide 2015 SAGE % mathematics proficiency.

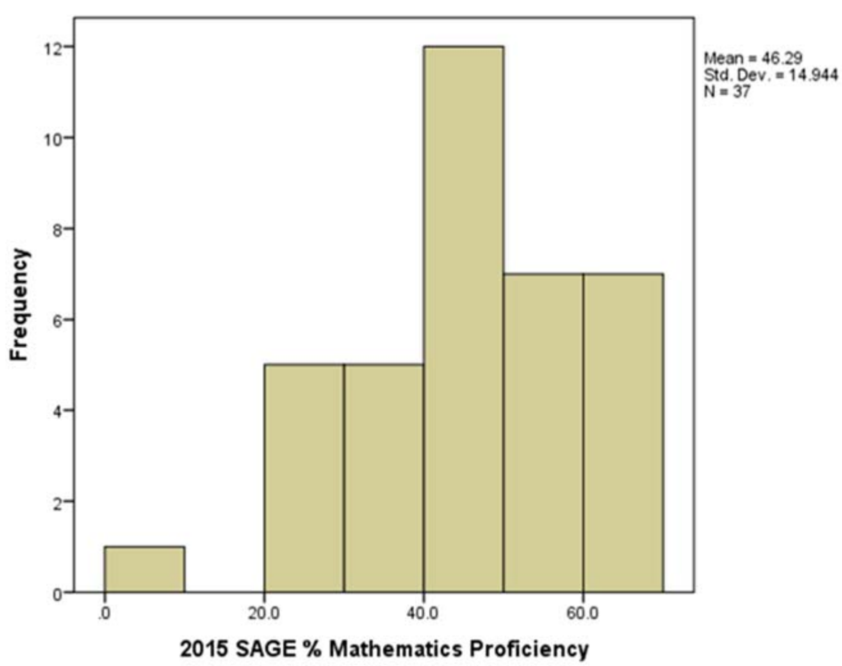

Figure J-329. Frequency by 2015 SAGE % Mathematics Proficiency for Inf_State_Leg2 = 3. This figure illustrates the number of school leaders who ranked Inf_State_Leg2 at 3 based on their school's school-wide 2015 SAGE % mathematics proficiency.

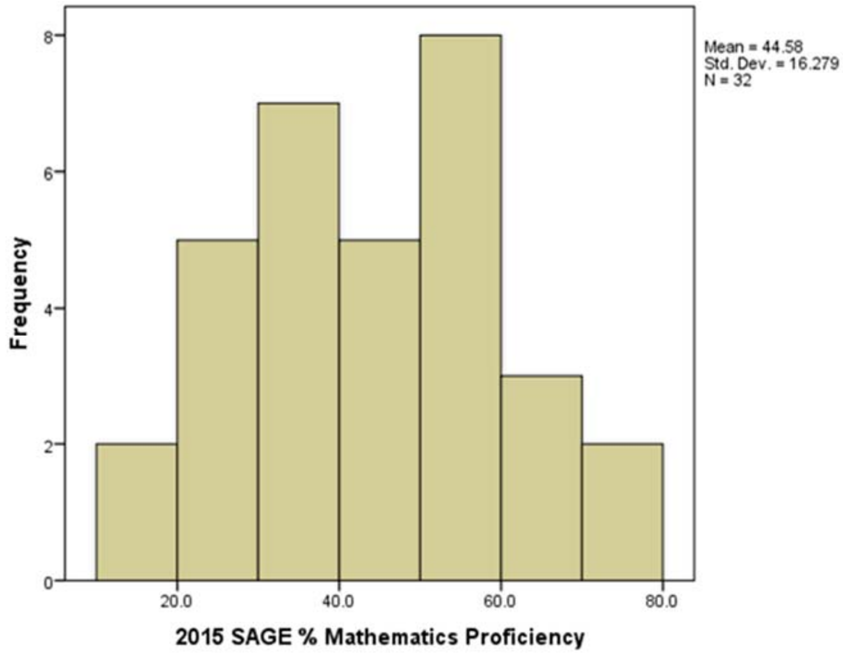

Figure J-330. Frequency by 2015 SAGE % Mathematics Proficiency for Inf_State_Leg2 = 4. This figure illustrates the number of school leaders who ranked Inf_State_Leg2 at 4 based on their school's school-wide 2015 SAGE % mathematics proficiency.

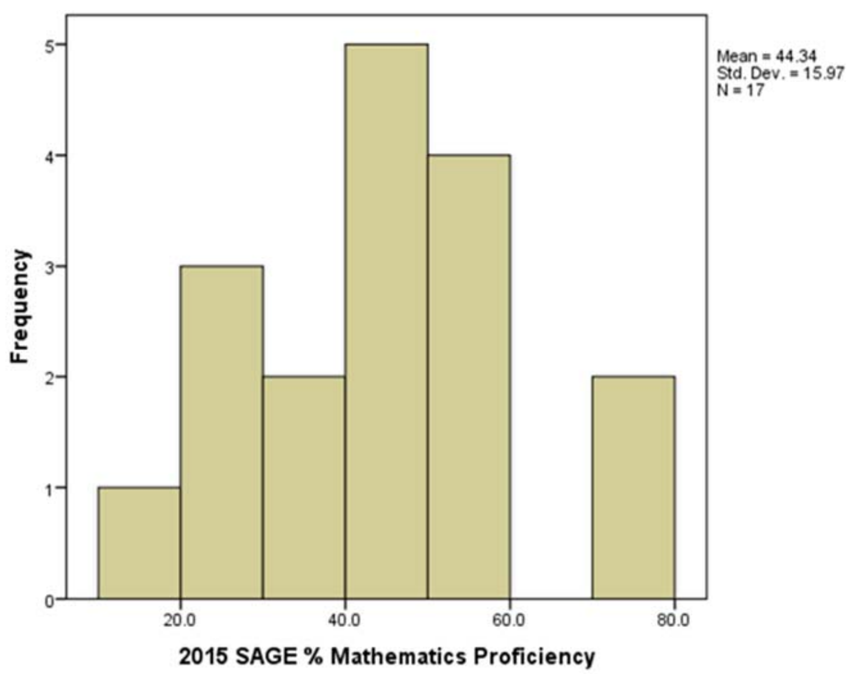

Figure J-331. Frequency by 2015 SAGE % Mathematics Proficiency for Inf_State_Leg2 = 5. This figure illustrates the number of school leaders who ranked Inf_State_Leg2 at 5 based on their school's school-wide 2015 SAGE % mathematics proficiency.

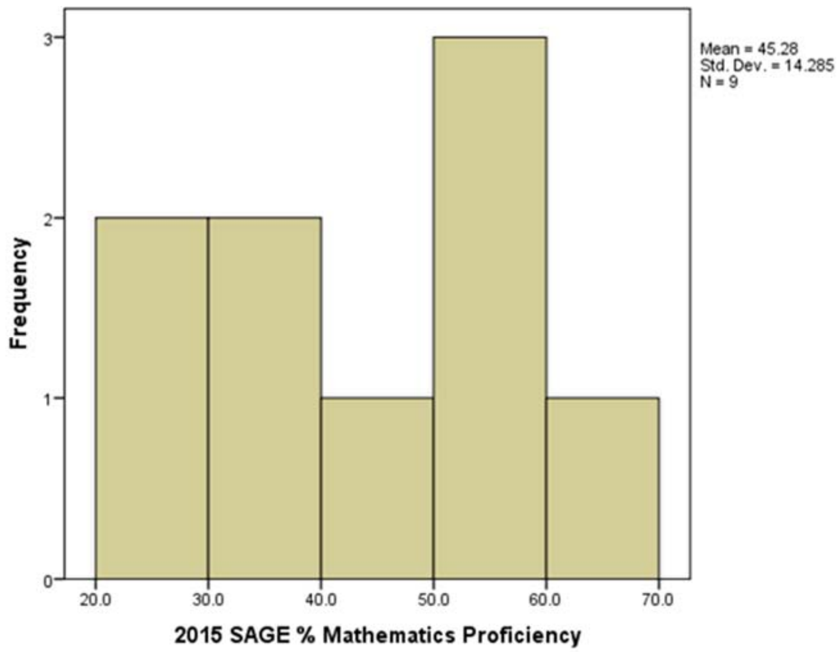

Figure J-332. Frequency by 2015 SAGE % Mathematics Proficiency for Inf_State_Leg2 = 6. This figure illustrates the number of school leaders who ranked Inf_State_Leg2 at 6 based on their school's school-wide 2015 SAGE % mathematics proficiency.

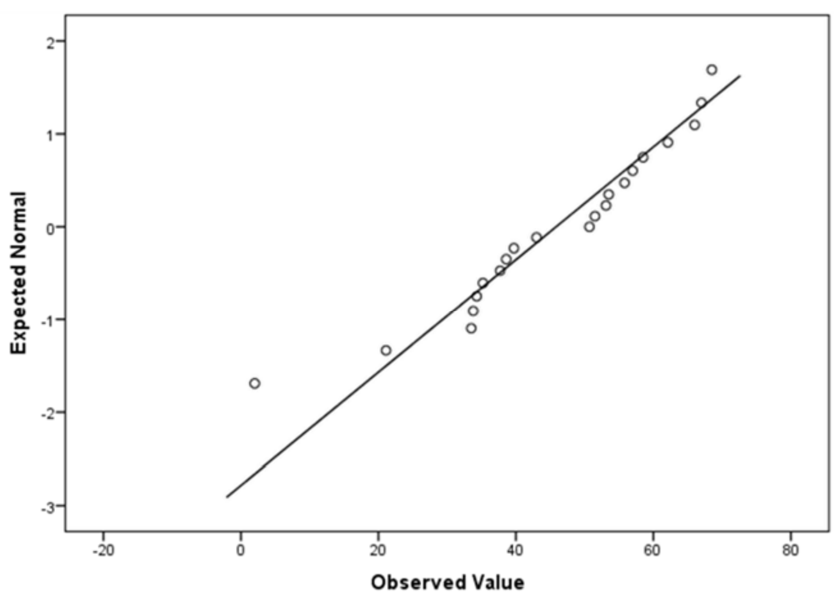

Figure J-333. Normal Q-Q Plot of 2015 SAGE % Mathematics Proficiency for Inf_State_Leg2 = 1. This figure illustrates the observed value versus the expected normal for school leaders who ranked Inf_State_Leg2 at 1 based on their school's school-wide 2015 SAGE % mathematics proficiency.

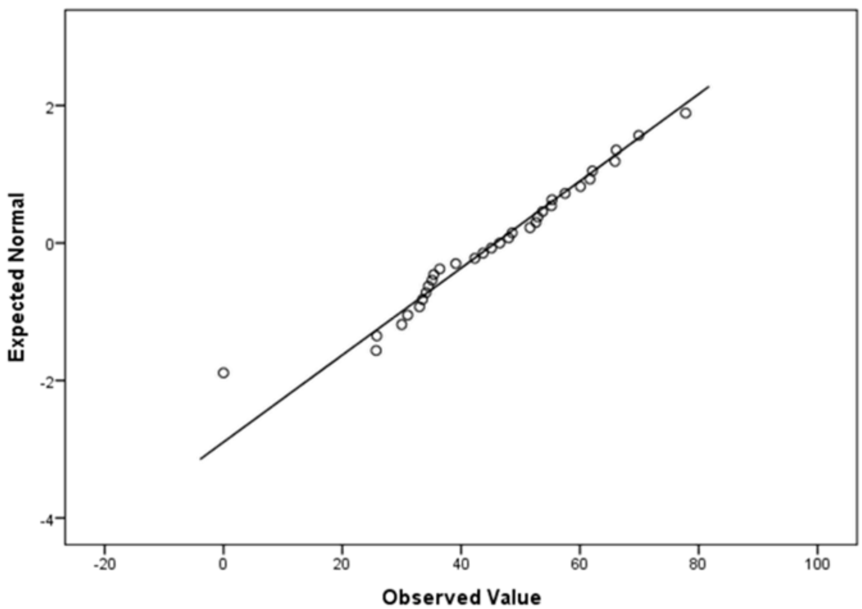

Figure J-334. Normal Q-Q Plot of 2015 SAGE % Mathematics Proficiency for Inf_State_Leg2 = 2. This figure illustrates the observed value versus the expected normal for school leaders who ranked Inf_State_Leg2 at 2 based on their school's school-wide 2015 SAGE % mathematics proficiency.

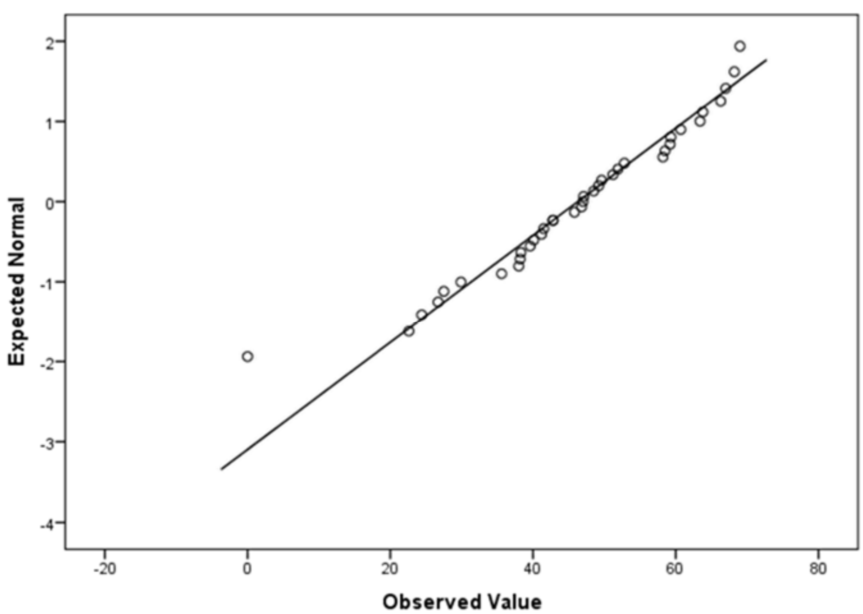

Figure J-335. Normal Q-Q Plot of 2015 SAGE % Mathematics Proficiency for Inf_State_Leg2 = 3. This figure illustrates the observed value versus the expected normal for school leaders who ranked Inf_State_Leg2 at 3 based on their school's school-wide 2015 SAGE % mathematics proficiency.

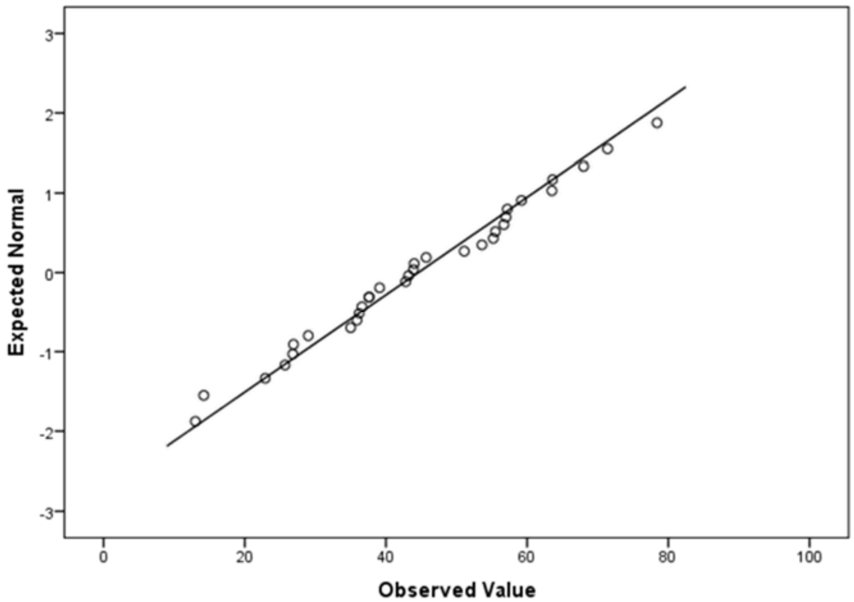

Figure J-336. Normal Q-Q Plot of 2015 SAGE % Mathematics Proficiency for Inf_State_Leg2 = 4. This figure illustrates the observed value versus the expected normal for school leaders who ranked Inf_State_Leg2 at 4 based on their school's school-wide 2015 SAGE % mathematics proficiency.

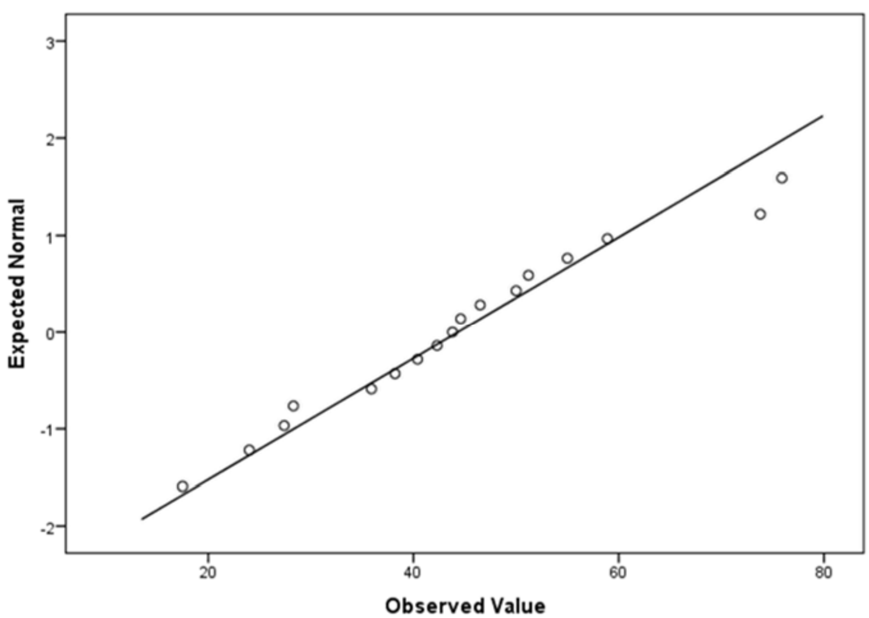

Figure J-337. Normal Q-Q Plot of 2015 SAGE % Mathematics Proficiency for Inf_State_Leg2 = 5. This figure illustrates the observed value versus the expected normal for school leaders who ranked Inf_State_Leg2 at 5 based on their school's school-wide 2015 SAGE % mathematics proficiency.

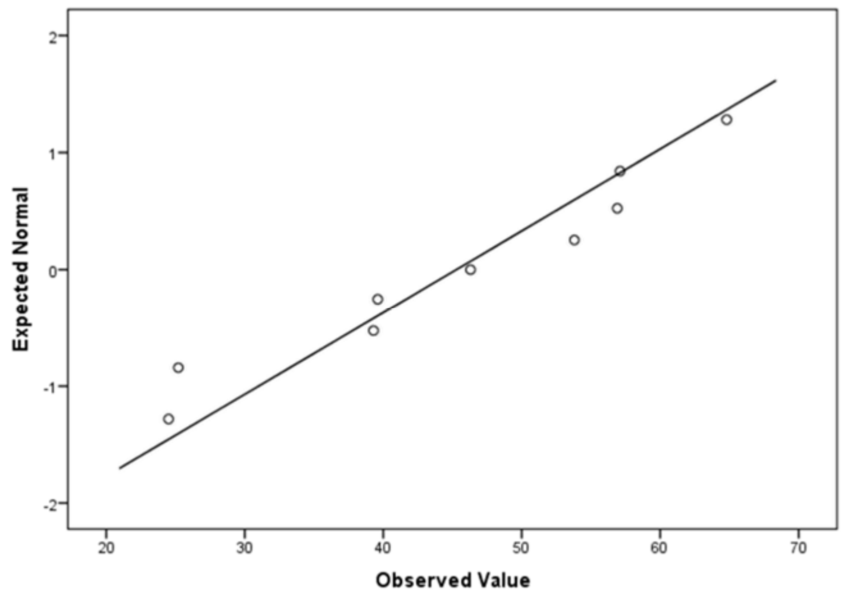

Figure J-338. Normal Q-Q Plot of 2015 SAGE % Mathematics Proficiency for Inf_State_Leg2 = 6. This figure illustrates the observed value versus the expected normal for school leaders who ranked Inf_State_Leg2 at 6 based on their school's school-wide 2015 SAGE % mathematics proficiency.

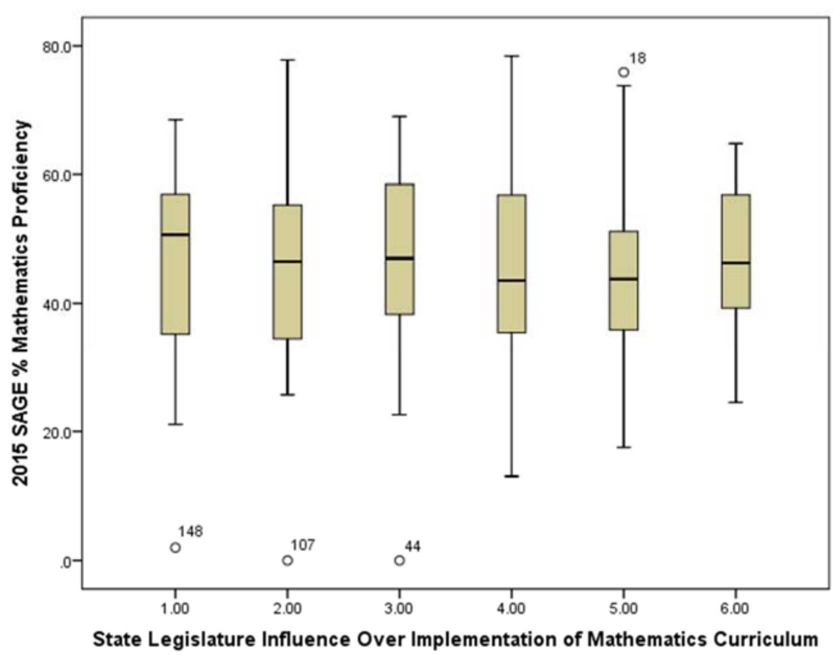

Figure J-339. Boxplot of 2015 SAGE % Mathematics Proficiency for Inf_State_Leg2. This figure illustrates spread of school-wide 2015 SAGE % Mathematics Proficiency scores based on school leaders' ranking of Inf_State_Leg2.

Table J-24

Sub_T_H_SS: Tests for Normality

Variable		Shapiro-Wilk Statistic	*df*	Sig.	Skewness	Std. Error	Kurtosis	Std. Error
Sub_T_H_SS	Yes	.98	82	.368	-.39	.27	.14	.53
	No	.98	67	.200	-.29	.29	.32	.58

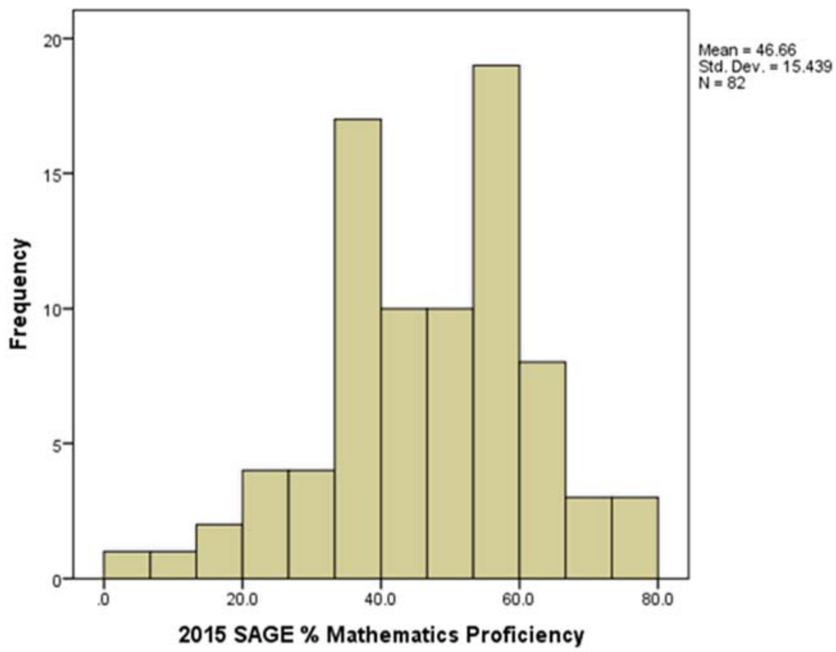

Figure J-340. Frequency by 2015 SAGE % Mathematics Proficiency for Sub_T_H_SS = Yes. This figure illustrates the number of school leaders who ranked Sub_T_H_SS at Yes based on their school's school-wide 2015 SAGE % mathematics proficiency.

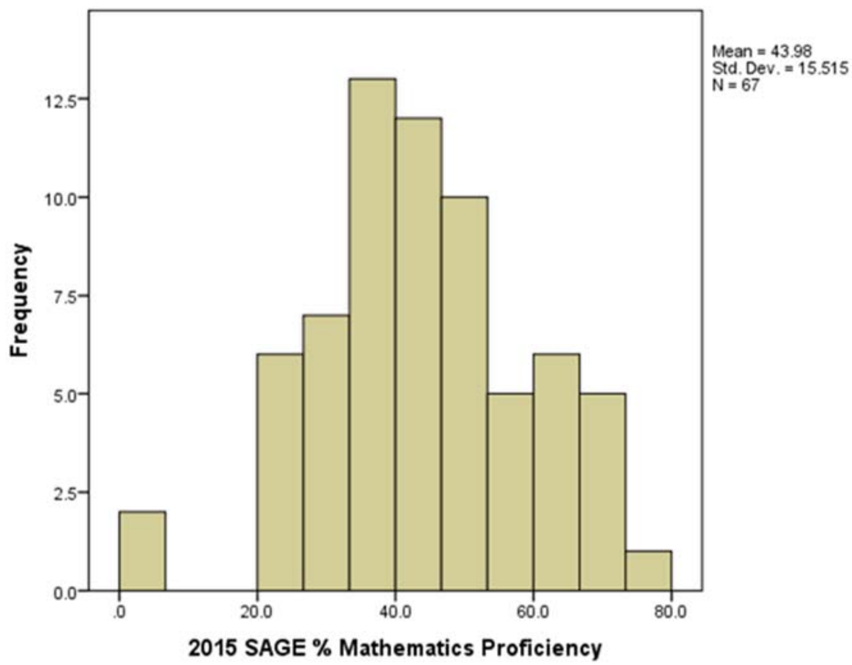

Figure J-341. Frequency by 2015 SAGE % Mathematics Proficiency for Sub_T_H_SS = No. This figure illustrates the number of school leaders who ranked Sub_T_H_SS at No based on their school's school-wide 2015 SAGE % mathematics proficiency.

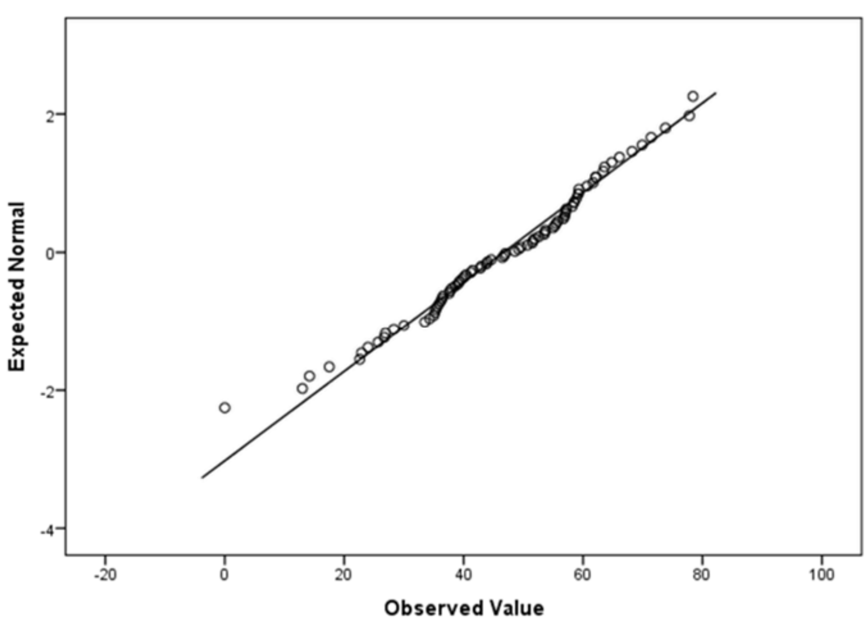

Figure J-342. Normal Q-Q Plot of 2015 SAGE % Mathematics Proficiency for Sub_T_H_SS = Yes. This figure illustrates the observed value versus the expected normal for school leaders who ranked Sub_T_H_SS at Yes based on their school's school-wide 2015 SAGE % mathematics proficiency.

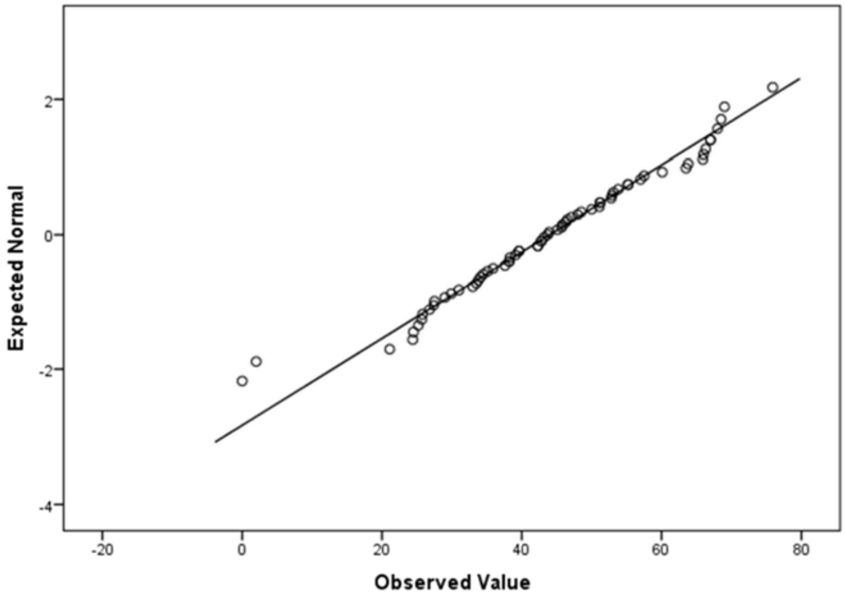

Figure J-343. Normal Q-Q Plot of 2015 SAGE % Mathematics Proficiency for Sub_T_H_SS = No. This figure illustrates the observed value versus the expected normal for school leaders who ranked Sub_T_H_SS at No based on their school's school-wide 2015 SAGE % mathematics proficiency.

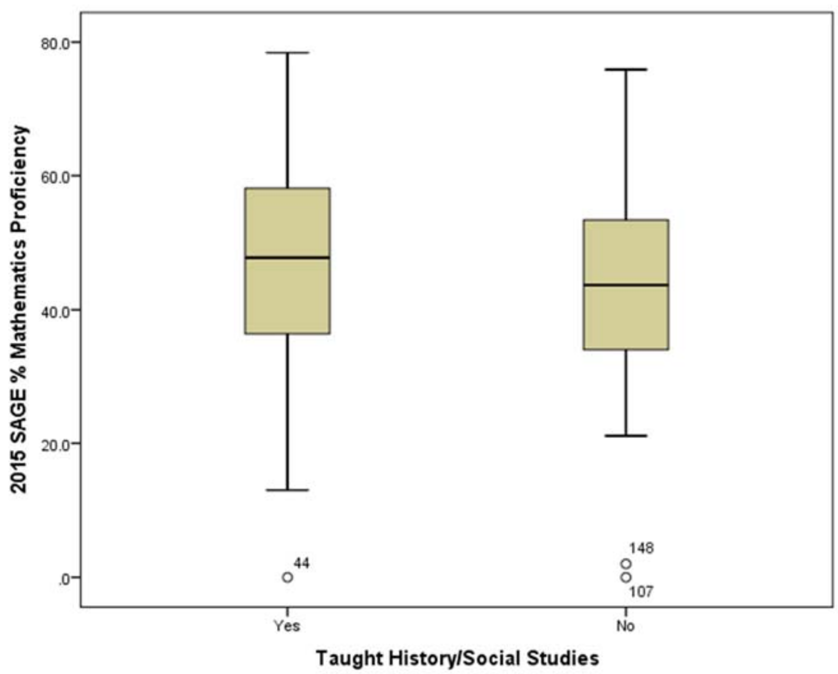

Figure J-344. Boxplot of 2015 SAGE % Mathematics Proficiency for Sub_T_H_SS. This figure illustrates spread of school-wide 2015 SAGE % Mathematics Proficiency scores based on school leaders' teaching or not teaching history/social studies.

Table J-25

Saxon_Math: Tests for Normality

		Shapiro-Wilk						
Variable		Statistic	*df*	Sig.	Skewness	Std. Error	Kurtosis	Std. Error
Saxon_ Math	Yes	.87	6	.206	1.41	.85	3.15	1.74
	No	.99	143	.144	-.30	.20	.09	.40

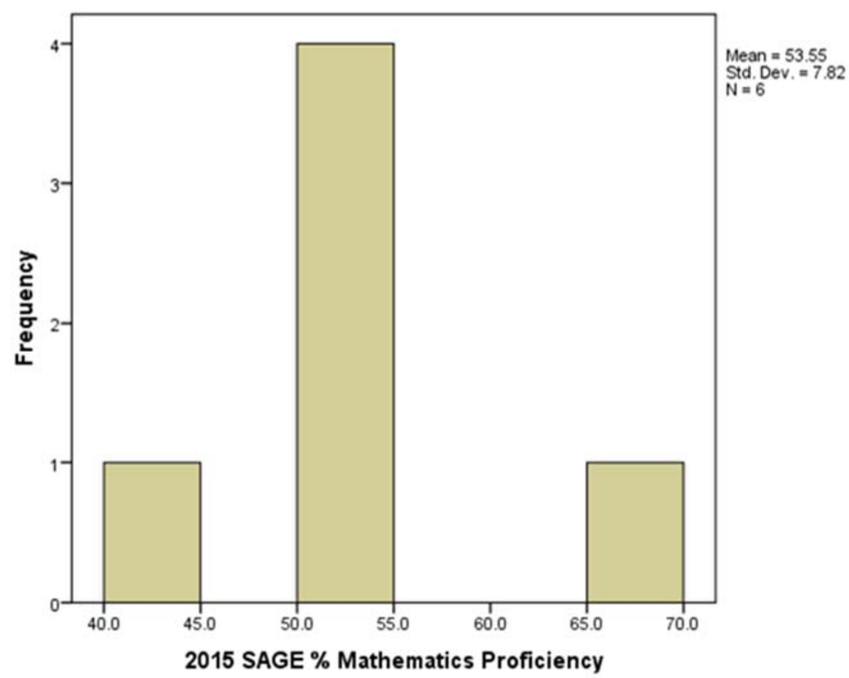

Figure J-345. Frequency by 2015 SAGE % Mathematics Proficiency for Saxon_Math = Yes. This figure illustrates the number of school leaders who ranked Saxon_Math at Yes based on their school's school-wide 2015 SAGE % mathematics proficiency.

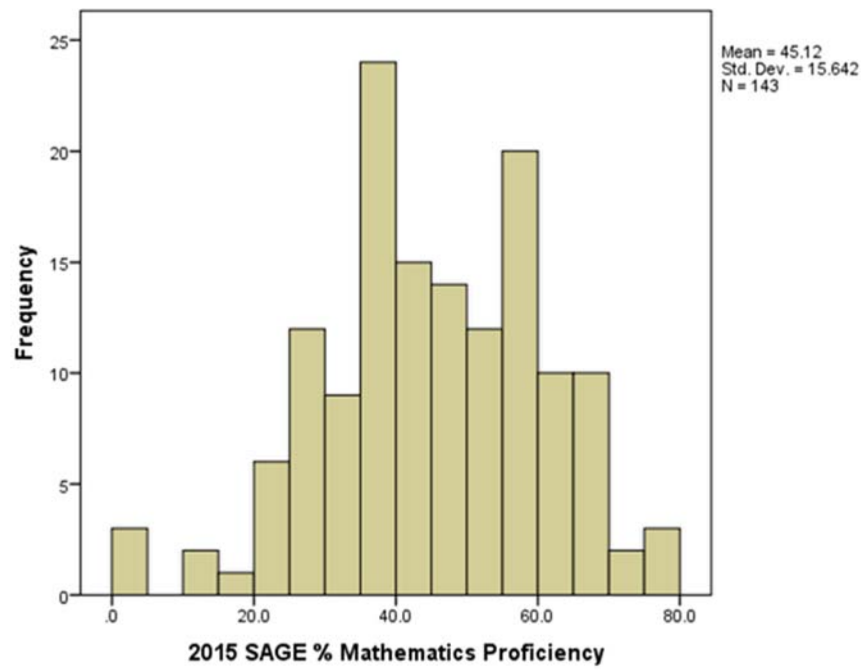

Figure J-346. Frequency by 2015 SAGE % Mathematics Proficiency for Saxon_Math = No. This figure illustrates the number of school leaders who ranked Saxon_Math at Yes based on their school's school-wide 2015 SAGE % mathematics proficiency.

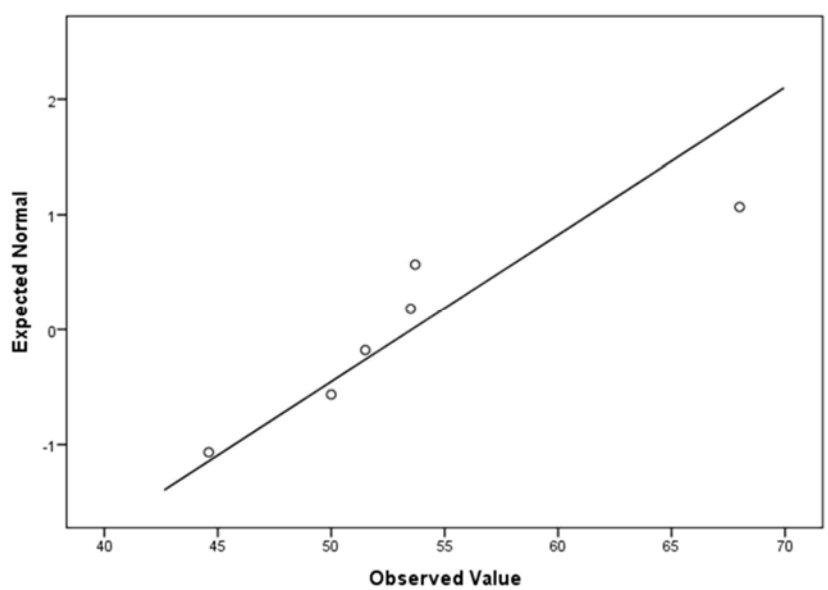

Figure J-347. Normal Q-Q Plot of 2015 SAGE % Mathematics Proficiency for Saxon_Math = Yes. This figure illustrates the observed value versus the expected normal for school leaders who ranked Saxon_Math at Yes based on their school's school-wide 2015 SAGE % mathematics proficiency.

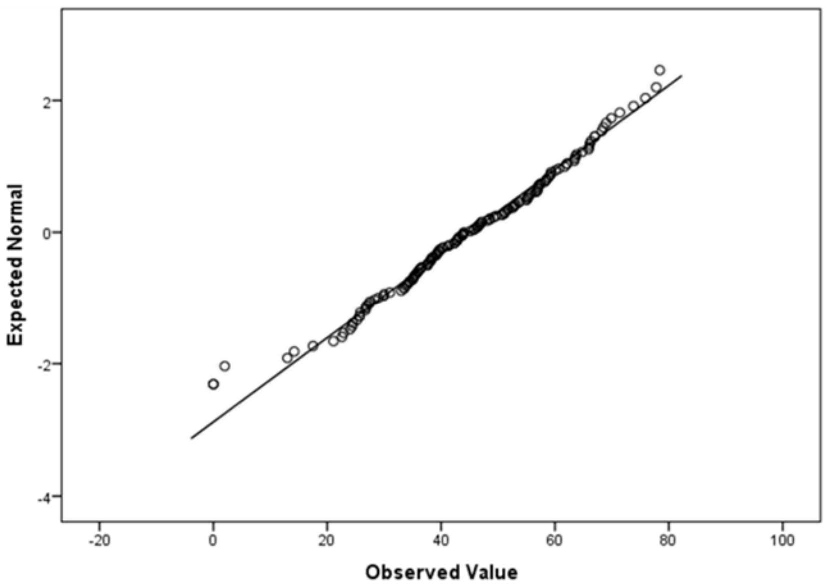

Figure J-348. Normal Q-Q Plot of 2015 SAGE % Mathematics Proficiency for Saxon_Math = No. This figure illustrates the observed value versus the expected normal for school leaders who ranked Saxon_Math at No based on their school's school-wide 2015 SAGE % mathematics proficiency.

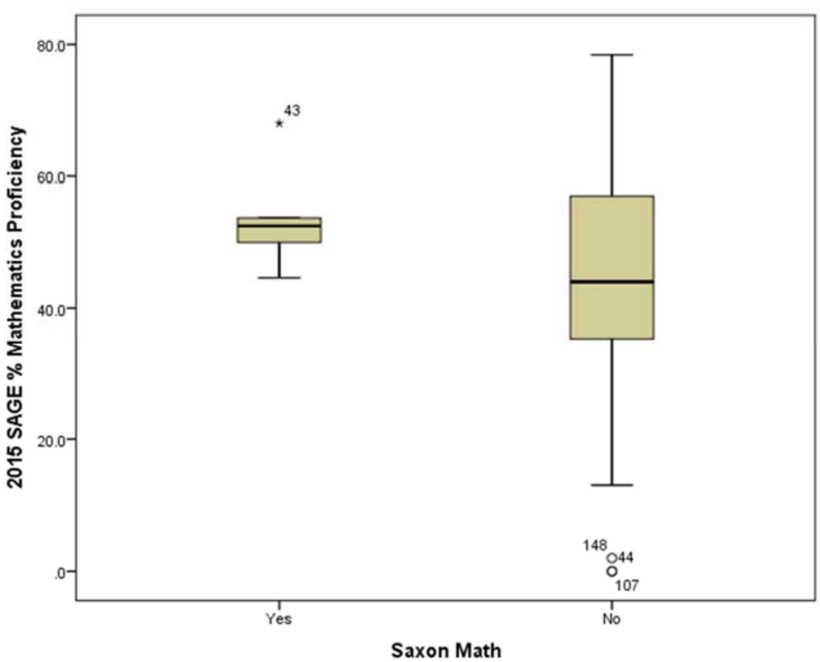

Figure J-349. Boxplot of 2015 SAGE % Mathematics Proficiency for Saxon_Math. This figure illustrates spread of school-wide 2015 SAGE % Mathematics Proficiency scores based on school leaders' teaching or not teaching history/social studies.

Table J-26

Gr_T_K: Tests for Normality

Variable		Shapiro-Wilk Statistic	*df*	Sig.	Skewness	Std. Error	Kurtosis	Std. Error
Gr_T_K	Yes	.95	9	.728	.04	.72	1.56	1.40
	No	.99	140	.219	-.33	.21	-.01	.41

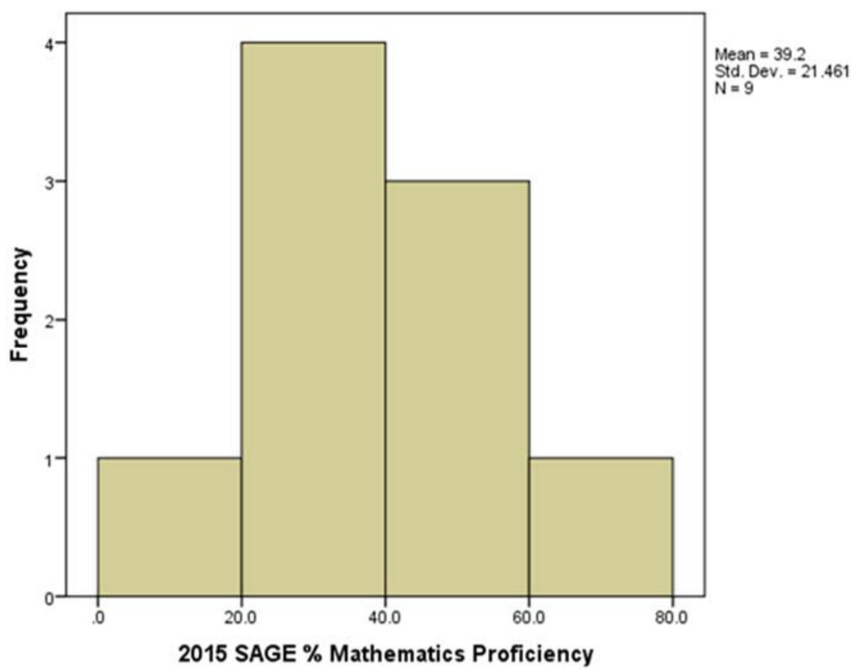

Figure J-350. Frequency by 2015 SAGE % Mathematics Proficiency for Gr_T_K = Yes. This figure illustrates the number of school leaders who ranked Gr_T_K at Yes based on their school's school-wide 2015 SAGE % mathematics proficiency.

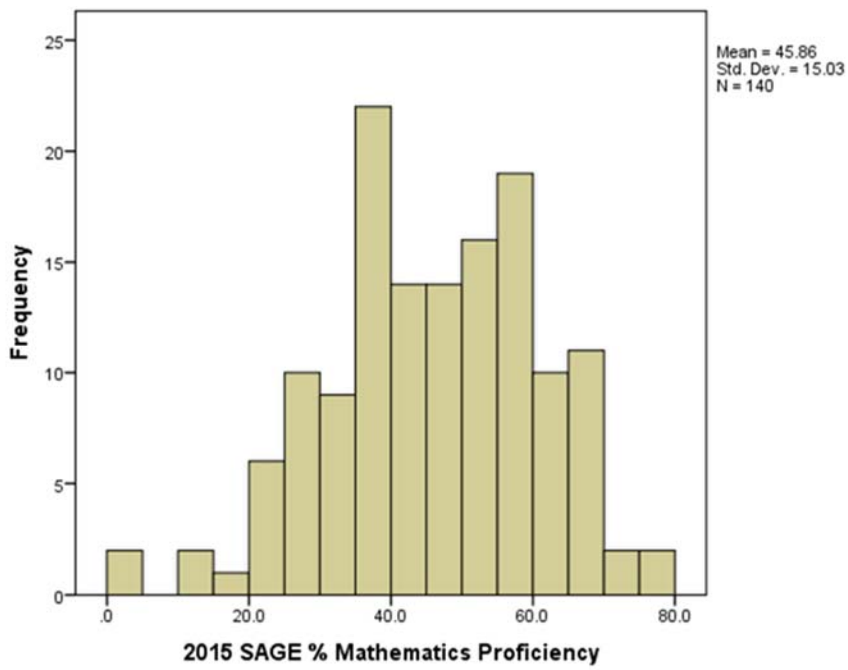

Figure J-351. Frequency by 2015 SAGE % Mathematics Proficiency for Gr_T_K = No. This figure illustrates the number of school leaders who ranked Gr_T_K at No based on their school's school-wide 2015 SAGE % mathematics proficiency.

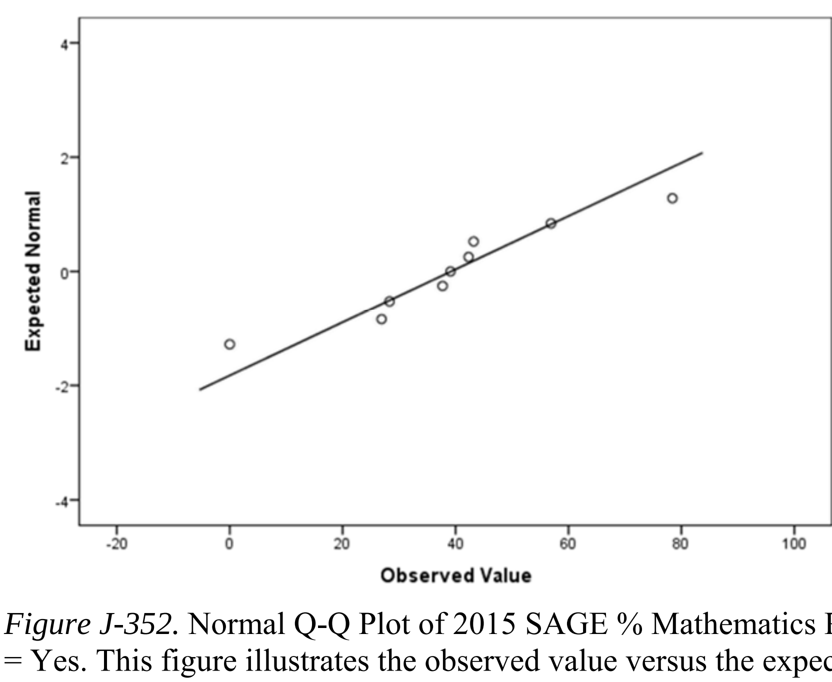

Figure J-352. Normal Q-Q Plot of 2015 SAGE % Mathematics Proficiency for Gr_T_K = Yes. This figure illustrates the observed value versus the expected normal for school leaders who ranked Gr_T_K at Yes based on their school's school-wide 2015 SAGE % mathematics proficiency.

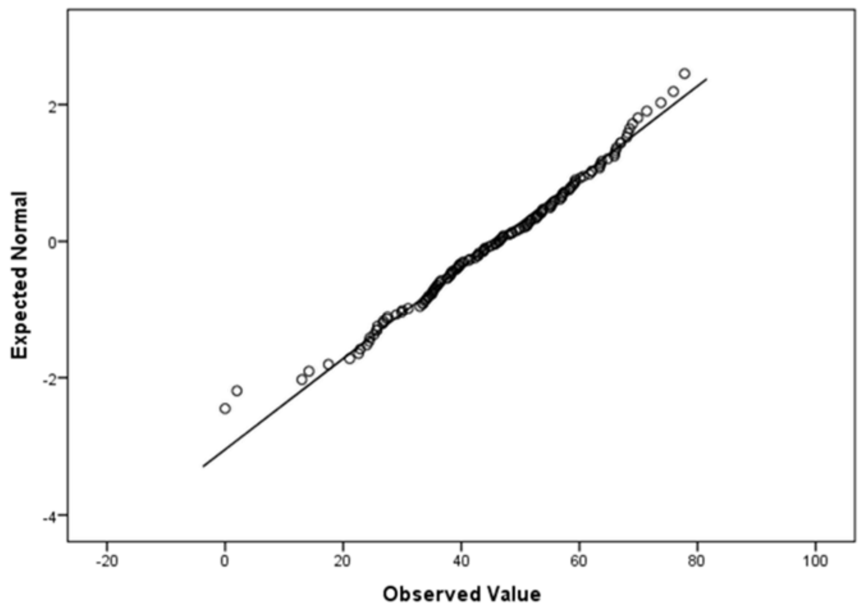

Figure J-353. Normal Q-Q Plot of 2015 SAGE % Mathematics Proficiency for Gr_T_K = No. This figure illustrates the observed value versus the expected normal for school leaders who ranked Gr_T_K at No based on their school's school-wide 2015 SAGE % mathematics proficiency.

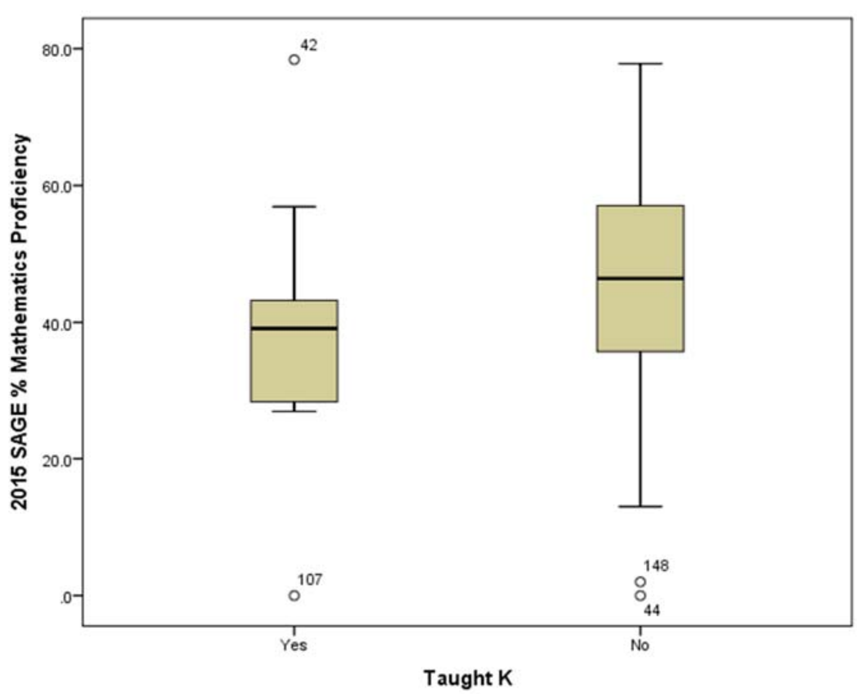

Figure J-354. Boxplot of 2015 SAGE % Mathematics Proficiency for Gr_T_K. This figure illustrates spread of school-wide 2015 SAGE % Mathematics Proficiency scores based on school leaders' teaching or not teaching kindergarten.

Table J-27

MTL36: Tests for Normality

Variable		Shapiro-Wilk			Skewness	Std. Error	Kurtosis	Std. Error
		Statistic	*df*	Sig.				
MTL36	1							
	2							
	3	.84	7	.090	.80	.79	3.17	1.59
	4	.98	86	.247	-.02	.26	-.44	.51
	5	.89	46	.000	-1.36	.35	2.68	.69

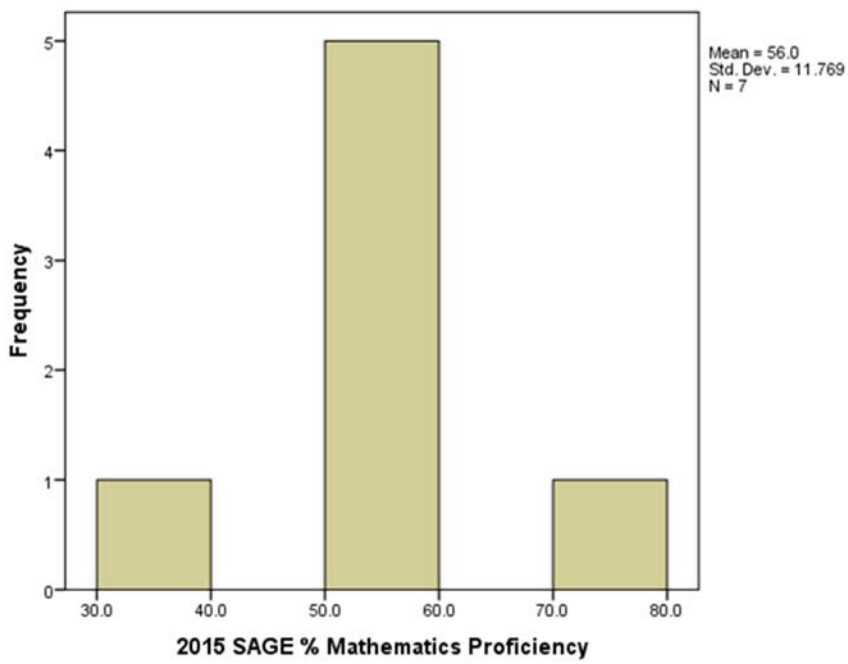

Figure J-355. Frequency by 2015 SAGE % Mathematics Proficiency for MTL36 = 3. This figure illustrates the number of school leaders who ranked MTL36 at 3 based on their school's school-wide 2015 SAGE % mathematics proficiency.

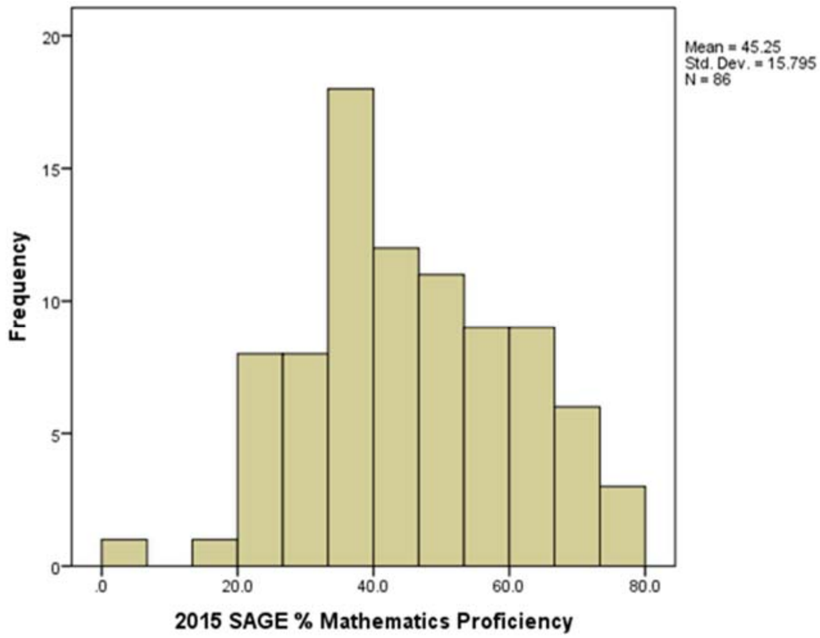

Figure J-356. Frequency by 2015 SAGE % Mathematics Proficiency for MTL36 = 3. This figure illustrates the number of school leaders who ranked MTL36 at 3 based on their school's school-wide 2015 SAGE % mathematics proficiency.

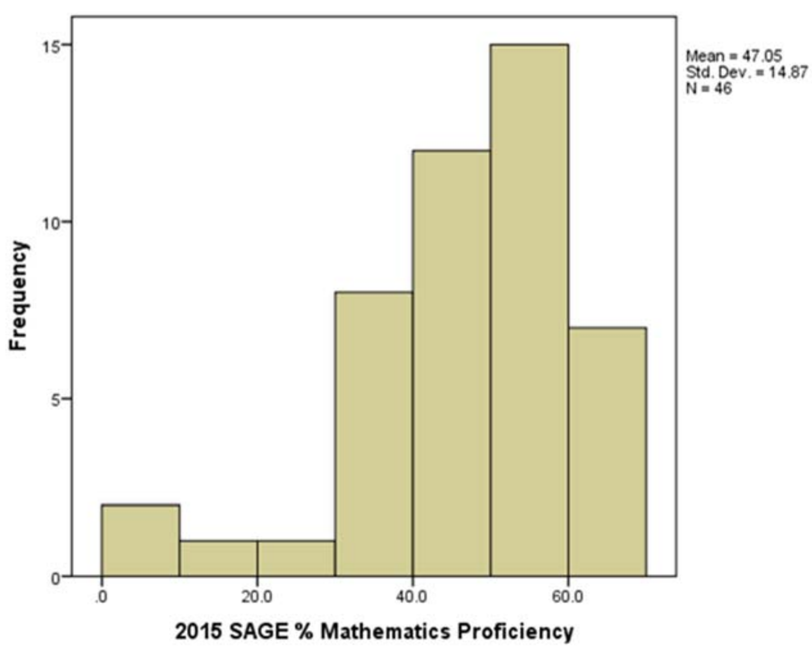

Figure J-357. Frequency by 2015 SAGE % Mathematics Proficiency for MTL36 = 5. This figure illustrates the number of school leaders who ranked MTL36 at 5 based on their school's school-wide 2015 SAGE % mathematics proficiency.

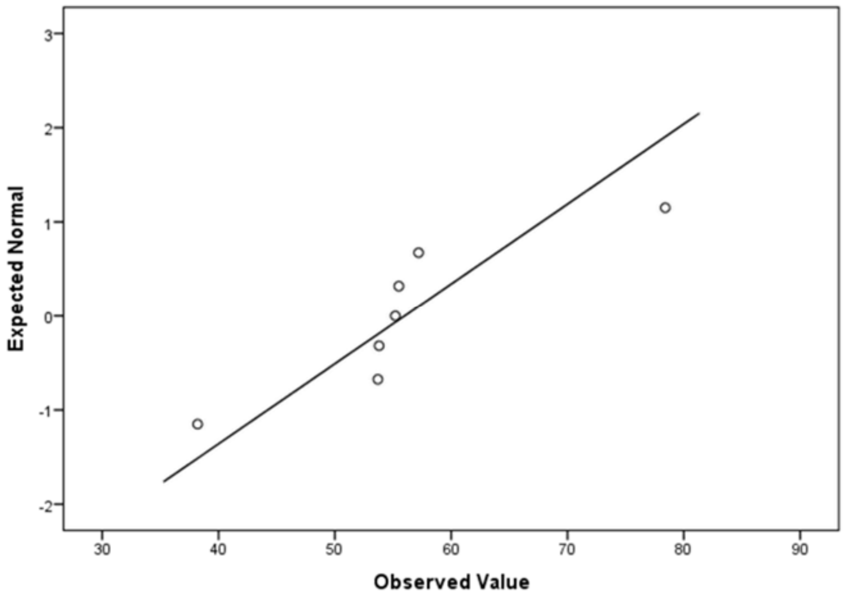

Figure J-358. Normal Q-Q Plot of 2015 SAGE % Mathematics Proficiency for MTL36 = 3. This figure illustrates the observed value versus the expected normal for school leaders who ranked MTL36 at 3 based on their school's school-wide 2015 SAGE % mathematics proficiency.

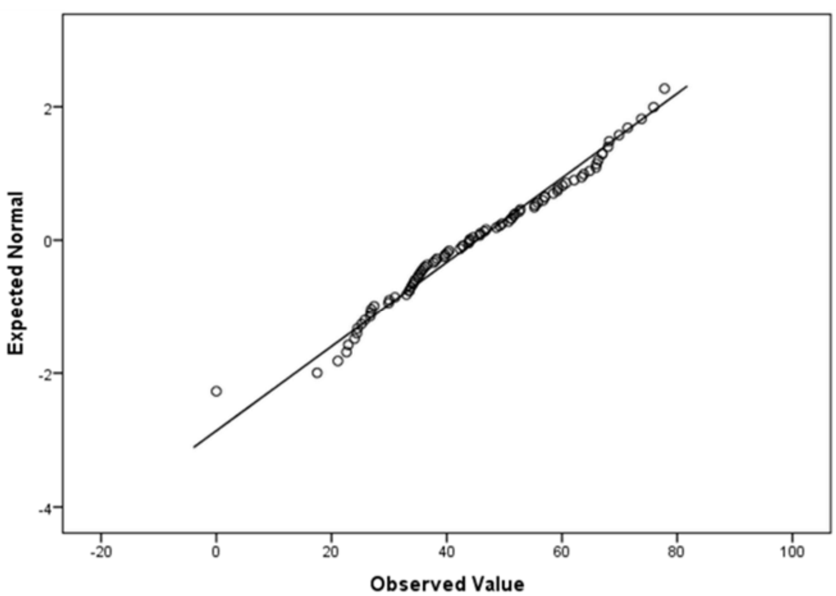

Figure J-359. Normal Q-Q Plot of 2015 SAGE % Mathematics Proficiency for MTL36 = 4. This figure illustrates the observed value versus the expected normal for school leaders who ranked MTL36 at 4 based on their school's school-wide 2015 SAGE % mathematics proficiency.

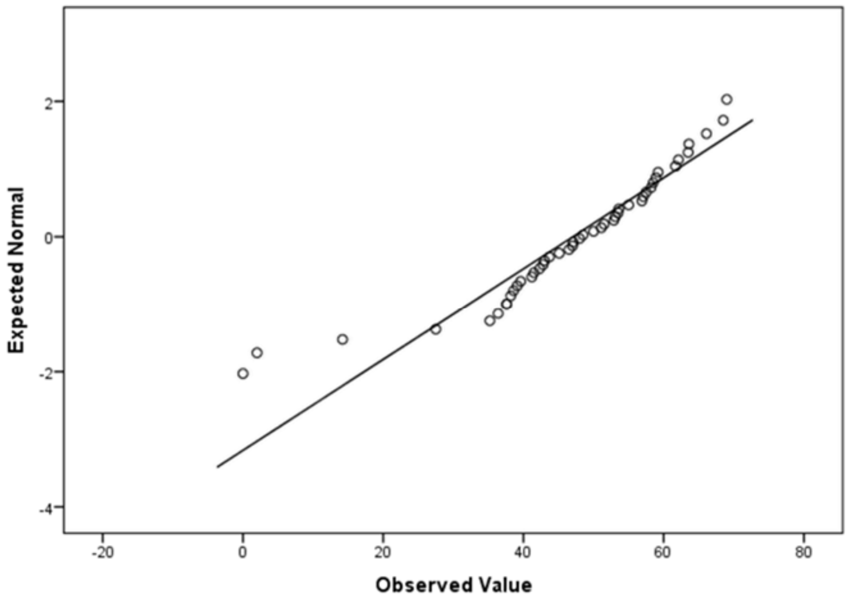

Figure J-360. Normal Q-Q Plot of 2015 SAGE % Mathematics Proficiency for MTL36 = 5. This figure illustrates the observed value versus the expected normal for school leaders who ranked MTL36 at 5 based on their school's school-wide 2015 SAGE % mathematics proficiency.

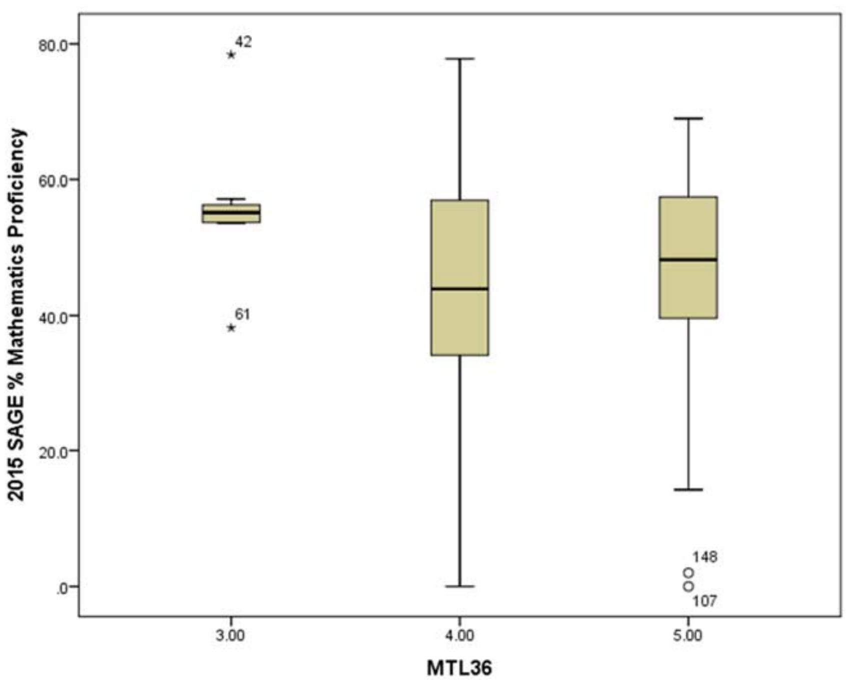

Figure J-361. Boxplot of 2015 SAGE % Mathematics Proficiency for MTL36. This figure illustrates spread of school-wide 2015 SAGE % Mathematics Proficiency scores based on school leaders' ranking of MTL36.

Table J-28

MTL44: Tests for Normality

		Shapiro-Wilk						
Variable		Statistic	*df*	Sig.	Skewness	Std. Error	Kurtosis	Std. Error
MTL44	1	.71	6	.008	2.10	.85	4.52	1.74
	2	.96	37	.158	-.22	.39	-1.02	.76
	3	.97	30	.645	-.31	.43	.44	.83
	4	.99	20	.999	-.08	.51	.39	.99
	5	.77	3	0.04	1.73	1.23		

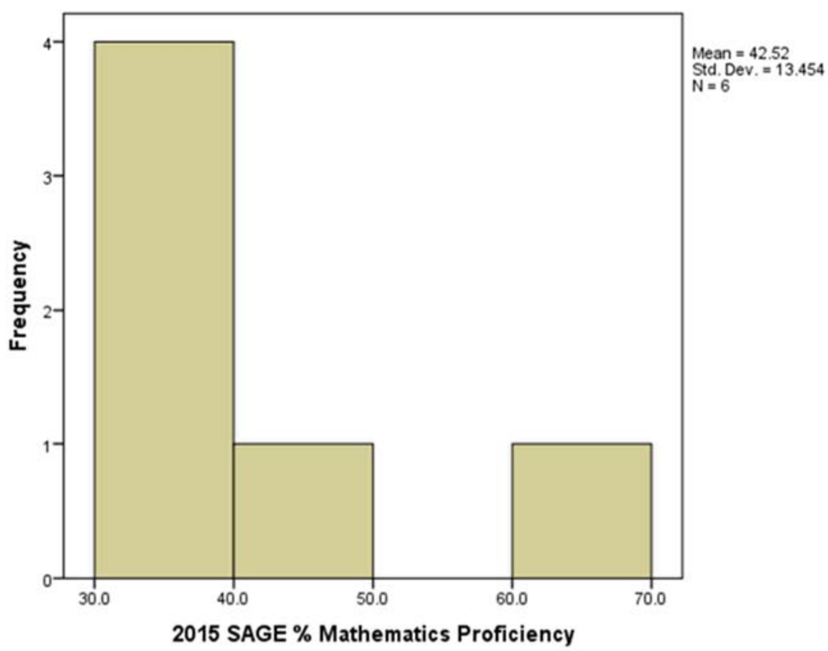

Figure J-362. Frequency by 2015 SAGE % Mathematics Proficiency for MTL44 = 1. This figure illustrates the number of school leaders who ranked MTL44 at 1 based on their school's school-wide 2015 SAGE % mathematics proficiency.

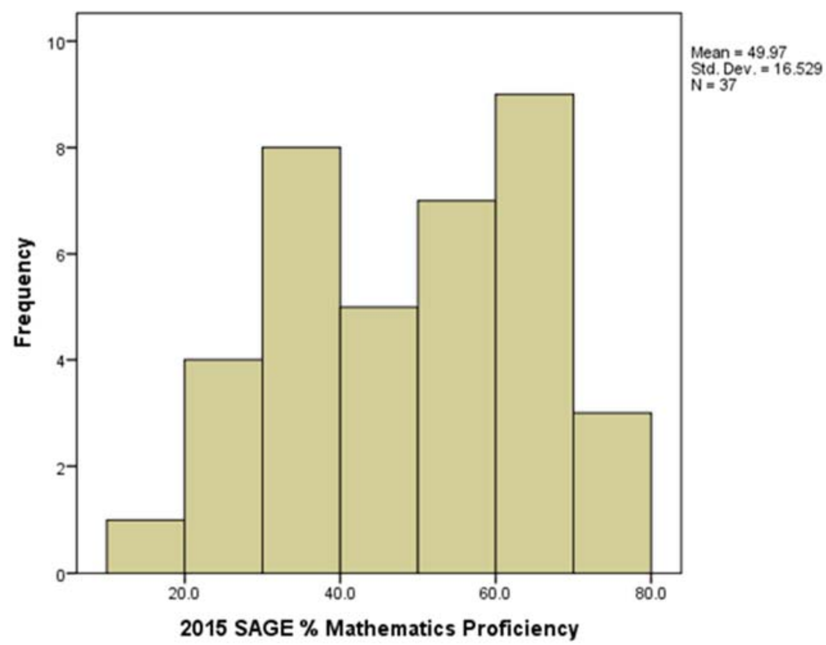

Figure J-363. Frequency by 2015 SAGE % Mathematics Proficiency for MTL44 = 2. This figure illustrates the number of school leaders who ranked MTL44 at 2 based on their school's school-wide 2015 SAGE % mathematics proficiency.

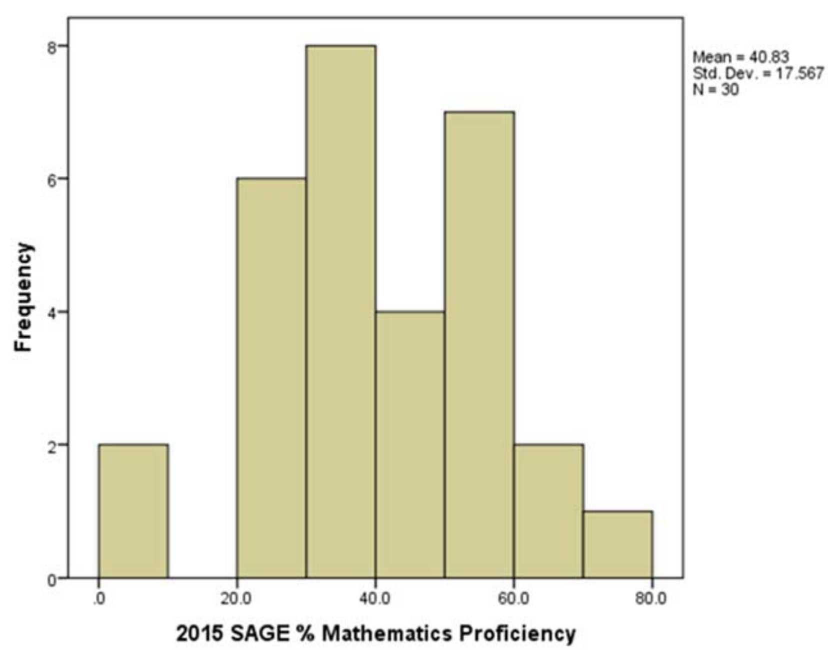

Figure J-364. Frequency by 2015 SAGE % Mathematics Proficiency for MTL44 = 3. This figure illustrates the number of school leaders who ranked MTL44 at 3 based on their school's school-wide 2015 SAGE % mathematics proficiency.

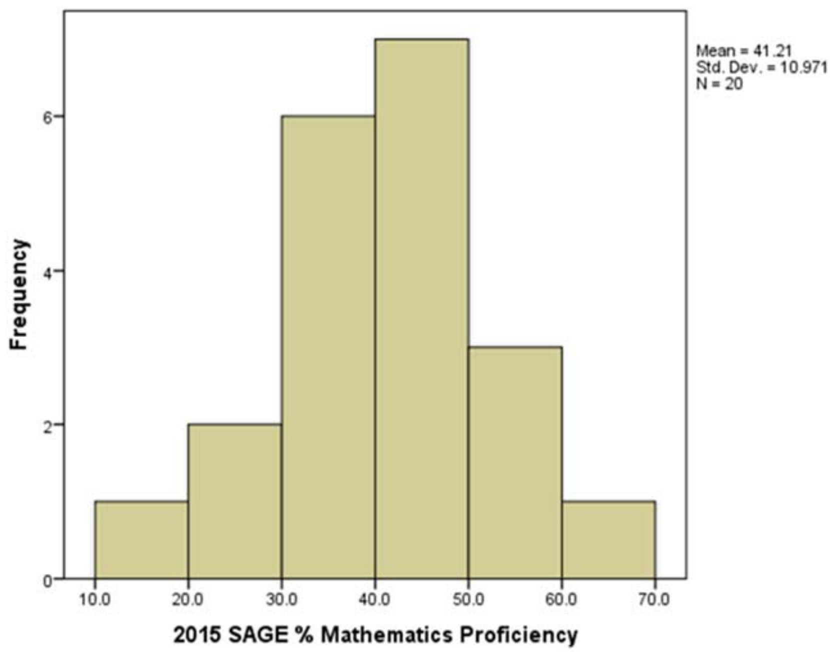

Figure J-365. Frequency by 2015 SAGE % Mathematics Proficiency for MTL44 = 4. This figure illustrates the number of school leaders who ranked MTL44 at 4 based on their school's school-wide 2015 SAGE % mathematics proficiency.

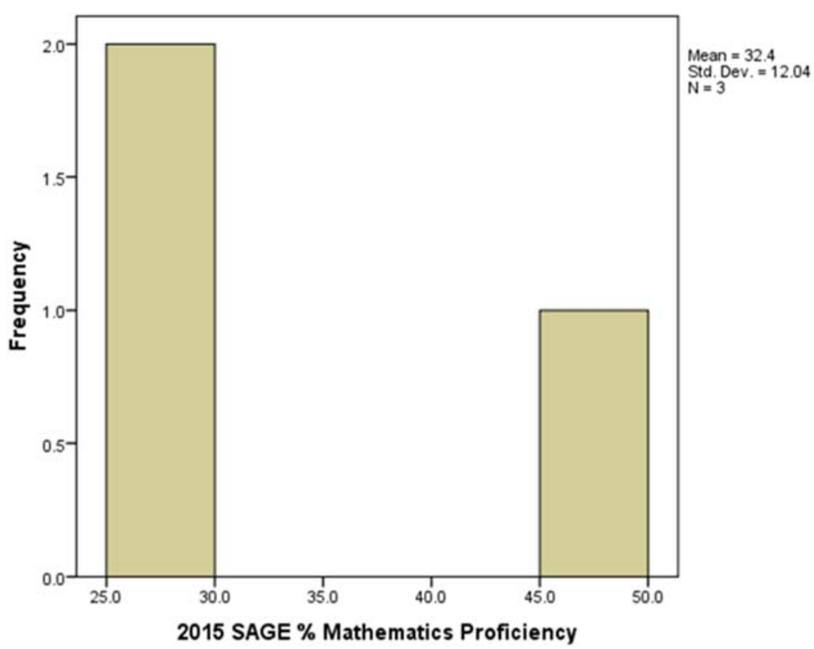

Figure J-366. Frequency by 2015 SAGE % Mathematics Proficiency for MTL44 = 5. This figure illustrates the number of school leaders who ranked MTL44 at 5 based on their school's school-wide 2015 SAGE % mathematics proficiency.

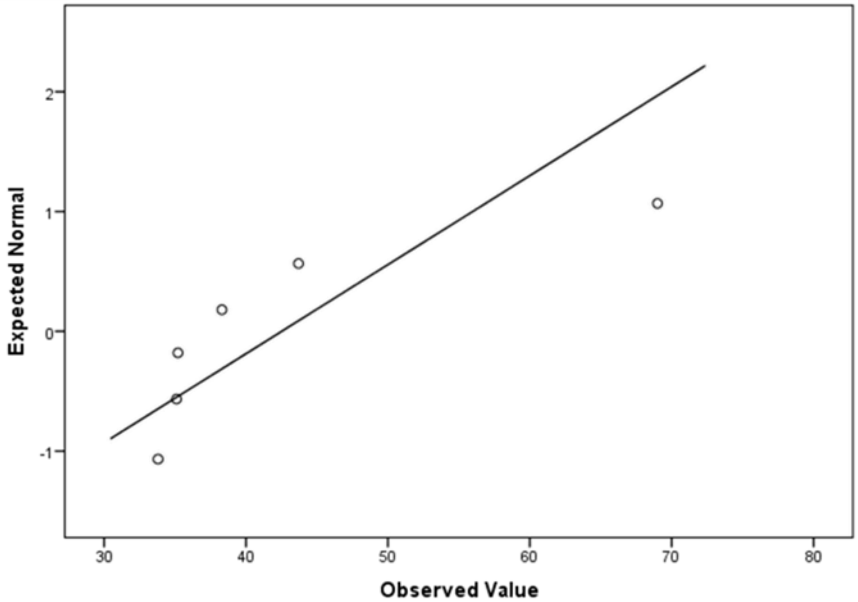

Figure J-367. Normal Q-Q Plot of 2015 SAGE % Mathematics Proficiency for MTL44 = 1. This figure illustrates the observed value versus the expected normal for school leaders who ranked MTL44 at 1 based on their school's school-wide 2015 SAGE % mathematics proficiency.

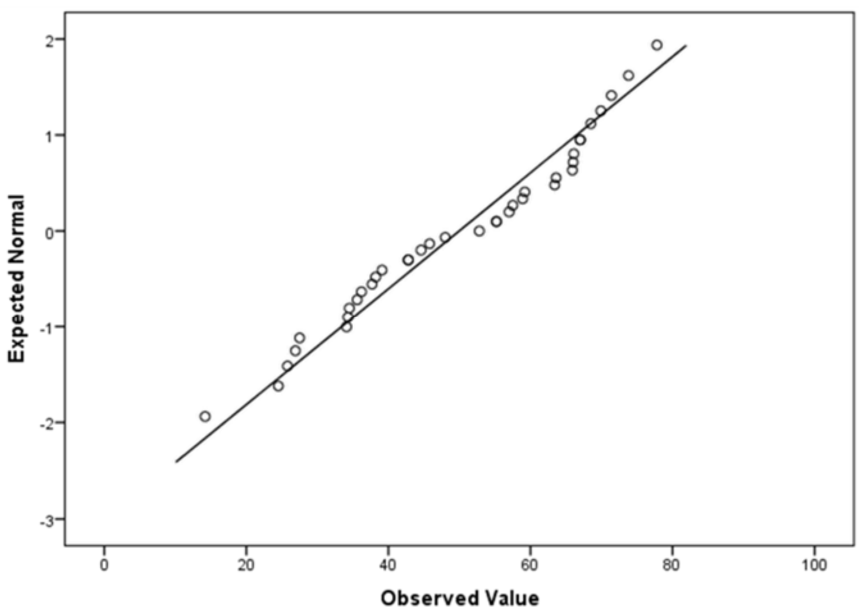

Figure J-368. Normal Q-Q Plot of 2015 SAGE % Mathematics Proficiency for MTL44 = 2. This figure illustrates the observed value versus the expected normal for school leaders who ranked MTL44 at 2 based on their school's school-wide 2015 SAGE % mathematics proficiency.

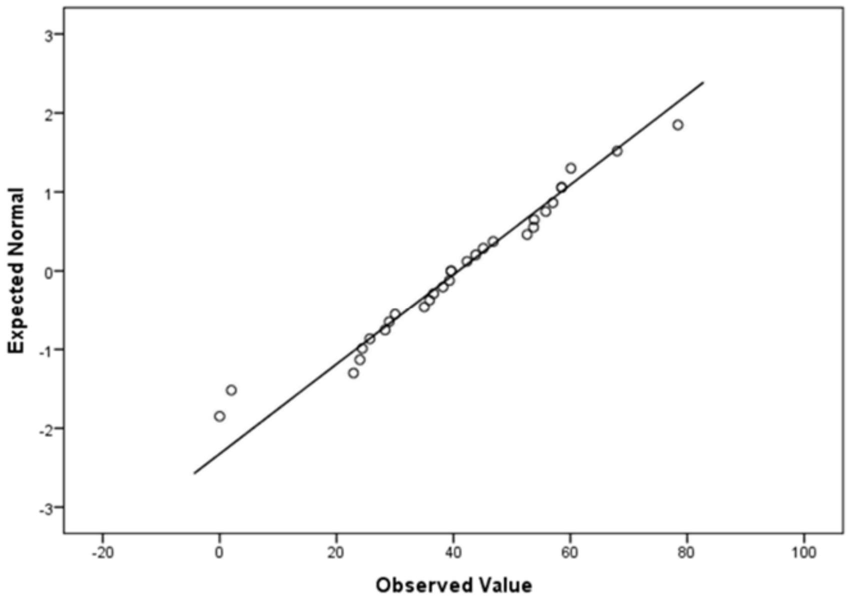

Figure J-369. Normal Q-Q Plot of 2015 SAGE % Mathematics Proficiency for MTL44 = 3. This figure illustrates the observed value versus the expected normal for school leaders who ranked MTL44 at 3 based on their school's school-wide 2015 SAGE % mathematics proficiency.

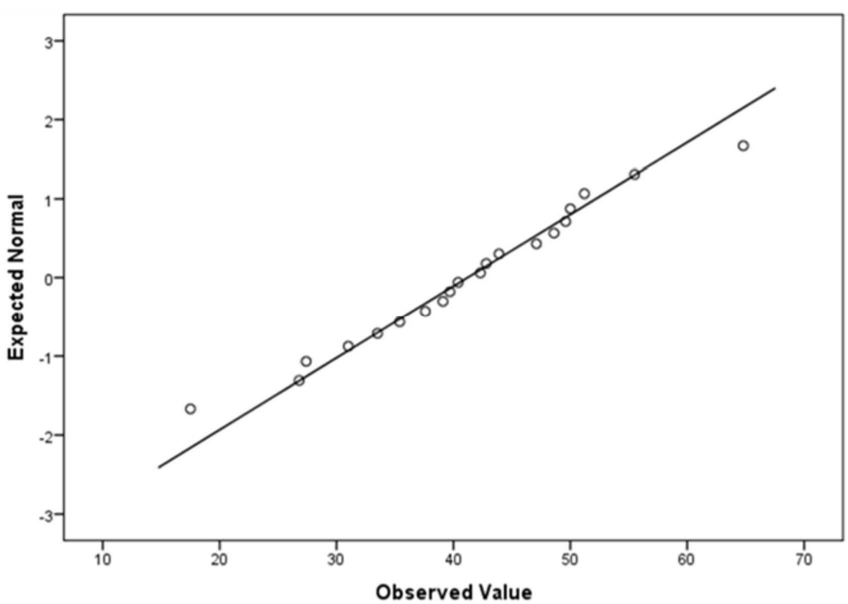

Figure J-370. Normal Q-Q Plot of 2015 SAGE % Mathematics Proficiency for MTL44 = 4. This figure illustrates the observed value versus the expected normal for school leaders who ranked MTL44 at 4 based on their school's school-wide 2015 SAGE % mathematics proficiency.

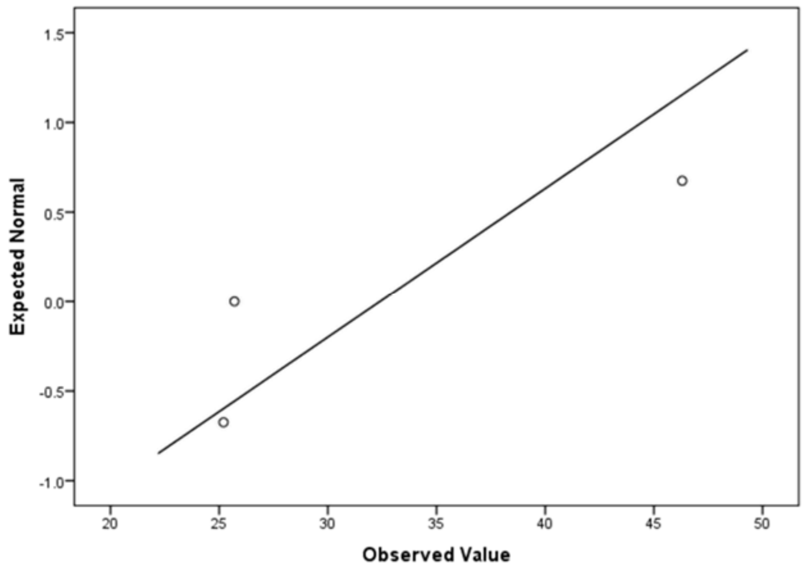

Figure J-371. Normal Q-Q Plot of 2015 SAGE % Mathematics Proficiency for MTL44 = 5. This figure illustrates the observed value versus the expected normal for school leaders who ranked MTL44 at 5 based on their school's school-wide 2015 SAGE % mathematics proficiency.

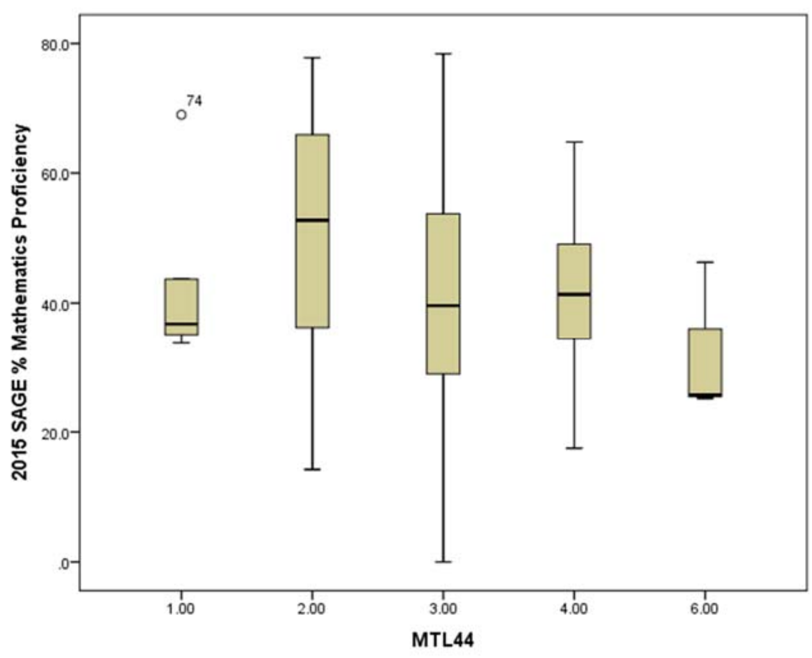

Figure J-372. Boxplot of 2015 SAGE % Mathematics Proficiency for MTL44. This figure illustrates spread of school-wide 2015 SAGE % Mathematics Proficiency scores based on school leaders' ranking of MTL44.

Table J-29

Coll_Alg: Tests for Normality

Variable		Shapiro-Wilk Statistic	*df*	Sig.	Skewness	Std. Error	Kurtosis	Std. Error
Coll_Alg	Yes	.99	121	.426	-.25	.22	-.17	.44
	No	.96	28	.436	-.45	.44	.79	.86

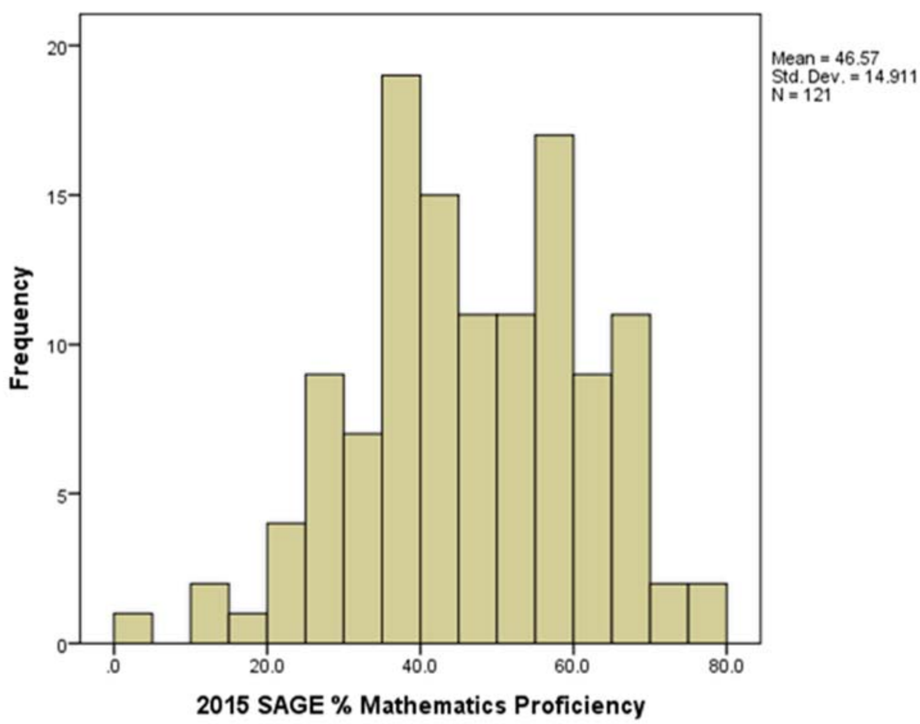

Figure J-373. Frequency by 2015 SAGE % Mathematics Proficiency for Coll_Alg = Yes. This figure illustrates the number of school leaders who ranked Coll_Alg at Yes based on their school's school-wide 2015 SAGE % mathematics proficiency.

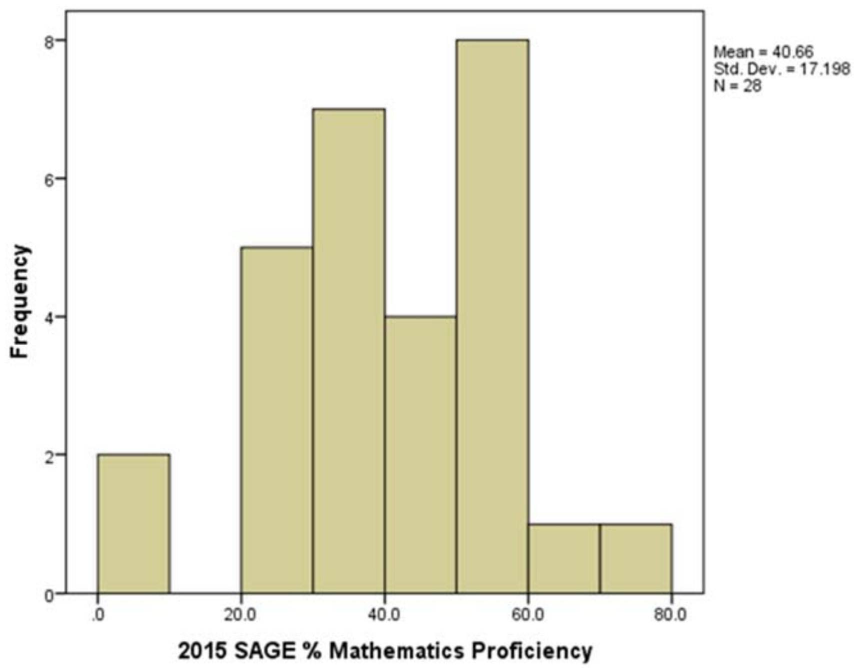

Figure J-374. requency by 2015 SAGE % Mathematics Proficiency for Coll_Alg = No. This figure illustrates the number of school leaders who ranked Coll_Alg at No based on their school's school-wide 2015 SAGE % mathematics proficiency.

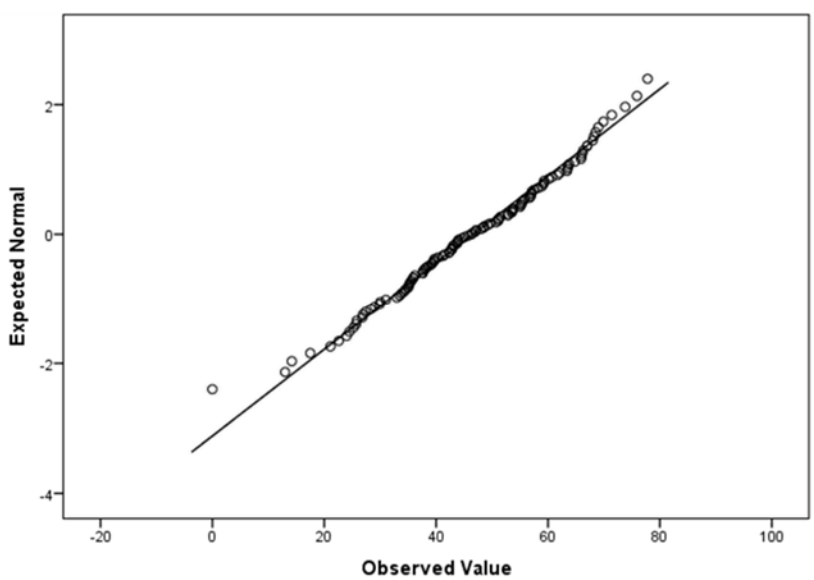

Figure J-375. Normal Q-Q Plot of 2015 SAGE % Mathematics Proficiency for Coll_Alg = Yes. This figure illustrates the observed value versus the expected normal for school leaders who ranked Coll_Alg at Yes based on their school's school-wide 2015 SAGE % mathematics proficiency.

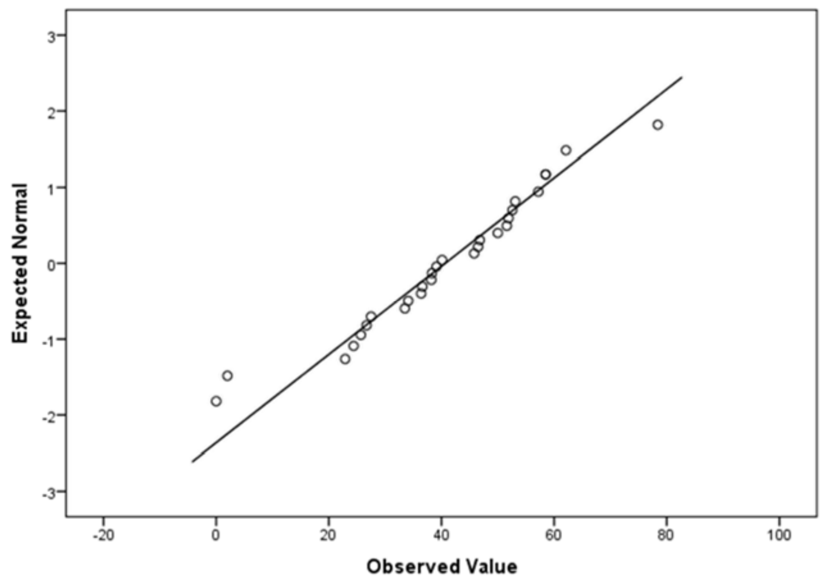

Figure J-376. Normal Q-Q Plot of 2015 SAGE % Mathematics Proficiency for Coll_Alg = No. This figure illustrates the observed value versus the expected normal for school leaders who ranked Coll_Alg at No based on their school's school-wide 2015 SAGE % mathematics proficiency.

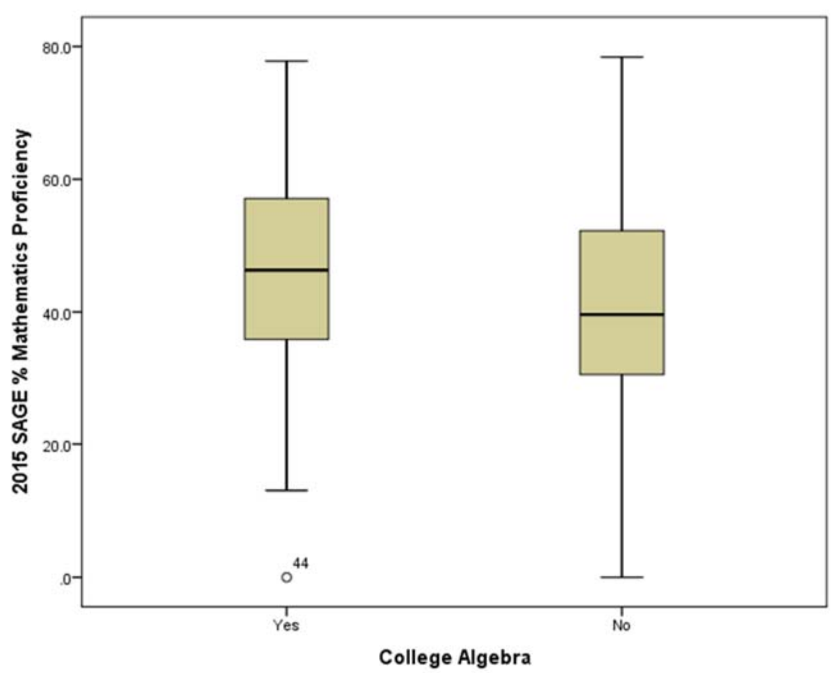

Figure J-377. Boxplot of 2015 SAGE % Mathematics Proficiency for Coll_Alg. This figure illustrates spread of school-wide 2015 SAGE % Mathematics Proficiency scores based on school leaders' taking or not taking of college algebra.

Table J-30

MTL39: Tests for Normality

		Shapiro-Wilk						
Variable		Statistic	*df*	Sig.	Skewness	Std. Error	Kurtosis	Std. Error
MTL39	1							
	2	.91	17	.110	-.47	.55	-1.06	1.06
	3	.99	58	.886	-.17	.31	.10	.62
	4	.95	41	.048	-.85	.37	.92	.72
	5	.96	20	.046	.40	.51	-.80	.99

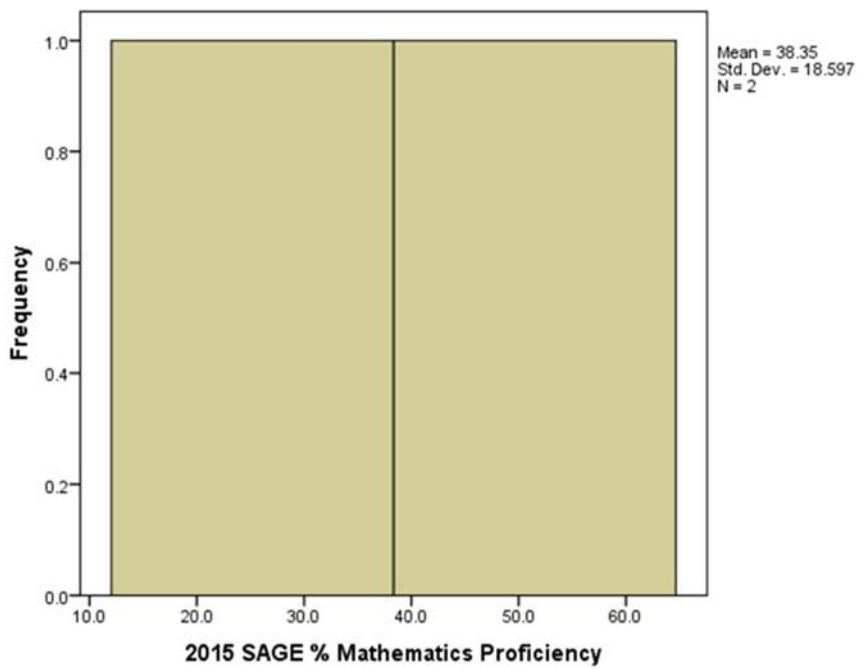

Figure J-378. Frequency by 2015 SAGE % Mathematics Proficiency for MTL39 = 1. This figure illustrates the number of school leaders who ranked MTL44 at 1 based on their school's school-wide 2015 SAGE % mathematics proficiency.

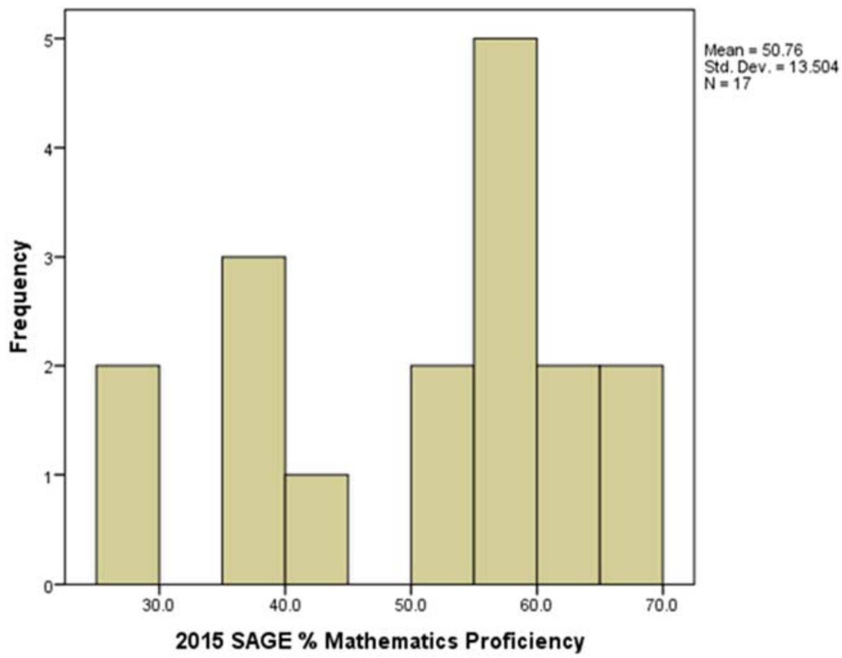

Figure J-379. Frequency by 2015 SAGE % Mathematics Proficiency for MTL39 = 2. This figure illustrates the number of school leaders who ranked MTL44 at 2 based on their school's school-wide 2015 SAGE % mathematics proficiency.

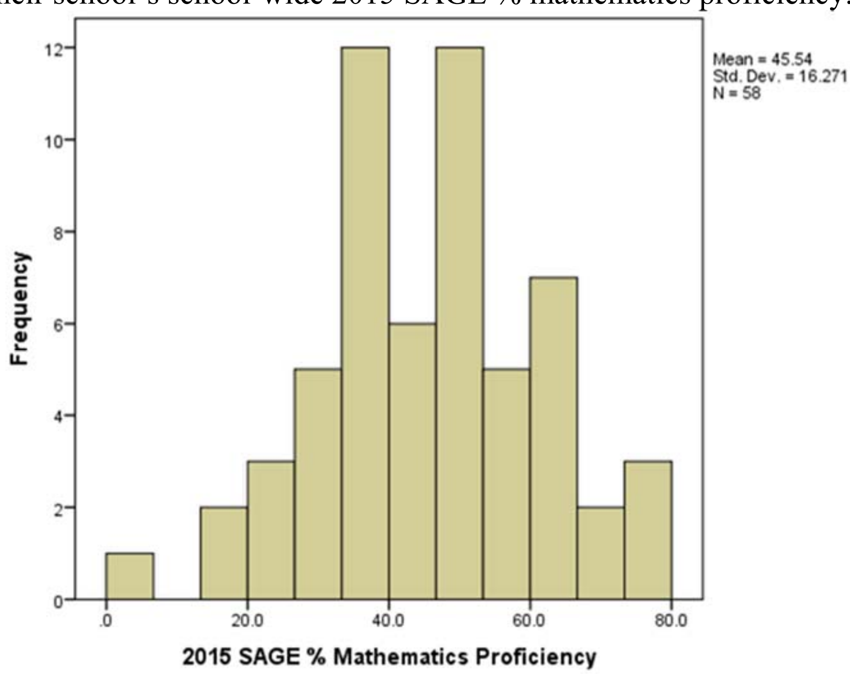

Figure J-380. Frequency by 2015 SAGE % Mathematics Proficiency for MTL39 = 3. This figure illustrates the number of school leaders who ranked MTL44 at 3 based on their school's school-wide 2015 SAGE % mathematics proficiency.

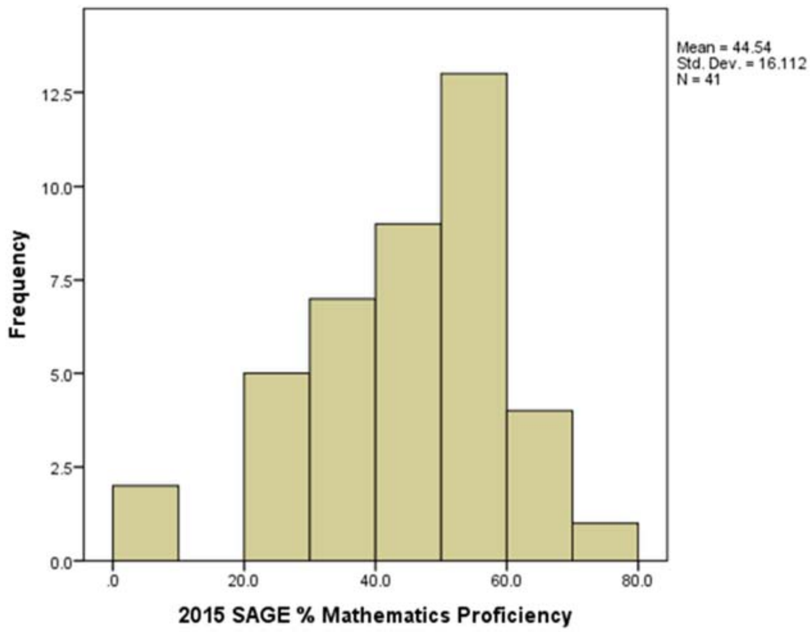

Figure J-381. Frequency by 2015 SAGE % Mathematics Proficiency for MTL39 = 4. This figure illustrates the number of school leaders who ranked MTL44 at 4 based on their school's school-wide 2015 SAGE % mathematics proficiency.

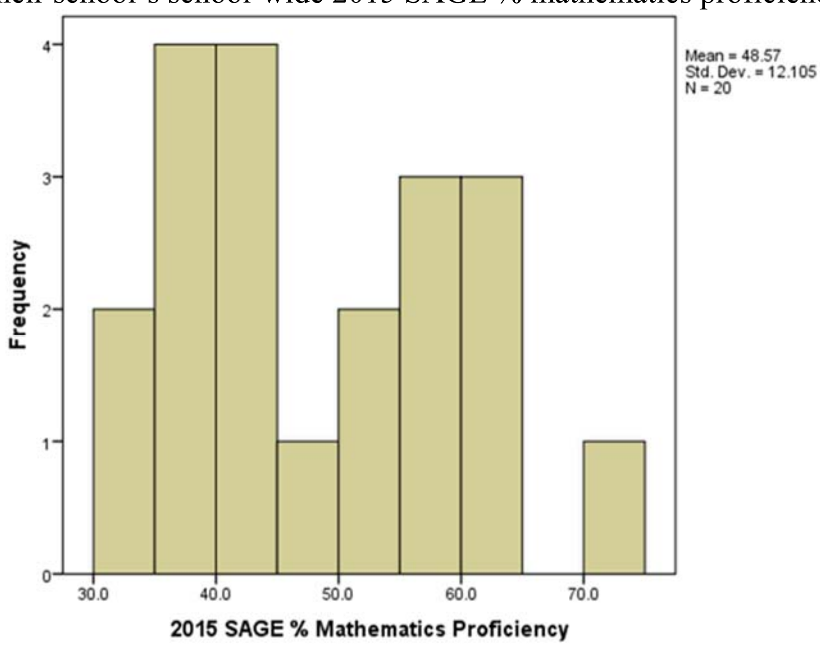

Figure J-382. Frequency by 2015 SAGE % Mathematics Proficiency for MTL39 = 5. This figure illustrates the number of school leaders who ranked MTL44 at 5 based on their school's school-wide 2015 SAGE % mathematics proficiency.

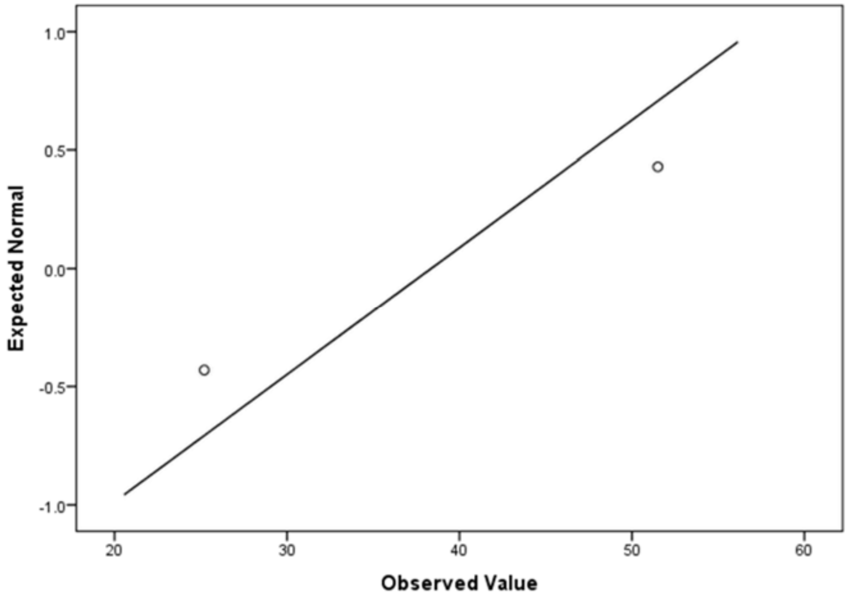

Figure J-383. Normal Q-Q Plot of 2015 SAGE % Mathematics Proficiency for MTL39 = 1. This figure illustrates the observed value versus the expected normal for school leaders who ranked MTL39 at 1 based on their school's school-wide 2015 SAGE % mathematics proficiency.

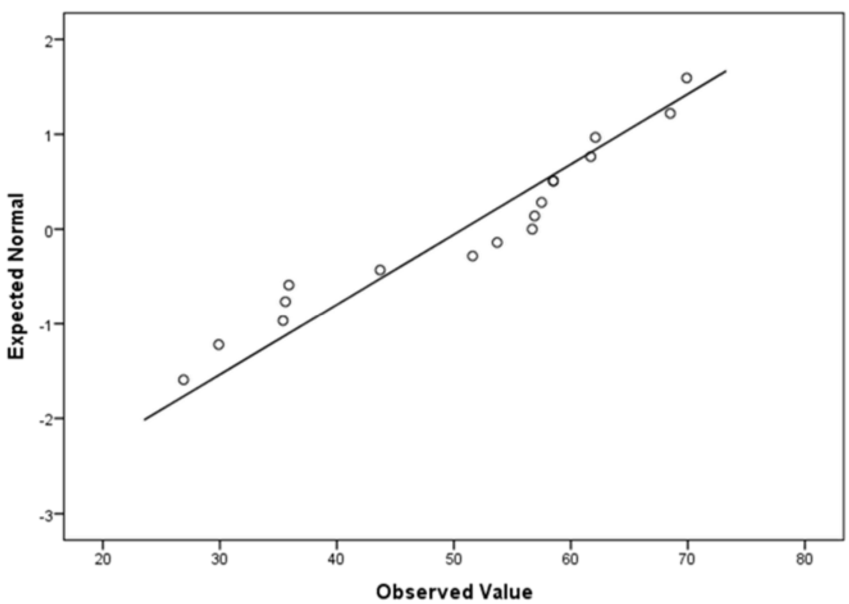

Figure J-384. Normal Q-Q Plot of 2015 SAGE % Mathematics Proficiency for MTL39 = 2. This figure illustrates the observed value versus the expected normal for school leaders who ranked MTL39 at 2 based on their school's school-wide 2015 SAGE % mathematics proficiency.

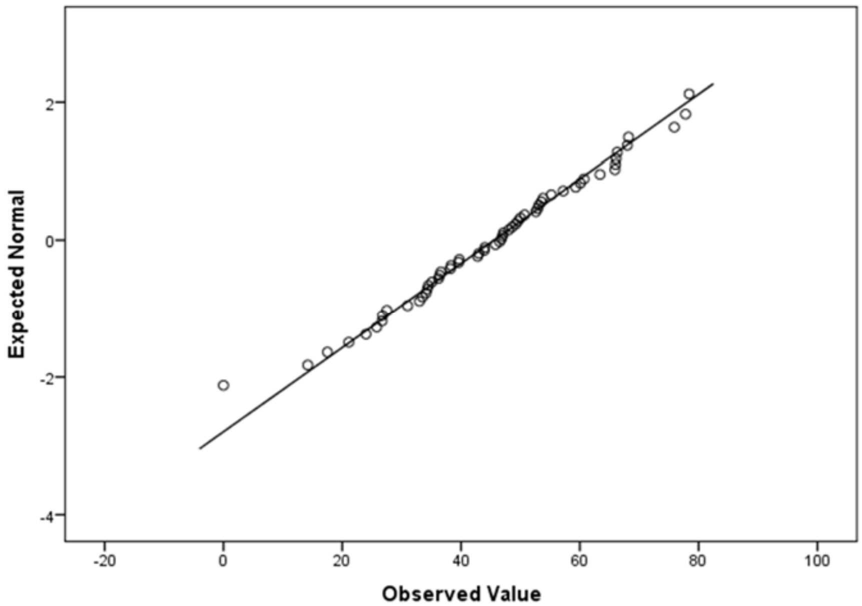

Figure J-385. Normal Q-Q Plot of 2015 SAGE % Mathematics Proficiency for MTL39 = 3. This figure illustrates the observed value versus the expected normal for school leaders who ranked MTL39 at 3 based on their school's school-wide 2015 SAGE % mathematics proficiency.

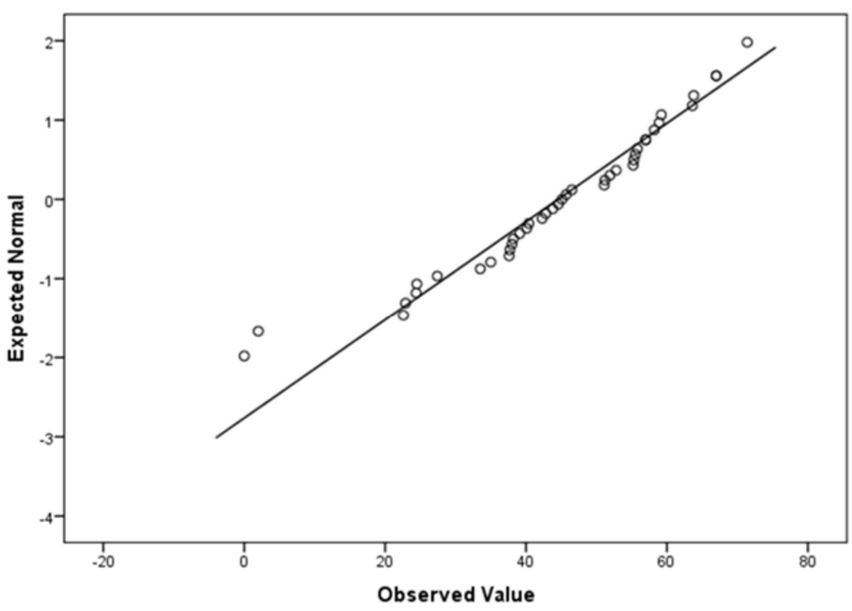

Figure J-386. Normal Q-Q Plot of 2015 SAGE % Mathematics Proficiency for MTL39 = 4. This figure illustrates the observed value versus the expected normal for school leaders who ranked MTL39 at 4 based on their school's school-wide 2015 SAGE % mathematics proficiency.

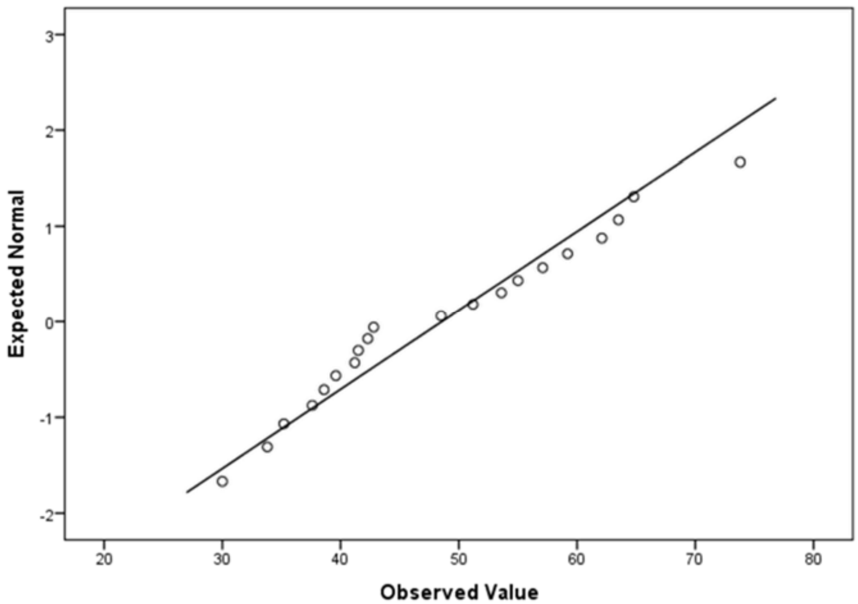

Figure J-387. Normal Q-Q Plot of 2015 SAGE % Mathematics Proficiency for MTL39 = 5. This figure illustrates the observed value versus the expected normal for school leaders who ranked MTL39 at 5 based on their school's school-wide 2015 SAGE % mathematics proficiency.

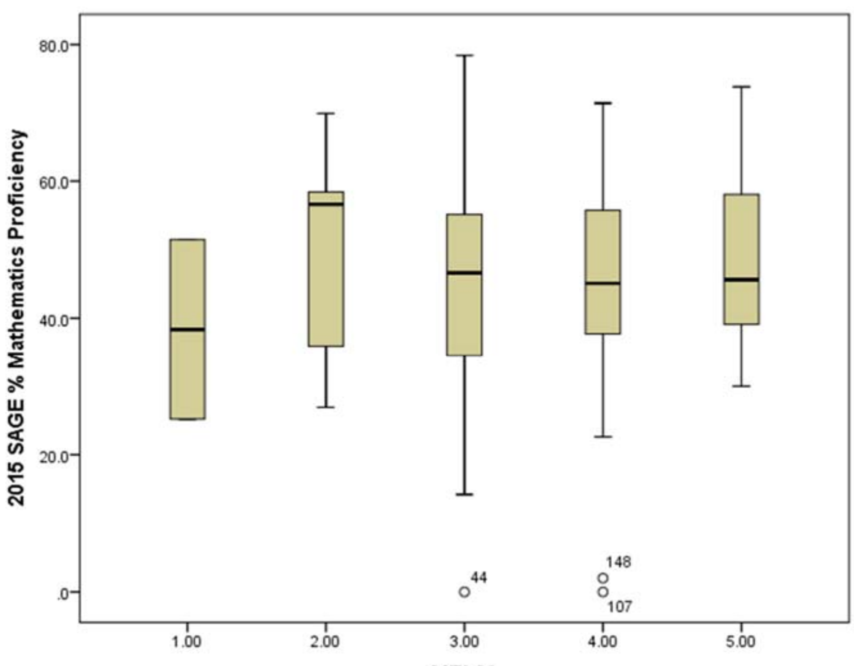

Figure J-388. Boxplot of 2015 SAGE % Mathematics Proficiency for MTL39. This figure illustrates spread of school-wide 2015 SAGE % Mathematics Proficiency scores based on school leaders' ranking of MTL39.

Appendix K

Correlations

Table K-1

Correlations Among the 30 Most Important Variables and the Independent Variable to Be Used in the Network Analysis

Variable[a]	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
1	-																														
2	.11	-																													
3	.08	.31**	-																												
4	-.11	.14	-.01	-																											
5	-.18	.04	.14	.07	-																										
6	-.14	.14	.00	.80**	.10	-																									
7	-.21**	.02	.14	.12	.25*	.10	-																								
8	.03	-.11	-.15	.15	-.05	.14	.02	-																							
9	.00	.02	.07	.03	-.05	-.03	-.07	.04	-																						
10	.16	.39**	.23**	-.01	.11	.06	.00	-.02	-.15	-																					
11	-.02	.03	.15	.06	-.03	.06	.11	.07	-.04	-.09	-																				
12	-.10	.21**	.05	.02	.15	.11	.07	.15	-.04	.22**	.04	-																			
13	.15	.54**	.35**	.03	.10	.04	-.01	-.06	-.18*	.40**	.03	.18*	-																		
14	.12	.87**	.32**	.09	.06	.10	.06	-.12	-.06	.41**	.07	.20*	.67**	-																	
15	-.13	.16	.09	.09	.19	.17*	-.03	.19*	-.06	.12*	-.05	.09	.18*	.14	-																
16	.04	-.12	.07	-.05	-.03	-.10	.04	.12	.06	-.07	.08	.01	-.12	-.12	-.15	-															
17	.17*	.27**	.40**	-.07	-.03	-.09	.02	-.17*	-.19*	.19*	-.09	-.01	.25**	.32**	.01	-.10	-														
18	-.16	-.09	-.03	.14	.12	.16	.03	-.02	-.18	.03	.05	-.04	-.04	-.09	.04	-.02	.08	-													
19	-.13	.11	-.07	.33**	.11	.42**	.05	.20*	-.11	-.01	.27**	.13	.04	.06	.06	-.07	-.12	.06	-												
20	.04	.09	.06	-.06	.06	.02	-.10	-.07	-.16	.18	.08	-.28**	.03	.08	.19	-.08	.12	.36**	.25*	-											
21	.09	-.21**	-.11	-.21**	-.13	-.29**	-.10	.10	.08	-.03	.04	-.11	-.12	-.21*	-.06	.24**	-.31**	-.17	-.19*	-.29**	-										
22	.16*	.23**	.07	.06	-.17	.07	.00	.07	.03	.12	.20*	.18*	.21**	.25**	-.10	-.03	.10	.19	.07	-.08	-.08	-									
23	.00	-.09	-.01	.00	-.04	.09	.01	.14	.04	.15	.01	.06	.02	.00	-.03	.21	-.12	.09	-.05	.11	.11	.05	-								
24	-.04	.21**	.10	.11	.03	.20*	.04	.06	.01	.15	.18*	.39**	.07	.22**	.10	-.03	-.12	.10	.15	-.01	.03	.18*	.03	-							
25	-.10	.05	-.03	.11	.01	-.08	.04	.10	.12	-.07	.03	.01	-.02	.03	-.08	.38**	-.14	.09	-.01	-.20	.12	-.13	.18	-.01	-						
26	-.17	.05	-.04	.18*	.11	.10	.01	.09	-.02	.07	-.07	.01	-.13	-.02	.01	-.08	.05	.03	-.06	.01	-.01	-.04	.06	.00	.09	-					
27	.09	-.06	-.04	-.14	-.14	-.11	-.07	.09	-.01	.07	-.05	.09	-.02	-.10	.05	.18*	-.17*	.02	-.09	-.05	.29**	-.04	.06	-.03	.06	-.06	-				
28	.03	.12	.21*	.15	.24*	.23**	.04	.09	-.08	.08	-.08	.02	.13	.10	.09	-.12	.25**	.20	.11	.17	-.36**	-.07	.08	-.17*	.01	.00	-.08	-			
29	-.21*	-.01	.22*	.09	.11	.00	.09	-.08	.02	-.01	.19	-.03	.00	-.02	.00	.08	-.08	.00	.08	.12	.09	-.12	.05	.30**	-.04	-.02	.06	-.21*	-		
30	-.13	.02	.08	.09	.08	.00	-.03	-.13	.03	-.18*	.01	-.08	-.01	-.02	-.02	-.07	-.05	-.04	.08	-.04	-.03	-.01	-.06	-.10	-.02	.04	-.09	-.07	.00	-	
31	-.02	.27**	.09	.11	.10	.13	.17*	-.03	-.14	.24**	-.14	.21*	.21*	.24**	.21*	-.15	.22**	-.06	.10	-.09	-.18*	-.05	-.05	.14	-.03	.06	.00	.22**	-.06	-.15	-

[a] See next page for descriptions of each variable.
* Correlation is significant at the 0.05 level (2-tailed).
** Correlation is significant at the 0.01 level (2-tailed).

Table K.2

Key to Table K-1

Variable abbreviation	Description
1. 2015 SAGE mathematics % proficiency	School-wide average mathematics proficiency score of each school
2. ISAM18	School leader agreement with this statement: “The best way to increase student achievement in mathematics is to educate members of the legislature on the curriculum and research-based instructional strategies.”
3. ISAM12	School leader agreement with this statement: “The best way to increase student achievement in mathematics is to provide teacher/aide tutoring for students.”
4. Yrs_Last_Teach_Pos	Number of years the school leader was in their last teaching position.
5. MTL64	School leader agreement with this statement: “Discussion of mathematics (mathematical discourse) should be used at least 50% of the time in the 10-12 mathematics classroom.”
6. Tot_Yrs_Teach	Numbers of years the school leader taught in some capacity.
7. Inf_Teach3	School leader perception of the amount of influence of teachers over the instructional methods used in the mathematics classroom at their school.
8. Math_Ed	School leader earned a major, minor, or special emphasis in mathematics education
9. MTL12	School leader agreement with this statement: “The use of calculators in early grades impedes the development of automaticity with basic facts.”
10. ISAM3	School leader agreement with this statement: “The best way to increase student achievement in mathematics is to work with university researchers in a collaborative professional development.”
11. MTL35	School leader agreement with this statement: “In grades K-9, mathematics instruction should be teacher directed more than 50% of the time.”
12. Inf_Nat_Org2	School leader perception of the amount of influence of national organizations such as NCTM over the implementation of the mathematics curriculum at your school.
13. ISAM16	School leader agreement with this statement: “The best way to increase student achievement in mathematics is to educate parents on the curriculum and research-based instructional strategies.”
14. ISAM17	School leader agreement with this statement: “The best way to increase student achievement in mathematics is to educate board members on the curriculum and research-based instructional strategies.
15. Fam_PD_CI_Doc	Amount of school leader familiarity with professional development/materials/readings in mathematics curriculum and instruction.

(*table continues*)

Variable abbreviation	Description
16. Sec_Ed	School leader earned a major, minor, or special emphasis in secondary education.
17. ISAM13	School leader agreement with this statement: “The best way to increase student achievement in mathematics is to provide appropriate Tier II and Tier III instruction for students.”
18. MTL62	School leader agreement with this statement: “In 10-12, certain aspects of geometry and measurement are critical foundations of algebra.”
19. Age	School leader age
20. MTL55	School leader agreement with this statement: “In 10-12, explicit instruction for students who struggle in math is effective in increasing student performance with word problems and computation.”
21. Gr_T_2	School leader taught second grade at some point in their teaching career.
22. Sub_T_Elec	School leader taught elective subjects at some point in their teaching career.
23. Other_Math	School leader earned a major, minor, or special emphasis in some other mathematics related field.
24. Inf_State_Leg2	School leader perception of the amount of influence of the state legislature over the implementation of mathematics curriculum at your school.
25. Sub_T_H_SS	School leader taught history/social studies at some point in their teaching career.
26. Saxon_Math	The school uses Saxon Math curriculum resources as part of their mathematics program.
27. Gr_T_K	School leader taught kindergarten at some point in their teaching career.
28. MTL36	School leader agreement with this statement: “In grades K-9, questioning should be an important instructional practice in the mathematics classroom.”
29. MTL44	School leader agreement with this statement: “Rote practice (drill) should be an important instructional practice in the 10-12 mathematics classroom.”
30. Coll_Alg	School leader took college algebra.
31. MTL39	School leader agreement with this statement: “Cooperative work should be the primary instructional practice in the K-9 mathematics classroom.”

Appendix L

Descriptive Statistics

Table L-1

Descriptive Statistics of Top 30 Most Important Characteristics of School Leader Variables in Order of Importance in Predicting a School-wide Average 2015 SAGE Mathematics Proficiency Score

Variable	*N*	Range	Min.	Max.	*M*	*SD*	Descriptions of measure
ISAM18	151	4	1	5	3.24	1.08	1. Strongly Disagree 2. Disagree 3. Neutral 4. Agree 5. Strongly Agree
ISAM12	151	4	1	5	3.70	0.84	1. Strongly Disagree 2. Disagree 3. Neutral 4. Agree 5. Strongly Agree
Yrs_Last_Teach_Pos	158	24	0	24	8.33	5.31	
MTL64	93	4	1	5	3.39	0.82	1. Strongly Disagree 2. Disagree 3. Neutral 4. Agree 5. Strongly Agree
Tot_Yrs_Teach	157	43	0	43	11.91	7.60	
Inf_Teach3	158	3	3	6	5.73	0.53	1. No Influence 2. Very small influence 3. Small Influence 4. Moderate Influence 5. Strong Influence 6. Very strong influence
Math_Ed	158	2	1	3	1.15	0.42	1. No 2. Yes, Minor/Sp. Emphasis 3. Yes, Major
MTL12	156	4	1	5	2.84	1.01	1. Strongly Disagree 2. Disagree 3. Neutral 4. Agree 5. Strongly Agree
ISAM3	152	4	1	5	3.73	0.87	1. Strongly Disagree 2. Disagree 3. Neutral 4. Agree 5. Strongly Agree
MTL35	144	4	1	5	2.80	0.94	1. Strongly Disagree 2. Disagree 3. Neutral 4. Agree 5. Strongly Agree
Inf_Nat_Org2	158	5	1	6	2.70	1.40	1. No Influence 2. Very small influence 3. Small Influence 4. Moderate Influence 5. Strong Influence 6. Very strong influence
ISAM16	151	4	1	5	3.39	0.89	1. Strongly Disagree 2. Disagree 3. Neutral 4. Agree 5. Strongly Agree
ISAM17	151	4	1	5	3.25	0.97	1. Strongly Disagree 2. Disagree 3. Neutral 4. Agree 5. Strongly Agree

(*table continues*)

Variable	*N*	Range	Min.	Max.	*M*	*SD*	Descriptions of measure
Fam_PD_CI_Doc	156	5	1	6	3.76	1.25	1. Not familiar 2. Vaguely Familiar 3. Somewhat Familiar 4. Moderately Familiar 5. Mostly Familiar 6. Strongly Familiar
Sec_Ed	158	2	1	3	1.59	0.85	1. No 2. Yes, Minor/Sp. Emphasis 3. Yes, Major
ISAM13	152	3	2	5	4.34	0.61	1. Strongly Disagree 2. Disagree 3. Neutral 4. Agree 5. Strongly Agree
MTL62	94	3	2	5	3.82	0.55	1. Strongly Disagree 2. Disagree 3. Neutral 4. Agree 5. Strongly Agree
Age	156	37	30	67	49.11	8.32	
MTL55	97	3	2	5	4.01	0.70	1. Strongly Disagree 2. Disagree 3. Neutral 4. Agree 5. Strongly Agree
Gr_T_2	158	1	1	2	1.85	0.35	1. Yes 2. No
Sub_T_Elec	158	1	1	2	1.97	0.18	1. Yes 2. No
Other_Math	158	2	1	3	1.07	0.28	1. No 2. Yes, Minor/Sp. Emphasis 3. Yes, Major
Inf_State_Leg2	158	5	1	6	3.11	1.40	1. No Influence 2. Very small influence 3. Small Influence 4. Moderate Influence 5. Strong Influence 6. Very strong influence
Sub_T_H_SS	158	1	1	2	1.45	0.50	1. Yes 2. No
Saxon_Math	158	1	1	2	1.95	0.22	1. Yes 2. No
Gr_T_K	158	1	1	2	1.94	0.23	1. Yes 2. No
MTL36	146	2	3	5	4.27	0.54	1. Strongly Disagree 2. Disagree 3. Neutral 4. Agree 5. Strongly Agree
MTL44	101	5	1	6	2.78	1.04	1. Strongly Disagree 2. Disagree 3. Neutral 4. Agree 5. Strongly Agree
Coll_Alg	158	1	1	2	1.19	0.40	1. Yes 2. No
MTL39	145	4	1	5	3.45	0.93	1. Strongly Disagree 2. Disagree 3. Neutral 4. Agree 5. Strongly Agree

Appendix M

Multicollinearity Diagnostics

Table M-1

Coefficients

Variable	Tolerance statistics	VIF
ISAM18	.138	7.272
ISAM12	.363	2.754
Yrs_Last_Teach_Pos	.219	4.557
MTL64	.545	1.834
Tot_Yrs_Teach	.178	5.604
Inf_Teach3	.472	2.118
Math_Ed	.571	1.750
MTL12	.633	1.579
ISAM3	.479	2.090
MTL35	.608	1.645
Inf_Nat_Org2	.423	2.366
ISAM16	.353	2.830
ISAM17	.108	9.251
Fam_PD_CI_Doc	.519	1.925
Sec_Ed	.480	2.085
ISAM13	.450	2.220
MTL62	.520	1.921
Age	.420	2.379
MTL55	.386	2.594
Gr_T_2	.302	3.308
Sub_T_Elec	.505	1.981
Other_Math	.654	1.529
Inf_State_Leg2	.337	2.970
Sub_T_H_SS	.567	1.763
Saxon_Math	.790	1.267
Gr_T_K	.559	1.790
MTL36	.563	1.776
MTL44	.584	1.711
Coll_Alg	0.623	1.605
MTL39	0.569	1.758

Table M.2

Eigenvalues

Dimension	Eigenvalue
1	28.600
2	0.536
3	0.322
4	0.260
5	0.187
6	0.161
7	0.124
8	0.109
9	0.089
10	0.082
11	0.076
12	0.069
13	0.056
14	0.051
15	0.041
16	0.040
17	0.033
18	0.029
19	0.024
20	0.020
21	0.018
22	0.014
23	0.011
24	0.010
25	0.009
26	0.007
27	0.006
28	0.006
29	0.004
30	0.002
31	0.001

CURRICULUM VITAE

EMMA KATHLEEN PRICE BULLOCK

Business Address:
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135 W. 280 N.
Providence, UT 84332

EDUCATION

Ph.D. May 2017
Education: Utah State University
Specialization: Curriculum and Instruction
Concentration: Mathematics Education and Leadership
Dissertation: *An Explanatory Sequential Mixed Methods Study of the School Leaders' Role in Students' Mathematics Achievement Through the Lens of Complexity Theory*

M.M. December 2016
Mathematics: Utah State University

M.Ed. May 2010
Master of Education in Educational Leadership, Argosy University.
Utah Professional Administrative License, K-12 (2011)

B.S. April 2001
Mathematics with an Emphasis in Combinatorics
Music with an Emphasis in Vocal Performance, Brigham Young University.
Utah Professional Teaching Level I License, 6-12 with a Math Level IV endorsement (2001).
Utah Professional Teaching Level II License, 6-12 with a Math Level IV endorsement (2007)

EMPLOYMENT HISTORY

Sam Houston State University

Assistant Professor, Mathematics Education (August 2017)
Sam Houston State University, Department of Mathematics and Statistics, College of Science and Engineering Technology, Huntsville, TX
Responsibilities will include teaching graduate and undergraduate courses in Mathematics Education (Elementary and Secondary) and Mathematics courses (such as Linear Algebra, etc.); assisting in the development and implementation of programs for students; advising students; supervising graduate assistants, and developing a professional agenda of teaching, citizenship, and scholarship within the university community.

Utah State University

Graduate Research and Teaching Assistant (2013-present)
Utah State University, College of Education & Human Services, Logan, UT
Research responsibilities include assisting professors on various research projects in mathematics education such as fulfilling the role of project coordinator (i.e. all participant recruitment and interview scheduling), development of interview protocols and other relevant documentation such as demographic/parent surveys, informed consent and parent information sheets, interviewing participants, coding video observations of participant actions, performing all levels of quantitative and qualitative data analysis, and participating in group papers and presentations. Virtual Manipulatives Database, manager (2015-present), which includes the following: (a) Maintain research database and review of articles for inclusion therein; (b) Develop and organize review and coding procedures for contributors

Teaching assistant responsibilities include teaching the Level III undergraduate mathematics methods course, supervising Level III practicum student teachers, collaborating with Edith Bowen Laboratory School teachers, and creating and teaching master's level elementary endorsement courses (i.e. Geometry and Measurement, Algebraic Reasoning, modules for the Elementary Mathematics Teachers Academy (EMTA)). These include face-to-face, distance broadcast, online, and hybrid classroom settings.

EDUCATIONAL LEADERSHIP/ADMINISTRATIVE EXPERIENCE

Mountainville Academy

Executive Director/Superintendent (2013-2014).
K-9 Utah Public Charter School, Alpine, Utah
As executive director/superintendent, responsibilities include supervising all aspects of school operation, achieving the school's mission of building leaders', one student at a time, through personal and academic excellence, overseeing the entire academic program, professional development of staff, managing the school's public relations efforts with the broader community, and ensuring legal compliance with public education laws and regulations. As the mathematics coordinator, responsibilities include initially assessing and placing all students, K-9, into appropriate math groups, managing movement between the groups based on data, throughout the school year, planning and conducting mathematics professional development for all math teachers, K-9, providing coaching, curriculum planning and ensuring the appropriate resources are available for students and teachers.

Administrative Director/Principal (2009-2013).
Mathematics Coordinator K-9 (2006-2014)
K-9 Utah Public Charter School, Alpine, Utah
As administrative director, responsibilities include supervising all aspects of school operation, achieving the school's mission of building leaders', one student at a time, through personal and academic excellence, overseeing the entire academic program, training and motivating all staff, managing the school's public relations efforts with students, parents, and the broader community, and ensuring legal compliance with public education laws and regulations. As the mathematics coordinator, responsibilities include initially assessing and placing all students, K-9, into appropriate math groups, managing movement between the groups based on data, throughout the school year, planning and conducting mathematics professional development for all math teachers, K-9, providing coaching, curriculum planning and ensuring the appropriate resources are available for students and teachers.

PUBLIC SCHOOL TEACHING EXPERIENCE

Mountainville Academy

Teacher, Pre-Calculus, Algebra II, Algebra I, Pre-Algebra, 7th grade math, 6th grade math, 5th grade math (2006-2009).
Middle School Department Chair/Lead Teacher (2008-2009)
Mentor Teacher (2009-2014)
K-8 Utah Public Charter School, Alpine, Utah
Responsibilities included teaching classes in accordance with Utah professional teaching and mathematics standards, acting as the liaison between the middle school teachers and administration, conducting middle school team meetings, as needed, working with other teachers in various disciplines to coordinate and integrate curriculum and logistical needs, and any other duties, as required.

Georgetown High School

Teacher, Algebra II Honors, Algebra II, Math Tech I, Student Council (2005-2006).
Georgetown School District, Georgetown, South Carolina
Responsibilities included teaching classes in accordance with South Carolina professional teaching and mathematics standards, acting as the advisor for the student counsel, and any other duties, as required.

John Hancock Charter School

Teacher, Algebra II, Algebra I, Pre-Algebra, 8th grade Integrated Science, 7th grade Integrated Science, 6th grade Integrated Science, 7th-8th Choir, Student Council (2003-2005).
K-8 Utah Public Charter School, Pleasant Grove, Utah
Responsibilities included teaching classes in accordance with Utah professional teaching, mathematics, science, and music standards, acting as the advisor for the student counsel, and any other duties, as required.

Payson Junior High School

Internship, Teacher, Algebra I, Pre-Algebra, Music Director for after school production of "Bye, Bye Birdie" (2000-2001).
Nebo School District, Payson, Utah
Responsibilities included teaching classes in accordance with Utah professional teaching and mathematics standards, acting as the music director for the after school musical production, and any other duties, as required.

AWARDS & PROFESSIONAL RECOGNITION

- 2017 Sherrie Reynolds Scholarship Award, Chaos and Complexity Theory SIG, AERA. (2017).
- 2016 Graduate Researcher of the Year, School of Teacher Education and Leadership (TEAL). (2015-16).
- 2016-17 Frederick Q. Lawson Fellowship Award. (2016-17).
- 2016-17 School of Graduate Studies Dissertation Fellowship Award. (2016-17).

- Graduate Student Senate Enhancement Award. (2016-17).
- Graduate Research and Creative Opportunities Grant Award. (2016).
- Division A Senior Graduate Representative, American Education Research Association (AERA). (2016-2017).
- Division A Junior Graduate Representative, American Education Research Association (AERA). (2015-2016).
- Graduate Research and Teaching Assistant, Utah State University. (2013-present).
- 2013 National Promising Practice Award, LLS Learning and Leadership Strategies, as Principal of the Mountainville Academy, Character Education Partnership (2013).
- 2012-present Principal of the National School of Character, Mountainville Academy. Character Education Partnership (2012).
- 2012 National Promising Practice Award, Leadership Day, as Principal of the Mountainville Academy. Character Education Partnership (2012).
- 2011-13 Principal of the State School of Character, Mountainville Academy, Eunice Kennedy Shriver National Center for Community of Caring (2011).
- 2011-2014 Principal of the Lighthouse School Designation, Mountainville Academy, Franklin Covey (2011).
- 2011 Utah State Promising Practice Award, Legacy Hour, as Principal of Mountainville Academy, Eunice Kennedy Shriver National Center for Community of Caring (2011).
- 2011 Red Robin School of Merit, as Principal of the Mountainville Academy for random acts of service. Red Robin, Corp. (2011).
- 2011 and 2009 Honorable Mention—PTL Magazine as Principal of the Mountainville Academy for Mountainville's Family School Organization (FSO), (2009; 2011).
- 2010 Innovating Practice Award, as Principal of the Mountainville Academy for Different Abilities Day, George Eunice Kennedy Shriver National Center for Community of Caring (2010).
- 2010 Charter School Innovations Excellence Award as Principal of the Mountainville Academy, Utah Association of Public Charter Schools (2010).
- 2010 Leader in Me School Designation as Principal of the Mountainville Academy Franklin Covey (2010).
- 2009 State Math Contest—2nd place 8th grade Team as Math Teacher/Principal of the Mountainville Academy.

RESEARCH PROJECTS

Affordances of Virtual Manipulatives Touch-Screen Apps for Mathematics Learning. (2016-2018). Project Coordinator. Utah State University. (with PI Dr. Patricia Moyer-Packenham and the Virtual Manipulative

Research Group). My roll: Responsible for all participant recruitment and interview scheduling. Participating in all aspects of project development, implementation, analysis and publication of results including data collection, coding of data, and both qualitative and quantitative analysis.

GreenWood Charter School: Growing GreenWood Teachers' Mathematics Pedagogical Content Knowledge Through Action Research in the Classroom. (2015-2018). Program Director/Coordinator. Action research collaboration between Utah State University and GreenWood Charter School in Harrisville, UT. My roll: Oversee and develop all on-site professional development and support of teachers, coordinate all research support for teacher publications and presentations, manage day to day budget and operations.

Captivated! Young Children's Learning Interactions with iPad Mathematics Apps. (2013-2015). Code video observations of participant actions and find emerging themes and data analysis. Utah State University (with PI Dr. Patricia Moyer-Packenham and the Virtual Manipulatives Research Group). My roll: Quantitative analysis for affordances across apps, oversee and participate in qualitative analysis for affordances across apps. Lead author of preschool papers on affordances across apps, second author over analysis of data and major portions (methods/results/discussion) of across grade papers on affordances across apps. Conference presentation preparation.

PUBLICATIONS

Journal Articles (Refereed)

Bullock, E. P., Shumway, J. F., Watts, C., Moyer-Packenham, P. S. (2017). Affordance Access Matters: Preschool Children's Learning Progressions While Interacting with Touch-Screen Mathematics Apps. *Technology, Knowledge and Learning.* Doi: 10.1007/s10758-017-9312-5

Moyer-Packenham, P. S., **Bullock, E. P.**, Shumway, J. F., Tucker, S. I., Watts, C., Westenskow, A., Anderson-Pence, K. L., Maahs-Fladung, C., Boyer-Thurgood, J., Gulkilik, H., & Jordan, K. (2016). The role of affordances in children's learning performance and efficiency when using virtual manipulative mathematics touch-screen apps. *Mathematics Education Research Journal,* 28(1), 1-27. Doi: 10-1007/s13394-015-0161-z

Moyer-Packenham, P. S., Watts, C., Tucker, S. I., **Bullock, E.P.**, Shumway, J. F., Westenskow, A., Boyer-Thurgood, J. M., Anderson-Pence, K. L., Mahamane, S., Jordan, K. (2016). An Examination of Children's Learning Progression Shifts While Using Touch Screen Virtual Manipulatives Apps. *Computers in Human Behavior, 64, 814-828.*

Bullock, E. P., Ashby, M.J., Spencer, B., Manderino, K., Myers, K. (2015). Saxon math in the middle grades: A content analysis. *International Journal of Learning, Teaching, and Educational Research, 14 (1), 63-96.*

Bullock, E. P., Kidd. J., O'Driscoll, T., Reid, A. (2015). Bridging research and practice: Growing greenwood elementary teachers' mathematics pedagogical content knowledge through action research in the classroom: The beginning. *Utah Mathematics Teacher, 8,* 40-45.

Moyer-Packenham, P. S., Shumway, J. F., **Bullock, E.**, Tucker, S. I., Anderson-Pence, K. L., Westenskow, A., Boyer-Thurgood, J., Maahs-Fladung, C., Symanzik, J., Mahamane, S., MacDonald, B., & Jordan, K. (2015). Young children's learning performance and efficiency when using virtual manipulative mathematics iPad apps. *Journal of Computers in Mathematics and Science Teaching, 34*(1), 41-69.

Journal Articles (Invited)

Bullock, E. (2014). Using the new SAGE assessment to increase student performance. *Charterology, 4(1), 24-25.*

Conference Proceedings (Refereed)

Bullock, E. P., Moyer-Packenham, P. S., Shumway, J. F., Watts, C., MacDonald, B. (2015, March). Effective teaching with technology: Managing affordances in iPad apps to promote young children's mathematics learning. In D. Rutledge & D. Slykhuis (Eds.), *Proceedings of the Society for Information Technology and Teacher Education International Conference* (pp. 2357-2364), Las Vegas, Nevada.

Moyer-Packenham, P. S., Westenskow, A., Shumway, J. F., **Bullock, E.**, Tucker, S. I., Anderson-Pence, K. L., Boyer-Thurgood, J., Maahs-Fladung, C., Symanzik, J., Mahamane, S., MacDonald, B., & Jordan, K., The Virtual Manipulatives Research Group at Utah State University. (2014, September). The effects of different virtual manipulatives for second graders' mathematics learning in the touch-screen environment. *Proceedings of the 12th International Conference of the Mathematics Education into the 21st Century Project*, (Vol. 1, p. 1-6). Herceg Novi, Montenegro.

Boyer-Thurgood, J., Moyer-Packenham, P., Tucker, S., Anderson, K., Shumway, J., Westenskow, A., & **Bullock, E**. (2014, January). Kindergartener's Strategy Development during Combining Tasks on the iPad. *Proceedings of the 12th Annual Hawaii International Conference on Education* (HICE), (pp. 1113-1114), Honolulu, Hawaii, ISSN# 1541-5880.

Moyer-Packenham, P. S., Anderson, K. L., Shumway, J. F., Tucker, S., Westenskow, A., Boyer-Thurgood, J., **Bullock, E.**, Mahamane, S., Baker, J., Gulkilik, H., Maahs-Fladung, C., Symanzik, J., & Jordan, K., The Virtual Manipulatives Research Group at Utah State University. (2014, January). Developing research tools for young children's interactions with mathematics apps on the iPad. *Proceedings of the 12thAnnual Hawaii International Conference on Education* (HICE), (pp. 1685-1694), Honolulu, Hawaii, ISSN# 1541-5880.

Tucker, S. I., Moyer-Packenham, P. S., Boyer-Thurgood, J. M., Anderson, K. L., Shumway, J. F., Westenskow, A., & **Bullock, E.**, The Virtual Manipulatives Research Group at Utah State University. (2014, January). Literature supporting investigations of the nexus of mathematics, strategy, and technology in children's interactions with iPad-based virtual manipulatives. *Proceedings of the 12th Annual Hawaii International Conference on Education* (HICE), (pp. 2338-2346), Honolulu, Hawaii, ISSN# 1541-5880.

Other Publications

Moyer-Packenham, P. S., Shumway, J. F., **Bullock, E.**, Tucker, S. I., Anderson-Pence, K., Westenskow, A., Boyer-Thurgood, J., Maahs-Fladung, C., Symanzik, J., Mahamane, S., MacDonald, B., & Jordan, K., The Virtual Manipulatives Research Group at Utah State University. (2014, April). *Young children's learning performance and efficiency when using virtual manipulative mathematics iPad apps.* Paper presented at the annual National Council of Teachers of Mathematics Research Conference (NCTM-R), New Orleans, Louisiana.

Accepted with Revisions

Moyer-Packenham, P.S., Litster, K., **Bullock, E.**, Shumway, J.F. (under review, 2017). *Using Video Analysis to Explain How Virtual Manipulative App Alignment Affects Children's Mathematics Performance and Efficiency. TSG 41 monograph.* Unpublished manuscript.

Revise and Resubmit

Bartholomew, S., Nadelson, L.S., **Bullock, E.P.** (revise and resubmit, 2017). *A Route Less Traveled: Principals' Perceptions of Alternative Licensed CTE Teachers. Career and Technical Education Research.* Unpublished manuscript.

In Progress

Bullock, E. P. (in progress). *Teaching the Teachers: An International Literature Review on Effective Professional Development in Mathematical Discourse Through the Lens of Complexity Theory*. Unpublished manuscript.

UNIVERSITY TEACHING

Utah State University, Logan, Utah (2013-present)
College of Education and Human Services

Course Taught-Utah State University
TEAL 6523/TEPD 5523—Mathematics for Teaching K-8: Algebraic Reasoning Graduate Course. Provides practicing teachers with a deeper understanding of algebraic expressions, equations, functions, real numbers and instructional strategies to facilitate the instruction of this content for elementary students.

TEAL 6524/TEPD 5524/EMTH 5060—Mathematics for Teaching K-8: Geometry & Measurement Graduate Course. Provides practicing teachers with an in-depth understanding of measurement and geometry content correlated with the state core curriculum, and instructional strategies that facilitate the teaching of this content. Blended Format.

ELED 4060—Teaching Mathematics and Practicum Level III
Undergraduate Course. Relevant mathematics instruction in the elementary and middle-level curriculum; methods of instruction, evaluation, remediation, and enrichment. Included the six-week supervision of Level III practicum students in participating public school settings. Traditional Format.

CURRICULUM DEVELOPMENT

Utah State University, Logan, Utah (2013-present)
Elementary Mathematics Teacher Academy - Developed course materials for master's level courses for Utah State University's Elementary Mathematics Teacher Academy (EMTA). Course designed to develop teachers' mathematical knowledge for teaching aligned with the Common Core State Standards for Mathematics. Materials developed included readings, video lectures, application assignments, and assessments for online course delivery. Developed the following fourth-grade curriculum modules (with more in progress regarding mathematical practices):

4.G.A.1 Drawing Points, Lines, and Angles and Identifying Them in Two-Dimensional Figures (2015)
4.G.A.2 Classifying Two-Dimensional Figures (2015)
4.G.A.3 Lines of Symmetry (2015)
4.G.Big Idea Classifying Properties of Objects: Conjecturing, Solving, Explaining, and Proving (2015)

4.OA.Big Idea Arithmetic as a Context for Algebraic Thinking (2014)

TEAL 6523/TEPD 5523/EMTH 5050—Mathematics for Teaching K-8: Algebraic Reasoning (2016)
Taught the course in a blended interactive broadcast hybrid format, used feedback to create completely online course containing 9 modules which include video presentations, slides, readings, learning activities, solutions to worked out problems, discussions, homework help and assessments. Available now through Utah State University's Elementary Mathematics Teacher Academy (EMTA) as an online course every term.

TEAL 6524/TEPD 5524/EMTH 5060—Mathematics for Teaching K-8: Geometry & Measurement (2015)
Taught the course in a blended interactive broadcast hybrid format, used feedback to create completely online course containing 9 modules which include video presentations, slides, readings, learning activities, solutions to worked out problems, discussions, homework help and assessments. Available now through Utah State University's Elementary Mathematics Teacher Academy (EMTA) as an online course every term.

PAID CONSULTANCY

Greenwood Charter School, Harrisville, Utah (2015-2018)

Providing professional development services in K-6 elementary mathematics education for Greenwood charter comprising 22 K-6 teachers. Professional development includes mathematics content knowledge and pedagogical content knowledge in the areas of numbers & operations, rational numbers & proportional reasoning, and geometry and measurement. In addition, the project includes professional development in action research, lesson study, and support for teacher lead publications and local, state, and national conference presentations.

Western Governors University, Salt Lake City, Utah (2013-2014)
Online Teachers College

Supervised administrative intern, Lisa Panek, as part of her Educational Leadership endorsement program.

GRANTS FUNDED

(Over *$155,000 Dollars in Total Grant Funding*)

Sherrie Reynolds Scholarship Award (Chaos and Complexity Theory SIG) ($500). *Best Graduate Student Paper Presentation.* (2017) American Educational Research Association (AERA)

Travel Grant, School of Teacher Education and Leadership (TEAL) ($800). *Presentations and Leadership Role at 101st American Educational Research Association (AERA) Conference.* (2017) Utah State University.

Graduate Student Travel Award, Office of Research and Graduate Studies ($300). *Presentations and Leadership Role at 101st American Educational Research Association (AERA) Conference.* (2017) Utah State University.

Frederick Q. Lawson Fellowship Award ($9000). *Emma Eccles Jones College of Education and Human Services.* (2016-2017). Utah State University.

School of Graduate Studies Dissertation Fellowship Award ($5000). *Dissertation Funding.* (2016-2017). Utah State University.

Graduate Student Senate Enhancement Award ($4000). *Utah State University Student Association (USUSA).* (2016-2017). Utah State University.

Graduate Research and Creative Opportunities (GRCO) Grant ($1000). *Utah State University Student Association (USUSA) Dissertation Funding.* (2016). Utah State University.

Graduate Research Assistant ($68,000). *Captivated! Young Children's Learning Interactions with iPad Mathematics Apps.* (2013-2017). Utah State University. Project Goal: build theory and knowledge about the nature of young children's ways of thinking and interacting with virtual manipulatives using touch-screen mathematics apps on the ipad. My role: code video observations of participant actions and find emerging themes. (with Principal Investigator Patricia Moyer-Packenham, Co-PI Cathy Maahs-Fladung, and the Virtual Manipulatives Research Group).

Division A Senior Graduate Representative (AERA) ($1600). *AERA 2017 Annual Meeting and Central Committee Meeting Travel Funding Stipend.* (2016-17) American Educational Research Association (AERA).

Division A Junior Graduate Representative (AERA) ($800). *AERA 2016 Annual Meeting Travel Funding Stipend.* (2015-16) American Educational Research Association (AERA).

Travel Grant, School of Teacher Education and Leadership (TEAL) ($700). *Presentation at 12th Annual Hawaii International Conference of Education (HICE).* (2014) Utah State University.

Research Travel Grant, Center for Women and Gender ($500). *Presentation at 12th Annual Hawaii International Conference of Education (HICE).* (2014) Utah State University.

Lead Writer. ($49,450). *Blue Sky Funding Award Mountainville Academy Solar Project.* (2012-2013). Rocky Mountain Power. Project goal: community-based renewable energy project. This funds the installation of solar panels at Mountainville Academy.

Co-Writer ($13,500). *Technology in the Classroom Initiative.* (2012). Daniel's Fund. Project goal: Provide SMARTboard technology to seven middle school classrooms at Mountainville Academy. (with co-writer - Becky Garzella, Grants and Donations Parent Volunteer)

Co-Writer ($2,900). *Storytelling Festival Initiative* (2012). Ashton Foundation. Project goal: Instigate a cross-curriculum storytelling program. In conjunction with money from the parent organization, the grant will help provide textbooks, a storytelling library, and interaction with professional storytellers from the Timpanogos Storytelling Festival. (with co-writer - Becky Garzella, Grants and Donations Parent Volunteer).

PRESENTATIONS

Invited Addresses

Bullock, E. P. (2016, April). *Discussant: Mathematics and Technology-Based Learning Environments.* Paper Session, American Educational Research Association (AERA) Annual Meeting, Washington, D.C.

International Presentations-Scholarship

Bullock, E. P. (2016, July). *Preliminary Results of an Explanatory Sequential Mixed Methods Study of the School Leader's Role in Students' Mathematics Achievement Through the Lens of Chaos and Complexity Theory.* 25th Annual International Society for Chaos Theory in Psychology & Life Sciences (SCTPLS), Salt Lake City, Utah.

Moyer-Packenham, P. S., Shumway, J. F., **Bullock, E.**, Anderson-Pence, K., Tucker, S. I., Westenskow, A., Boyer-Thurgood, J., Gulkilik H., Watts, C. M., & Jordan, K., The Virtual Manipulatives Research Group at Utah State University. (2016, July). *Using Virtual Manipulatives on IPads to Promote Young Children's Mathematics Learning.* 13th International Congress on Mathematical Education (ICME), Hamburg, Germany.

Moyer-Packenham, P.S., **Bullock, E.**, Watts, C., Tucker, S. I., Shumway, J. F., Anderson-Pence, K. L., Westenskow, A., Boyer-Thurgood, J., Gulkilik, H. Jordan, K., (2015, April), *The Relationship Between Affordances od Virtual Manipulatives Mathematics Apps and Young Children's Learning Performance and Efficiency.* Paper Presentation, International Conference on Education in Mathematics, Science, & Technology, Anatalya, Turkey.

Bullock, E. P., Moyer-Packenham, P. S., Shumway, J. F., MacDonald, B., Watts, C. (2015, March). *Effective teaching with technology: Managing affordances in iPad apps to promote young children's mathematics learning*. Paper Presentation, Society for Information Technology and Teacher Education International Conference 2015, Las Vegas, Nevada.

Moyer-Packenham, P. S., Westenskow, A., Shumway, J. F., **Bullock, E**., Tucker, S. I., Anderson-Pence, K. L., Boyer-Thurgood, J., Maahs-Fladung, C., Symanzik, J., Mahamane, S., MacDonald, B., & Jordan, K., The Virtual Manipulatives Research Group at Utah State University. (2014, September). *The Effects of Different Virtual Manipulatives for Second Graders' Mathematics Learning and Efficiency in the Touch-Screen Environment.* Paper Presentation, 12th International Conference of the Mathematics Education into the 21st Century Project, Herceg Novi, Montenegro.

Moyer-Packenham, P. S., Shumway, J., Westenskow, A., Tucker, S., Anderson, K., Boyer-Thurgood, J., & **Bullock, E**. (2014, January). *Young Children's Mathematics Interactions with Virtual Manipulatives on iPads*. Research Presentation, 12thAnnual Hawaii International Conference on Education (HICE), Honolulu, Hawaii.

Tucker, S. I., Moyer-Packenham, P. S., Boyer-Thurgood, J. M., Anderson, K. L., Shumway, J., Westenskow, A., & **Bullock, E**. (2014, January). *The Nexus of Mathematics, Strategy, and Technology in Second-Graders' Interactions with an iPad-Based Virtual Manipulative*. Paper Session, 12th Annual Hawaii International Conference on Education (HICE), Honolulu, Hawaii.

Boyer-Thurgood, J., Moyer-Packenham, P. S., Shumway, J., Westenskow, A., Tucker, S., Anderson, K., & **Bullock, E**. (2014, January). *Kindergartener's Strategy Development during Combining Tasks on the iPad*. Research Presentation, 12thAnnual Hawaii International Conference on Education (HICE), Honolulu, Hawaii.

National Presentations-Scholarship

Moyer-Packenham, P. S., **Bullock, E. P.**, Shumway, J. S. (2017, April). *The Impact of Technology Affordances in Children's Mathematical Learning*. Paper Presentation—Paper Session: Achieving the Promise in Digital Leadership. National Council of Teachers of Mathematics (NCTM) Research Conference and Annual Meeting, San Antonio, TX

Bullock, E. P. (2016, November). *The School Leaders' Role in Students' Mathematics Achievement Through the Lens of Complexity Theory*. Paper Presentation. 30th Annual University Council for Educational Administration (UCEA) Convention, Detroit, Michigan.

Bullock, E. P. (2016, November). *GSS The School Leaders' Role in Students' Mathematics Achievement Through the Lens of Complexity Theory*. Graduate Student Paper Presentation. 30th Annual University Council for Educational Administration (UCEA) Convention, Detroit, Michigan.

Moyer-Packenham, P. S., **Bullock, E.**, Shumway, J. F., Tucker, S. I., Watts, C. M., Westenskow, A., Anderson-Pence, K., Maahs-Fladung, C., Boyer-Thurgood, J., Gulkilik H., & Jordan, K., The Virtual Manipulatives Research Group at Utah State University. (2016, April). *Using Virtual Manipulatives on iPads to Promote Young Children's Mathematics Learning.* American Educational Research Association (AERA) Annual Meeting, Washington, D.C.

Bullock, E. P. (2015, Nov.). *Growing Teachers' Mathematics Pedagogical Content Knowledge Through the Expectation of Action Research in the Classroom,* Graduate Student Abstract Exchange Round Table Session, Graduate Student Summit, University Council for Educational Administration (UCEA), San Diego, CA

Moyer-Packenham, P. S., Shumway, J. F., **Bullock, E.**, Tucker, S. I., Anderson-Pence, K., Westenskow, A., Boyer-Thurgood, J., Maahs-Fladung, C., Symanzik, J., Mahamane, S., MacDonald, B., & Jordan, K., The Virtual Manipulatives Research Group at Utah State University. (2014, April). *Young children's learning performance and efficiency when using virtual manipulative mathematics iPad apps.* Paper presented at the annual National Council of Teachers of Mathematics Research Conference (NCTM), New Orleans, Louisiana.

Moyer-Packenham, P. S., Shumway, J., Tucker, S., Boyer-Thurgood, J., Hunt, J., & **Bullock, E**. (2014, April). *Children's Mathematics Interactions with Virtual Manipulatives on iPads.* Paper Presentation, National Council of Teachers of Mathematics (NCTM) Research Conference, New Orleans, Louisiana.

State & Regional Presentations

Bullock, E.P. (2016, November). *Addressing the Standards Equitably in a Multi-Grade Expeditionary Setting.* Workshop Presentation. The Utah Council of Teachers of Mathematics (UCTM) Annual Conference, Salt Lake City area, Utah.

Bullock, E. P. (2016, June). *Effective Teaching with Technology: Managing Affordances in IPad Apps to Promote Young Children's Mathematics Learning.* 10th Annual Utah Association of Public Charter Schools (UAPCS) Conference, Layton, Utah.

Bullock, E.P. (2016, June). *Teaching Algebraic Reasoning Through the Criteria for Representation-Based Proof.* 10th Annual Utah Association of Public Charter Schools (UAPCS) Conference, Layton, Utah.

Bullock, E.P & Kidd, J. (2015, Nov.). *A Model of Principles to Actions: Growing GreenWood Teachers' Mathematics Pedagogical Content Knowledge Through Action Research—Results so Far,* Workshop Presentation, Utah Council of Teachers of Mathematics Annual State Conference (UCTM), Lehi, Utah.

Bullock, E.P. and Kidd, J. (2015, June). *Growing GreenWood Elementary Teachers' Mathematics Pedagogical Content Knowledge Through Saxon Math and Action Research in the Classroom,* Workshop Presentation, Utah Association of Public Charter Schools (UAPCS) Annual Conference, Provo, Utah.

Bullock, E., (2014, November) *Orchestrating Whole Class Discourse as Part of a Problem-Solving Intervention Group in a 5th grade Classroom: One Practitioner/Researcher's Experience*. Workshop Presentation, Utah Council of Teachers of Mathematics Annual State Conference (UCTM), Layton, Utah.

Bullock, E., (2014, November) *Subitizing and Counting: Foundations for Pattern Building and Algebraic Reasoning.* Workshop Presentation, Utah Council of Teachers of Mathematics Annual State Conference (UCTM), Layton, Utah.

Bullock, E.P. (2014, June). *Don't Throw the Baby Out with the Bath Water: A School Leader's Guide to Developing Elementary Teachers' Mathematics Capacity and Pedagogy to Meet the Needs of the CCSSM*, Workshop Presentation, Utah Association of Public Charter Schools (UAPCS) Annual State Conference, Layton, Utah.

Bullock, E.P., Spencer, B., Ashby, J., Myers, K, & Manderino, K. (2014, June). *Saxon Math in the Middle Grades: A Content Analysis,* Workshop Presentation, Utah Association of the Public Charter Schools (UAPCS) Annual State Conference, Layton, Utah.

Bullock, E.P. (2012). *Saxon Math and the Common Core,* Workshop Presentation, Utah Association of Public Charter Schools (UAPCS) Annual State Conference, Sandy, Utah.

Bullock, E.P. and Fountaine, C. (2008, June). *Ability Grouping: The Good, the Bad, and the Ugly: Mathematics Ability Grouping at Mountainville Academy: A Case Study,* Workshop Presentation, Utah Association of Public Charter Schools (UAPCS) Annual State Conference, Provo, Utah.

Professional Presentation

Presenter, (2012, June), *Why Do You Want To Be a Charter School Principal?* Principal's Candidate Seminar, USOE, Provo, Utah.

Professional Presentations - Panels

Panelist, (2016, September). *Welcome to AERA Division A: Who We Are, What We Do, And How to Get Involved*. Connect Series Panel, Online, Live Interactive Broadcast, Division A, American Educational Research Association (AERA).

La Londe, P. G., **Bullock, E.** (2016, April). *Division A Fireside Chat—Politics and Power in Community Policing and Community Schooling.* Co-chair Panel Presentation Special Session, American Educational Research Association (AERA) Annual Meeting, Washington, D.C.

Rivera, M. D., DeMartino, L., La Londe, P. G. & **Bullock, E.P.** (2015, Nov.). *AERA Division A & L Graduate Student Breakfast: Publish and "Live": Taking the Fear out of Publishing,* Co-chair Panel Presentation Special Session, University Council for Educational Administration (UCEA), San Diego, CA.

Panelist, (2015, November), *What Are Utah Charter Schools?* Utah State University Charter School Panel, USU, Logan, Utah.

Panelist, (2015, October), *Sharing PhD Experiences* Division A. Connect Series Panel, Online, Live Interactive Broadcast, Division A, American Educational Research Association (AERA).

Panelist, (2015, July), *What Are Utah Charter Schools?* Utah State University Charter School Panel, USU, Logan, Utah.

Panelist, (2010, May). *Principal Training Panel*. Brown Bag Panel Discussion, USOE, Salt Lake City, Utah.

National Presentations-Scholarship (Pending)

Bullock, E. P. (2017, April). *The School Leaders' Role in Students' Mathematics Achievement Through the Lens of Complexity Theory.* Roundtable Paper Presentation—Roundtable Session: Teaching, Learning and Educational Leadership from a Complexity Perspective. American Educational Research Association (AERA) Annual Meeting, San Antonio, TX.

Moyer-Packenham, P. S., **Bullock, E. P.**, Shumway, J. S., Tucker, S. I., Watts, C. M., Westenskow, A., Anderson-Pence, K. L., Boyer-Thurgood, J. Jordan, K. (2017, April). *Affordances of Virtual Manipulative Math Apps: How They Help and Hinder Young Children's Learning*. Paper Presentation. American Educational Research Association (AERA) Annual Meeting, San Antonio, TX

Watts, C., Moyer-Packenham, P.S., Tucker, S.I., **Bullock, E.P.**, Shumway, J.F., Westenskow, A., Boyer-Thurgood, J., Anderson-Pence, K., Mahamane, S., Jordan, K. (2017, April). *Learning Progression Shifts: How Touch-Screen Virtual Manipulative Mathematics App Design Promotes Children's Productive Struggle.* Poster Presenttion—Poster Session: Expanding the Scope of Learning with Innovative Technologies. American Educational Research Association (AERA) Annual Meeting, San Antonio, TX.

Bullock, E. P. (2017, April). *Chair: Leadership in High-Poverty Schools.* Roundtable Session. American Educational Research Association (AERA) Annual Meeting, Washington, D.C.

Professional Presentations - Panels (Pending)

Bullock, E., Sun, W.L. (2017, April). *Division A Fireside Chat— STEM Education and School Leadership: Equitably Accessing the Playing Field.* Co-chair Panel Presentation Special Session, American Educational Research Association (AERA) Annual Meeting, San Antonio, TX.

Panelist, (2017, April). *Graduate Student Orientation: Navigating AERA's Multiple Offerings*. Invited Speaker Session. American Educational Research Association (AERA) Annual Meeting, San Antonio, TX.

SOFTWARE SKILLS

Proficient in the following mathematics/statistical analysis software/code:

- SPSS
- NVIVO
- MatLab
- LaTek
- Wolfram Mathematica
- Geometer's SketchPad
- R

STATE SERVICE—LEADERSHIP ACTIVITIES

Board Trustee (2014-present) — *Thomas Edison Charter Schools—North and South Campus. (Academic Achievement Committee)* Help oversee the fidelity of charter implementation, ensure fiscal responsibly, practice sound governance, and ensure adherence to laws and charter requirements regarding employees, students, and the school environment. Protect the public's interests and ensure that the schools are organizationally stable. Chair: Academic Excellence Committee

Committee Member (2013-2014) — *Utah State Office of Education Policy Advisory Committee on Assessment.* Represent Utah Public Charter Schools at state meetings. Collaborate with traditional public school representatives, state office representatives, and political representatives in the development and implementation of state-wide assessment systems. Meet monthly, or as needed to advise on state standardized assessment needs and/or changes.

Professional Affiliations & Leadership Roles

AMERICAN EDUCATIONAL RESEARCH ASSOCIATION (AERA)

- Division A Senior Graduate Representative/AERA Graduate Student Council Member (2016-2017) Responsibilities include: Collaborating with the Division A Graduate Student Committee to strengthen and broaden the graduate school experience for Division A students by disseminating information about annual AERA and UCEA conference sessions, inviting participation in the Connect Series webinars, and informing of various scholarships and awards through the AERA Graduate Student listserv and social media outlets. AERA Division A conference sessions and the Connect Series are planned to help fellow graduate students navigate academic life, to provide opportunities for networking with fellow graduate students, faculty, and practitioners in the field, and to offer guidance in transitioning from graduate student life to careers as professional scholars and researchers.
- Division A Junior Graduate Representative (2015-2016)
- Division C Learning and Instruction
- Division K Teaching and Teacher Education
- Division L Educational Policy and Politics
- SIG Chaos and Complexity Theory
- SIG Research in Mathematics Education
- SIG Charters and School Choice
- SIG Leadership for School Improvement
- SIG Mixed Methods
- SIG Professional Development
- SIG Supervision and Leadership
- Member (2014-present)

SOCIETY FOR CHAOS THEORY IN PSYCHOLOGY & LIFE SCIENCES (SCTPLS)
- Member (2016-present)

NATIONAL COUNCIL OF TEACHERS OF MATHEMATICS (NCTM)
- Member (2001-present)

UTAH COUNCIL OF TEACHERS OF MATHEMATICS (UCTM)
- Member (2009-present)

UTAH ASSOCIATION OF PUBLIC CHARTER SCHOOLS (UAPCS)
- Member (2009-present)

SOCIETY FOR INFORMATION TECHNOLOGY AND TEACHER EDUCATION (SITE)
- Member (2015-present)