Mathematic Achievement of Youth in Juvenile Facilities

By

Carolyn Q. Mason

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Approved:

Joseph H. Wehby, Ph.D.

Lynn S, Fuchs, Ph.D.

Blair P. Lloyd, Ph.D.

Andrea M. Capizzi, Ph.D.

Jade Wexler, Ph.D.

This dissertation is dedicated to my husband David, our three children, Maddie, Marina, and Jessa, who each did their part to make this happen, and to each child who agreed to participate in this study.

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Abstract

Youth in correctional facilities often exhibit low mathematical achievement, which may threaten their future independence. In order to build math literacy among youth in correctional facilities, facility instructors need access to timely and informative mathematical assessment (Grigorenko et al., 2013; Hart et al, 2012). Researchers also need data on the math achievement of youth in correctional facilities in order to support math intervention research. To date, no peer-reviewed research has reported on the specific math achievement deficits of youth in juvenile corrections in a way that could be used to inform instruction. The purpose of this descriptive study was to measure and report the comprehensive math achievement of youth in short- and long-term juvenile justice facilities overall and by demographic characteristics. For all youth participants, the assessment battery included two standardized measures of math achievement, one broad and one specific to skills that support algebra, and an assessment of math achievement related to algebra readiness. Math achievement was also measured by student acquisition of Algebra I credit. Study findings indicated that in long- and short-term facilities, youth demonstrated standardized math achievement deficits, and youth with disabilities and African American youth scored lower on individual measures of standardized achievement than their nondisabled, White peers. In regression analyses controlling for race, it was found that race did not significantly contribute to the variance student math scores, although special education status did, as did Algebra I completion. Overall, youth demonstrated a high rate of Algebra I completion, although this outcome varied according to special education status and setting type. Implications for policymakers, research, and practice are discussed.

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Chapter I

INTRODUCTION

Youth leaving long-term juvenile facilities are unlikely to return to school post-release and are unlikely to complete a General Equivalency Diploma (GED) program. Haberman and Quinn (1986) reported that more than half of a sample of 759 youth, aged 14 to 17 years, released from long-term custody in Wisconsin, neither returned to school nor completed a GED program in the three years following the incarceration period. In another study, over two-thirds of youth leaving formal custody did not return to school (Roy-Stevens, 2004). According to data from Florida State University's Juvenile Justice Educational Enhancement Program, approximately 58% of Florida high school students aged 16 or older enrolled in juvenile justice programs were, on average, at least six academic credits behind (i.e., a full school year) at program entry. Of these youth, 79% did not return to school following their release (The Florida Legislature Office of Program Policy Analysis and Accountability [OPPAA], 2010).

These outcomes are not surprising given the literature on the population's academic deficits demonstrated prior to and during confinement. Within juvenile facilities, rates of academic deficiency are often pronounced (Foley, 2001). In a study of 555 committed and detained youth with an average age of 16 years 4 months, Krezmien, Mulcahy, and Leone (2008) reported that standardized achievement scores in reading and math were about four years behind their expected performance. Among their sample of committed youth, Haberman and Quinn (1986) described average math achievement on the fifth grade level. Given the low estimates of academic achievement, it is not surprising that special education rates among youth in juvenile justice facilities range from 30% to 70% of the total population (Foley, 2001; Beebe & Mueller, 1993; Leone, Meisel, & Drakeford, 2002). This research highlights a critical issue affecting adjudicated youth in and out of corrections and provides an understanding of the challenges facing youth transitioning from corrections and back to their communities (Haberman & Quinn, 1986; Keeley, 2006).

Academic Rehabilitation

Research suggests that boosting the academic achievement of youth committed to juvenile facilities may improve post-release outcomes, specifically related to recidivism, school re-entry, and diploma completion. Hoffmann, Lance, and Spence (2013) provided evidence that academic improvement was associated with less delinquent behavior over time. In a study of 1,717 males, aged 16-21, released from Texas juvenile facilities, Jeffords and McNitt (1993) reported that recidivism rates among youth who earned a GED while committed were significantly lower than those who did not. Further, Blomberg, Bales, and Piquero (2012) reported that youth who earned more academic credits while committed were more likely to attend school after release, and attendance in school resulted in youth being less likely to be rearrested within two years of release. This suggests that achievement within a facility, return to school, and consistent school attendance following release were positively associated with one another and these factors were negatively related to recidivism.

Mathematics Achievement

While it is well established that youth detained or committed to correctional facilities exhibit low levels of reading achievement on average (Foley, 2001; Leone et al., 2002), and that improving literacy among detained and committed youth may be good for society, it is not their only academic challenge. While reading is critical to the academic success of detained youth, mathematics is as critical to re-entry and success at the high school level and in the workforce.

Mathematics literacy (i.e., successful completion of curricula generally including algebra and geometry) is required for high school graduation in most states (Center for Public Education, 2013), and GED requirements are similar (GED Testing Service, 2014). Math literacy is increasingly essential to compete in the workforce, and inadequate math skills may contribute to poor earning outcomes post-school (Mathematical Sciences Education Board, 1995).

According to data from the National Longitudinal Survey of Youth (2012), high school math content courses are associated with securing employment and average earnings, and these trends exist even for youth that have dropped out of high school. The median wage for full-time workers aged 20-30, who dropped out of high school after completing Algebra I or less in high school was $12.70 per hour, with an unemployment rate of 33%. In contrast, dropouts with Geometry or Algebra II had a median wage of $14.36 and an unemployment rate of 27% (James, 2013). Thus, mathematic skill building in facilities is of critical importance.

While youth in correctional facilities are often behind in math knowledge and credits, facility instructors may not be aware of these deficits. Teachers in juvenile facilities often wait weeks for educational records to arrive (Macomber et al., 2010). These delays impact subsequent instruction, either costing valuable instructional time on assessments delivered at facility entry, or push a student into content for which youth are not prepared.

Literature Review of the Mathematical Achievement of Committed Youth

In order to understand the mathematical needs of detained and committed youth, it was first necessary to explore the literature to determine what it is already known about the math achievement deficits experienced by these youth. Therefore, a systematic review of the literature on math and adjudicated youth was conducted. To be included in this review, studies must have collected standardized mathematical achievement scores from youth in short- or long-term juvenile corrections. Youth committed in *long-term facilities* are typically serving out sentences in excess of four months. These youth are often referred to as committed or incarcerated in the literature. Throughout this paper, these youth are described as committed. Youth detained to *short-term facilities* are generally considered to be in detention. These youth may be held for a period as short as a day or as long as several months (awaiting trial, further placement, serving a short-term punishment) although the average length of stay is about 15 days (Snyder & Sickmund, 2006).

Studies that examined the academic achievement of a subsample of a larger population (e.g., sex offenders) were excluded from this review, as these studies would not likely provide results generalizable to the larger population of committed youth. Studies that examined a subsample along with a larger sample of detained or committed youth were included. Studies that provided data on recidivating youth, youth that had not recidivated, and youth with and without disabilities were included if data on both groups were provided.

Search. Three electronic searches were conducted using the PsycINFO, ERIC, and ProQuest Criminal Justice, Education, Psychology, Social Science and Sociology databases to search for peer-reviewed journal articles published through September 5, 2014. These searches used combinations of the terms *juvenile justice, juvenile delinquency, juvenile offenders, juvenile corrections, incarcerated youth, youth in corrections, detained juveniles, committed juveniles, psychological assessment, academic aptitude, cognitive assessment, academic achievement, and math**, yielding 414 studies, of which ten studies were identified as meeting inclusion for this review. Next, we searched the reference lists of identified studies and relevant literature reviews, yielding five additional studies. Finally, forward and backward searching identified three additional studies for inclusion. After removing studies that did not meet inclusion criteria, 18 studies were identified to be included in the present review.

Initial Literature Summary

To frame an understanding of what we can learn about the mathematical achievement of youth in corrections from the peer-reviewed literature, this review is divided into three sections: a) the purpose of each study, b) the reported mathematical achievement, and c) a review of the findings.

Study Purposes, Settings and Youth Characteristics

Study purposes. A review of the purposes and rationales of included studies provides a frame for understanding the diversity of methods for data collection and data analysis.

Recidivism. In all, six of the included studies addressed youth recidivism, and five of the studies involved affiliated research groups. Katsiyannis and Archwamety (1997) and Archwamety and Katsiyannis (1998) examined youth factors associated with recidivism among committed male and female samples, respectively. Similarly, Katsiyannis and Archwamety (1999) explored the association between recidivism and achievement, including the contribution of GED scores and academic improvement. Archwamety and Katsiyannis (2000) investigated factors associated with recidivism or parole violation, while Katsiyannis et al. (2004) expanded to include the relative contribution of alcohol abuse, depression, level of parental attachment, and personality traits to recidivism outcomes. Finally, McMackin et al. (2005) examined the relation between academic achievement and recidivism, educational outcomes, and escape.

Student-level correlates of academic achievement. Juvenile delinquency and youth commitment to juvenile facilities are complex issues with many potential associations to individual, family, and community characteristics. Authors of eight studies examined how academic achievement of youth in corrections correlated with student characteristics, including racial background (Baltodano et al., 2005; Lansing et al., 2014; Rincker et al., 1990), offense history (Beebe & Mueller, 1993), mental health (Krezmien et al., 2008), intellectual functioning (Oudekerk et al., 2013; Rincker et al., 1990), gender (Lansing et al., 2014; Rincker et al., 1990), special education status (Baltodano et al., 2005; Krezmien et al., 2008; Zabel & Nigro, 2001), and youth risk and protective factors (Oudekerk et al., 2013).

***Disability or trial competence prevalence studies*.** Two studies provided descriptive data in order to better understand the prevalence of youth in correctional custody who were incompetent to stand trial (Ficke et al., 2006) or who demonstrated learning disability (Grigorenko et al., 2013). The inclusion of mathematical achievement data in these studies indicates the potential contribution of math achievement to overall juvenile functioning.

Measurement validation. Ollendick et al. (1975) and Marshall et al. (1978) both attempted to establish the validity of specific test measures. These studies focused on the assessment rather than the achievement of youth in corrections, but since they included mathematical achievement data, these studies were relevant to this review.

***Summary of purposes*.** While the studies presented above indicated a wide variety of research purposes, all but two (validity studies; Ollendick et al., 1975; Marshall et al., 1978) presented a rationale for research focused on improving programs for youth in corrections. The authors also sought to increase the focus on groups underrepresented in the research, and noted the dearth of research related to the academic needs or functioning of juveniles as a whole (e.g., Baltodano et al., 2005; Grigorenko et al., 2013; Lansing et al., 2014; McMackin et al., 2005) or among subgroups of juveniles in facilities, like girls (Archwamety & Katsiyannis, 1998; Oudekerk et al., 2013).

Study settings. This review included studies conducted in either long-term or short-term juvenile detention settings. While some authors did not identify the type of facility in which they gathered data, the authors generally did refer to the setting as either a facility of detention or of incarceration/ commitment. Incarceration or commitment implies longer-term placements (Krezmien et al., 2008), while detention is considered short-term confinement (Snyder & Sickmund, 2006).

Long-term facilities. In all, 11 of the reviewed studies included math achievement data of youth committed to long-term facilities (Archwamety & Katsiyannis, 1998; 2000; Baltodano et al., 2005; Katsiyannis & Archwamety, 1997; 1999 Katsiyannis et al., 2004; McMackin et al., 2005; Ollendick et al., 1975; Oudekerk et al., 2013; Perkins et al., 2014). This number includes Krezmien et al. (2008), who reported data from both long- and short-term facilities.

Short-term facilities. The remaining seven studies took place in detention centers (Beebe & Mueller; 1993; Ficke et al., 2006; Grigorenko et al., 2013; Lansing et al., 2014; Rincker et al., 1990; Zabel & Nigro, 2001). Again, Krezmien et al. (2008) reported data from both long and short-term settings. Of the studies reviewed, only Marshall et al. (1978) provided inadequate information to determine the type of facility that served as the research setting, indicating only that it was a “public agency with residential care facilities” (p. 408), where the youth were held for six to ten weeks. Because the described length of stay was under two months, for purposes of this paper, it was considered a short-term setting.

Study setting summary. While studies examining the academic achievement of youth in either type of facility generally reported lower than average academic skills, only Krezmien et al. (2008) compared samples from both long- and short-term placements in order to explore differences between the two groups. Krezmien and colleagues reported that the two groups did not differ in terms of achievement or intellectual functioning. This finding indicates that both groups face shared academic challenges.

Youth characteristics.

Race or ethnicity. According to the Office of Juvenile Justice and settings in 2011, 32% were white, 40% were African American, 23% were Hispanic, 2% were American Indian, and 1% was Asian. Of the 18 studies included in this review, four provided no racial demographic information (Beebe & Mueller, 1993; Marshall et al., 1978; Ollendick et al., 1975; Zabel & Nigro, 2001), and three more included the percentage of African-American and White students, but not Hispanic youth (Ficke et al., 2006; Oudekerk et al., 2013; Perkins et al., 2014).

Among the 14 studies (comprising 6,343 youth) that reported any racial demographic information, 40.62% were African American and 33.63% were White. Hispanic youth made up an overall 23.01% of 11 studies reporting Hispanic ethnicity (combined n = 5,840). These data map closely onto national statistics, but unfortunately do not allow for conclusions about the population given the heterogeneity of the samples by facility type, gender, and geography. Indeed, these overall numbers mask several non-representative samples that were either majority White (Archwamety & Katsiyannis, 1998; 2000; Katsiyannis & Archwamety, 1997; 1999; Katsiyannis et al., 2004) or majority African American (Krezmien, et al., 2008; Lansing et al. 2014). Additionally, two studies (Grigorenko et al., 2013; Baltodano et al., 2005) reported larger than expected proportions of Hispanic youth. Baltodano et al. (2005) and Katsyannis et al. (2004) both indicated that the region may have influenced sample demographics, while Krezmien and colleagues indicated that their sample might have been influenced by setting type, as committed youth were significantly more likely to be African American than detained youth.

Gender. According to OJJDP (2014), almost eight times as many males as females were held in correctional custody in 201. Of the included studies, only McMackin et al. (2005) did not report sample gender. The remaining 17 studies, which were conducted in both mixed-gender and single-sex facilities, reported a combined 21.02% female participants, a higher proportion of females than the national detained and committed youth population. Of the seven included mixed-gender studies (Beebe & Mueller, 1993; Ficke et al., 2006; Grigorenko et al., 2013; Lansing et al., 2014; Marshall et al., 1978; Rincker et al., 1990; Zabel & Nigro, 2001), all reported this larger than expected share of female participants, ranging from 16.3% (Beebe & Mueller, 1993) to 36.3% female (Marshall et al., 1978). Eight studies were conducted in all male facilities (Archwamety & Katsiyannis, 2000; Baltodano et al., 2005; Katsiyannis, & Archwamety, 1997; Katsiyannis & Archwamety, 1999; Katsiyannis et al., 2004; Krezmien et al., 2008; Ollendick et al., 1975; Perkins et al., 2014) and two in all female facilities (Archwamety & Katsiyannis, 1998; Oudekerk et al., 2013).

The two studies (Archwamety & Katsiyannis, 1998; Oudekerk et al., 2013) reporting female-only samples indicated a dearth of information regarding girls in juvenile justice, but overall, the studies included in this review indicated a focus on committed and detained girls that may slightly over-represent national statistics.

Special education status. A national survey of long-term youth correctional facilities conducted in 2005 reported an overall 33.4% rate of special education identification among committed juveniles (Quinn, Rutherford, Leone, Osher, & Poirier, 2005). Nine of the studies included in this review reported at least some information related to the special education status of their samples (Archwamety & Katsiyannis, 1998; Baltodano et al., 2005; Katsiyannis & Archwamety, 1997; Katsyannis et al., 2004; Krezmien et al., 2008; Oudekerk et al., 2013;

Perkins, et al, 2014; Rincker et al., 1990; Zabel & Nigro, 2001). Grigorenko et al. (2013) did not report special education status prior to correctional custody, but measured rates of learning disability (LD) within Connecticut detention facilities at 24.9% using a researcher-created screener and researcher-developed LD criteria. Because these youth were not identified in a means compliant with federal special education law (Individuals with Disabilities Education Act; IDEA, 2004), they were not included in the current review of special education status.

Overall, most of the studies reported special education identification rates higher than 40% (Katsiyannis & Archwamety, 1997; Oudekerk et al., 2013; Krezmien et al., 2008; Perkins et al., 2014; Rincker et al., 1990). Three studies described rates between 20% and 40% (Baltodano et al., 2005; Katsyannis et al., 2004; Zabel & Nigro, 2001), and only Archwamety and Katsiyannis (1998) reported a special education rate lower than 20%. The above average rates of special education identification may have been related to the inclusion of past and current special education identification, small sample sizes, increasing trends in disability prevalence, or improved systems of special education identification within schools and youth facilities. Additionally, since no national special education prevalence review exists for youth in short-term settings, the estimate provided by Quinn et al. (2005) may be of limited utility for estimating the generalizability of studies conducted in short-term settings.

Intellectual Assessment. Research indicates that youth in juvenile corrections score lower than their peers on measures of intellectual ability, although a broad range of scores, from below to above average, have been reported (Foley, 2001). Given the connection between intellectual functioning and academic achievement, it is not surprising that 13 of the included studies collected data related to the intellectual functioning of their samples, with most reporting low-average to average scores. The highest mean full-scale score of 96.49 on the Wechsler

Intelligence Test for Children, Revised (WISC-R; Wechsler, 1974) (Katsiyannis et al., 2004; no range or *SD* provided) to the lowest of 73.7 (*SD* = 14.1) on the Wechsler Intelligence Scale for Children (WISC-III; Wechsler, 1999) (ages 9 to 12; Ficke et al., 2006).

All of the studies that provided verbal and non-verbal intelligence scores indicated that youth in corrections scored four to nine points higher on measures of non-verbal ability than verbal ability (Archwamety & Katsiyannis, 1998; 2000; Katsiyannis & Archwamety, 1997; 1999; Lansing et al., 2014; Ollendick et al., 1975; Perkins et al., 2014; Rincker et al., 1990). Although the discrepancies between scores were not within the threshold of what Wechsler (1974) indicated was important, this consistent pattern does indicate that overall, the youth sampled in the included studies performed somewhat higher on measures that required perceptual organization and processing speed rather than in verbal reasoning.

Youth characteristics summary. Although several samples included in this review contained higher than expected rates of special education eligibility and larger proportions of females than is found in the population, several noteworthy themes emerged that warrant discussion. First, youth ethnicity reported in the included studies mirrored national patterns of minority overrepresentation in youth facilities overall, despite the fact that several studies reported higher than expected proportions of White students. Second, minority youth scored lower than non-minority youth on average intellectual functioning. Finally, across ethnicity, youth in corrections demonstrated greater non-verbal than verbal performance on measures of intellectual functioning. These patterns, although subject to limitations, are important and may require the further investigation by researchers and policy makers.

Mathematic Achievement

Overall, the study samples included in this review scored lower than their non-detained or committed peers on measures of mathematical achievement, but the degree of academic deficiency varied between studies. First, I review the mathematical achievement scores reported in the included studies. Researchers that relied on existing records to gather mathematic achievement data generally reported less information regarding the measure or assessment administration than researchers assessing achievement as a part of their studies. Because the scores reported by researchers using existing records were subject to issues with reliability, these studies are discussed together. Following this description of scores, I provide information regarding math achievement of youth samples by certain youth characteristics, including ethnicity, gender, age, and special education status in an effort to understand how particular subgroups of youth perform on measures of math achievement.

In all, ten of the 18 included studies reviewed records to obtain math achievement scores (Archwamety & Katsiyannis, 1998; 2000; Baltodano et al., 2005; Beebe & Mueller 1993; Katsiyannis & Archwamety, 1997; 1999; Katsiyannis et al., 2004; McMackin et al., 2005; Oudekerk et al., 2013; Rincker et al., 1990), while five studies assessed youth to collect math achievement scores (Ficke et al., 2006; Grigorenko et al., 2013; Lansing et al., 2014; Perkins et al., 2014; Zabel & Nigro, 2001). Krezmien et al. (2008) reported that data were collected from records, but also reported that researchers observed test procedures for fidelity. Finally, Marshall et al. (1978) and Ollendick et al. (1975) did not specify their methods of data collection.

Record review. Of the studies relying on record review, only Rincker et al. (1990) and Baltodano et al. (2005) provided information regarding assessment instruments. Rincker et al. noted that the measures used were “commonly used in the schools,” (p. 124), while Baltodano et al. described the subtests used for academic assessment and indicated that the measure was a "robust assessment tool" (p. 363). While these descriptions provide some clarity, specific information regarding the technical aspects of the measures would provide more confidence in the reported scores. Two of the studies provided no information regarding the academic measure used (Katsiyannis & Archwamety, 1997; Archwamety & Katsiyannis, 1998), and six more provided the name of the instrument with no explanation of the measure's technical aspects or use (Beebe & Mueller, 1993; Katsiyannis & Archwamety, 1999; Archwamety & Katsiyannis, 2000; Katsiyannis et al., 2004; McMackin et al., 1990; Oudekerk et al., 2013).

Math achievement scores. Of the ten studies that used record review to collect math achievement data, only Katsiyannis et al. (2004) reported standard scores (SS) in the average range. The remaining studies reported grade equivalent (GE) scores below youth expected age/ grade performance or SS below the mean on standardized measures (*M*=100; *SD*=15).

Archwamety and Katsiyannis (1998) indicated that a committed female sample achieved an overall SS of 87.2 (no *SD* reported) on an unnamed measure of math achievement at intake, and Katsiyannis and Archwamety (1997) reported that the males in their sample scored a GE 7.82 (no *SD* reported) on an unnamed measure of math achievement. The average age was 15 years, four months, putting them at least two grade levels behind expected age performance.

The youth in Katsiyannis and Archwamety's 1999 study scored an overall GE mean of 8.06 (no *SD*) on the WJ-ACH's Broad Math Cluster at intake. The authors also measured academic improvement during the incarceration period via WJ-ACH scores at post-test, at least four months following pre-test. On average, youth raised their Broad Math Cluster scores to a 9.0 GE (no *SD*), with the largest gains made in math achievement versus reading or writing. This finding indicates that youth in juvenile custody may be able to make significant gains during the commitment period.

In their 2000 study, Archwamety and Katsiyannis used the Peabody Individual Achievement Test (PIAT; Dunn & Markwardt, 1975; no subtest information reported) to measure GE achievement by group membership or non-membership in Title I remedial education (assigned by subject level performance below the 50th percentile in reading and math) and recidivism status. Across remedial and non-remedial groups, youth scored a mean GE of 7.34 (no *SD*) on PIAT mathematics achievement. In their 2004 study, Katsiyannis et al. reported an average WJ-III math achievement SS of 94.09 (no *SD* or subtest information provided), which was the closest among all the samples included in this review to a standardized mean of 100.

Baltodano and colleagues (2005) reported that 163 youth earned a mean SS of 89.11 (*SD* = 14.6) on the Math Calculation subtest and 86.94 (*SD* = 15.5) on the Math Fluency subtest of the WJ-III. The Math Calculation subtest measured untimed paper and pencil procedures, while the Math Fluency subtest assessed knowledge of math facts under timed conditions. Beebe and Mueller (1993) indicated that a variety of measures were used to collect math assessment information at intake, but that the most common achievement assessment was the *Wide Range Achievement Test* (WRAT; Jastack & Jastack, 1965). The mean math achievement SS was an 81.66 (*SD* not provided). Overall, Beebe and Mueller found that 98% of the 583 youth entering a Michigan detention center were behind grade level in math.

Rincker et al. (1990) examined the arithmetic computation of 70 youth entering detention in the Midwest via the Stanford Test of Academic Skills (STAS; Gardner & Callis, 1975), and reported a mean Arithmetic GE score of 4.7 (*SD*=1.1), however no specific subtests were provided. Rinker et al.'s sample was one of the youngest in the included studies, with a mean age of 14.7 years (range: 11-17 years). Despite the sample's youth however, Rincker et al.'s findings indicated that the sample was an average of five years below grade level in math achievement.

McMackin et al. (2005) reported achievement data collected from 144 youth at intake during the years 1978-1996. Overall, youth scored a GE 6.89 (*SD* = 2.7) on the Computational subtest of the California Achievement Test (CAT; Tiegs & Clark, 1970). The authors did not indicate what skills were assessed on the measure. Oudekerk et al. (2013) measured the achievement of girls at intake, and reported a mean SS of 86.64 (*SD* = 9.72) on an unspecifed math subtest of the Woodcock-Johnson Test of Achievement.

Overall, the studies reviewed in this section reported math achievement scores below expected grade/ age performance and below the standardized mean of 100 (*SD* = 15) across several measures. Math scores were reported in either GE, ranging from 4.7 for a sample with a mean age of 14.7 years (Rincker et al., 1990), to 8.06 for a sample with a mean age of 15.6 years (Katsiyannis & Archwamety, 1999). Katsiyannis et al.'s study, which was conducted in a long-term facility, reported the highest mean SS of 94.09 (no *SD*), while the lowest SS of 81.66 (no *SD*) was from a study conducted in a short-term facility (Beebe & Mueller, 1993).

All studies examined reading achievement alongside math, and scores on reading achievement were higher than math achievement scores across all the studies described above except Katsiyannis and Archwamety (1997). The biggest difference between reading and mathematics achievement SS was reported in Oudekerk et al. (2013), in which the mean was 6.92 points higher on WJ reading than on math, while Archwamety and Katsiyannis (1998) reported the smallest difference in SS, with a mean 2.7 points higher on reading versus math. In terms of GE reports, youth scored from 1.5 grades lower in STAS math achievement than reading (McMackin et al., 2005) to .02 grade levels lower on PIAT math than PIAT reading (Archwamety & Katsiyannis, 2000). While most of the authors did not report on significant differences between academic areas, Beebe and Mueller (1993) indicated that the difference between math and reading skills was significant within their sample (*p*-value not reported). Overall, these data indicate that youth in juvenile facilities are behind academically, especially in the area of math.

Researcher-conducted assessment. Overall, the five studies reporting researcher-collected data provided more information than studies relying on record review. Most of these studies (except Perkins et al., 2014) provided at least some description of the instrument used to assess mathematic achievement. Similarly, most studies included some information regarding test administration. Ficke et al. (2006) and Lansing et al. (2014) indicated that trained research personnel conducted testing sessions, although the training protocol was not provided. Lansing et al. indicated that information on authors' methods was provided in other publications, with citation to that work. Grigorenko et al. (2013) reported that youth were administered a computer adaptive screener, but did not provide information on the administration of the WRAT to a subsample of youth in a single detention center. Zabel and Nigro (2001) did not provide information on the assessment administrator of the Test of Adult Basic Skills (TABE; 1994), but did indicate that an examiner administered assessment in a one-on-one setting. Of the studies that assessed via study personnel, only Ficke and colleagues assessed inter-rater reliability.

Math achievement scores. In terms of achievement, four of the five studies reviewed in this section reported math achievement SS, one reported GE scores (Zabel & Nigro, 2001), and Grigorenko et al. (2013) reported both. Overall, the 247 youth in Ficke et al.'s (2006) study of detained youth in the Midwest scored an 81.9 SS (no *SD* for whole group) in mathematic achievement on the WRAT-3, a brief measure of basic arithmetic skills. Lansing et al. (2014) provided SS on gender performance, reporting that females achieved an SS of 83.8 (*SD* = 0.9), and males a 78.3 (*SD* = 0.8) on the WRAT-3 Arithmetic subtest, which asked youth to "count, read number symbols, and solve word problems" (p. 20). Perkins et al. (2014) reported that youth in a long-term facility achieved a SS of 84.56 (*SD*=15.3) on the WRAT-3 math achievement (no subtest information provided), and Grigorenko et al. (2013) used a screener in all Connecticut detention facilities, and the WRAT Arithmetic subtest in a single detention facility. The screener was developed by the research group in a previous study (Hart et al., 2011) and was based on Connecticut math standards. The math portion of the screener included 25 areas of math competence for youth in grades three through eight. For both measures, Grigorenko et al. reported SS and GE scores. In terms of grade equivalence, the authors reported that youth, whose mean age was 14.81 (*SD* not reported, grade range: 5-9), scored at 5.28 (*SD* = 0.1) on the math screener, and 5.03 (*SD* = 0.1) on the WRAT Arithmetic subtest. The authors indicated that youth demonstrated deficits in the computation and reasoning portions of the screener, but provided no additional information on math deficits. In a sample of 130 youth (mean age = 15.71), Zabel and Nigro (2001) reported GE scores of 5.91 (*SD* = 3.0) on the TABE Mathematics subtest that measured computational and applied skills.

Overall, these studies demonstrated patterns consistent with those that emerged in studies using record review. The youth performed below their same-age peers across studies, although the degree of deficit varied. All of the studies included in this review relied on some nationally normed measure of achievement. Only Grigorenko et al. (2013) used a screener, normed via a public school and juvenile detention sample in a previous study (Hart et al., 2012), to measure academic deficits, although little specific information regarding achievement was provided in the study.

In terms of reading versus math achievement, only the youth in Ficke et al. (2006) did not score lower in math than reading. Like the studies using record review, the youth in these five studies generally exhibited greater deficiency in math as compared to reading, although the study authors did not report on whether these differences were statistically significant.

Mixed or unknown methods of data collection. In a mixed approach, Krezmien et al. (2008) assessed procedural fidelity by monitoring the testing administrator (a trained diagnostician) via direct observation. They also described the instrument and the technical aspects of the WJ III subtest. The authors reported a mean SS of 81.1 (*SD* = 14.8) across long- and short-term settings on the subtest, which was not named. Math achievement was slightly lower than reading achievement, although significance was not reported. The authors also reported insignificant differences between participants by setting type on both math and reading.

As indicated previously, Marshall et al. (1978) and Ollendick et al. (1975) did not specify how achievement data were collected but provided information on the assessment instruments and technical properties. Marshall et al. reported a mean WRAT Arithmetic subtest SS of 75.05 (*SD* = 7.93), while Ollendick et al. reported a mean WRAT Arithmetic subtest SS of 76.44 (*SD* = 8.5) and a mean PIAT Mathematics SS of 88.94 (*SD* = 13.3). The authors indicated that the PIAT and the WRAT math scores were significantly different from each other ($p < .001$), and did not measure the same dimensions of mathematical achievement. Specifically, the PIAT Mathematics subtest measured abstract concepts, while the WRAT Arithmetic measured computational skills. In terms of reading versus math, the 18 youth in Ollendick et al.'s study performed as well or better on math as they did in reading. Marshall et al. did not measure reading achievement.

Math achievement by race or ethnicity. Of the 14 studies that contained information on racial makeup, eight examined the association between race and math achievement (Baltodano et al., 2005; Krezmien et al., 2008; Lansing et al., 2014; Grigorenko et al., 2013), achievement and/or intellectual functioning (Oudekerk et al., 2012; Perkins et al., 2014; Rincker et al., 1990), or remedial group membership (Archwamety & Katsiyannis, 2000).

Baltodano and colleagues (2005) reported that Hispanic students achieved a SS of 88.08 (*SD* = 12.8) on math calculation and 86.10 (*SD* = 14.1) on math fluency, which was lower than their White peers who scored a 94.27 (*SD* = 15.0) in math calculation and 90.25 (*SD* = 17.3) in math fluency. African American youth scored lower than both these groups, achieving an 83.93 (*SD* = 14.4) in calculation and 81.67 (*SD*=14.2) in fluency. Native American youth were the furthest behind academically, scoring mean SS of 54.00 (*SD* = 35.4) and 73.50 (*SD*=31.8) on math calculation and fluency, respectively. An analysis of variance (ANOVA) demonstrated significant differences by racial group and mathematic achievement ($p < .05$), although the specific relationships were not reported.

Lansing et al. (2014) reported that African American and Hispanic youth scored significantly lower than White youth on math achievement in a post-hoc analysis following a regression analysis ($p < .05$), and Krezmien et al. (2008) reported that across settings, African-American students performed slightly below the mean SS in math achievement, White students scored slightly above the mean, and Hispanic youth scored close to the mean. Grigorenko and colleagues (2013) reported a statistically significant difference by race ($p < .05$), with White students scoring higher than Hispanic and African American students on both the screener and

WRAT. Rincker et al. (1990) indicated that African-American students scored significantly lower than both White and Hispanic youth ($p < .05$).

Oudekerk et al. (2012) separated math achievement from global academic achievement when examining race, but found that White youth scored significantly higher on measures of achievement than a group termed “minority” ($p < .05$). Since Oudekerk et al. only identified the sample proportion of African American and White youth, it was not clear whether the youth within the minority group were exclusively African American or of other ethnicities. Perkins et al. (2014) combined academic achievement with intellectual functioning into a cognitive processing cluster that did not allow for breakdown of performance by skill area, but indicated that White youth made up the largest proportion (81.8%; $p < .05$) in the high cognitive processing group cluster. Archwamety and Katsiyannis (2000) compared the race of math and reading remedial group membership to each other and to non-remedial group membership. They found that the math remedial group contained a significantly higher proportion of minority youth ($p < .05$).

Overall, the studies that compared mathematical achievement by race or ethnicity reported that minority youth scored lower or significantly lower in measures of math achievement than white youth in both detention and commitment settings. Studies that provided associations on race and general achievement (Oudekerk et al., 2012; Perkins et al., 2014) or remedial group membership (Archwamety & Katsiyannis, 2000) reported similar, unmistakable findings: Minority youth, who were overrepresented in juvenile facilities, were at heightened risk for low mathematic achievement.

Math achievement by gender. Seven of the 18 included studies were conducted in mixed gender facilities, and five of these compared gender and achievement (Grigorenko et al., 2013; Lansing et al., 2014; Marshall et al., 1978; Rincker et al., 1990; Zabel & Nigro, 2001).

Lansing et al. (2014) reported that on WRAT-3 math achievement, females significantly outperformed males with a mean SS of 83.8 (*SD* = 0.9) compared to a 78.3 (*SD* = 0.8) for males ($p < .05$). Grigorenko et al. (2013) also found that females significantly outperformed males on math portion of the WRAT ($p < .05$), but not on the math portion of the screener. Marshall et al. (1978) reported that males and females were not significantly different on the WRAT, although females did score significantly higher than their males in math coursework. Rincker et al. (1990) examined gender and race by achievement, so the overall gender performance of the sample is unclear, although Hispanic males scored the lowest on a measure of math achievement, and African American females were the next lowest on math achievement. Finally, Zabel and Nigro (2001) reported no significant academic score differences (math or otherwise) based on gender.

Overall, the five studies that examined gender and achievement found that females in correctional settings outperformed males on measures of math achievement. This difference was significant in Lansing et al.'s (2014) sample, which was the largest sample included in this review (female $n = 657$; male $n = 1172$). Additionally, while both Grigorenko et al. (2013) and Marshall et al. (1978) found no significant gender difference for one measure of math achievement, each found consistent significant differences on additional mathematic performance measures, males scoring lower than females.

In all, 11 of the included studies were conducted in gender-specific facilities. Of these, only two included female-only samples (Archwamety & Katsiyannis, 1998; Oudekerk et al., 2013). These two samples demonstrated mean math achievement scores within one SD of the mean, as did most of the male samples. Given these results and the small number of mixed-gender samples, conclusions regarding math performance by gender are difficult, although the findings presented here reveal potential patterns that warrant further study.

Math achievement by special education status. A discussion of math achievement by special education status within juvenile facilities is complicated by the notion held by some researchers that youth in juvenile facilities requiring special education may have gone unidentified prior to commitment, due to student truancy or exclusionary discipline practices, both of which could undermine school-based evaluation (Krezmien et al. 2008; Rutherford, Bullis, Anderson, & Griller-Clark, 2002). Indeed, Rincker et al. (1990) indicated that of 54 children not identified as special education eligible, 16 were two to five years below expected levels academic achievement, and three demonstrated IQ scores below 69 points.

Despite the possibility that reported special education rates may not accurately reflect a sample's particular special education needs, four of the included studies provided mathematic achievement data by special education status, and in all cases, youth identified as special education eligible significantly underperformed their peers without special education status. Krezmien et al. (2008) indicated that special education students in both short- and long-term settings presented significantly lower achievement scores in all areas, including math. Youth in special education achieved an overall SS of 75.2 (*SD* = 13.5) on a WJ-III math subtest, while peers scored an 85.9 (*SD* = 14.1). Baltodano et al. (2005) reported that mean WJ-III SS across academic areas were an average 10 points lower for special education students than peers, and this difference was significant ($p < .05$). Specific to math achievement, youth identified as special education eligible achieved a SS of 84.80 (*SD* = 16.6) on Math Calculation and an 80.02 (*SD* = 16.7) on Math Fluency, while their non-identified peers scored 90.96 (*SD* = 13.8) and

89.91 (*SD* = 14.0), respectively. In a similar vein, Zabel and Nigro (2001) indicated that youth eligible for special education in their sample scored significantly lower ($p < .0003$) than peers on TABE math performance. Oudekerk et al. (2012) did not break down math achievement scores by educational category, but did indicate that a history of special education was significantly associated with low academic achievement ($p < .001$).

Discussion

Major findings.

Low mathematic achievement. The first and primary finding of the present review is that youth in juvenile facilities are behind their same-age peers in math achievement. Most participants in the reviewed studies demonstrated math achievement four or more grade levels below expected age / grade performance in GE scores (McMackin et al., 2005; Rincker et al., 1990; Zabel & Nigro, 2001) or more than one SD below the mean in SS (Beebe & Mueller, 1993; Ficke et al., 2006; Grigorenko et al. 2013; Krezmien et al., 2008; Lansing et al., 2014; Marshall et al., 1978; Perkins et al., 2014). Altogether, these low-performing youth made up approximately 70% of the sample population across all studies.

A smaller proportion of youth from the corpus of studies scored within one SD of the population mean (Archwamety & Katsiyannis, 1998; Baltodano et al., 2005; Katsiyannis et al., 2004; Oudekerk et al., 2013) or three or fewer grade levels below their expected age performance (Archwamety & Katsiyannis; 2000; Katsiyannis & Archwamety, 1997; 1999), suggesting that while many youth have a large math achievement deficits, others may have academic skills that may remediated through targeted, effective academic intervention. It is noteworthy that all but two of the studies reporting higher levels of math achievement were conducted in samples that were disproportionately White. Given the research in this review and elsewhere regarding the performance of White and minority youth on measures of achievement, these results should be interpreted with caution.

Math versus reading achievement. First, most of the studies included in this review reported similar mathematics deficiency as compared to reading. While it is not clear whether the differences between the levels of reading and mathematics performance were statistically significant in any study except Beebe and Mueller (1993), it was clear from these studies that assessment and intervention in the area of mathematics is at least as critical as assessment and intervention in the area of reading.

***Math achievement by demographic and setting*.** A third important finding was that certain groups of youth, including African American and Hispanic youth, demonstrated math achievement lower than their White peers. All of the studies examining the association between race and achievement reported that minority youth scored lower or significantly lower on math achievement or general achievement

Likewise, youth eligible for special education underperformed their peers on math achievement in every study examining this association. This disparity, along with the possibility that some youth in facilities may be unidentified (Beebe & Mueller, 1993), highlights the need for timely assessment, eligibility identification, and intervention for youth with disabilities.

Finally**,** youth in both short- and long-term settings are behind academically. Although Krezmien et al. (2008) indicated that youth across settings were not significantly different on achievement, in all eight studies conducted in short-term settings, youth scored below a SS of 85 on math achievement or four or more grade levels below expected performance. Conversely, all studies that reported math achievement SS at 85 points or higher occurred in long-term settings. Further, GE scores within three grade levels of expected performance were also from studies in long-term settings. While the makeup of some samples limits the generalizability of individual study score reports, the present review suggests that youth in either setting type require increased attention from researchers and policy-makers interested in juvenile rehabilitation.

Research Limitations

Record review. These overall findings must be interpreted in light of the limitations present in the reviewed literature. It is understood that research within any youth facility is a complicated proposition, given that these youth are a varied and highly mobile population, and research schedules are susceptible to interruptions due to facility and juvenile justice demands (Houchins, Jolivette, Krezmien, & Baltodano, 2008). A research procedure that relies on record review may be a pragmatic alternative to live assessment, but this approach is not without its own challenges. Research using facility records for data collected before study commencement may rely on incomplete data collected by unidentified assessment administrators with unknown credentials.

Most of the studies using record review failed to describe assessment administration, which created uncertainty regarding the validity and reliability of measures and reported scores. Only two studies using an exclusive record review approach indicated that administrators were clinical staff (Oudekerk et al., 2013) or trained (Rincker et al., 2005). Moreover, record review conducted by multiple individuals is subject to bias and human error. Information about the training of data collectors would increase confidence in the reliability of reported data. Only Archwamety and Katsiyannis (2000) and Katsiyannis et al. (2004) indicated that data collectors were trained, and only Archwamety and Katsiyannis (2000) described the training program. Some of the studies collecting data via record review were subject to other issues as well, including a demographic sample that included youth excluded from the study (Boltadano et al.,

2005) or inconsistent data between text and tables (Bebee and Mueller, 1993; Rincker et al., 1990). Given these limitations, study results should be interpreted with appropriate caution. Marshall, et al., 1978 also reported inconsistent data between tables and text, so this may be an issue more related to the age of the studies than data collection method. In any case, when tables and data did not agree, I reported data from the study text.

Sample representativeness. Four of the studies lacked information regarding sample racial demographics (Beebe & Mueller, 1993; Marshall et al., 1978; Ollendick et al., 1975; Zabel & Nigro, 2001), and several had large proportions of White (Archwamety & Katsiyannis, 1998; 2000; Katsiyannis & Archwamety, 1997; 1999; Katsiyannis et al., 2004), African American (Lansing et al., 2014; Krezmien et al. (2008), Hispanic (Baltodano et al., 2005; Grigorenko et al., 2013), or Mixed-race youth (Perkins et al., 2014). According to Quinn et al. (2004), many facility samples vary from the population on special education status, although the application of these estimates apply only to long-term settings. Finally, many studies conducted in mixed gender facilities had larger than expected female representation (Lansing et al., 2014, Marshall et al., 1975; Rincker et al., 2006).

Specific areas of math deficit. Finally, the present review highlights the fact that while math assessment in youth correctional facilities has been examined in the peer-reviewed research for four decades, surprisingly little research has investigated specific areas of math achievement deficits in this population. In this way, not only does this review corroborate the critical mathematical deficiency of youth in corrections; it adds to the literature by identifying specific areas of deficiency in the research, including for whom mathematical deficiency may be more significant.

Implications for future research and practice. Given the overall findings of this review, researchers should begin investigating areas of math skills and deficits among samples of youth in short- and long-term correctional settings in order to develop a clearer picture of education and intervention needs. Practitioners also should assess deficits with math assessment tools. The evidence suggests that many youth in correctional facilities can collect more academic credits per semester than youth in typical high schools (OPPAA, 2010), so appropriate math intervention could yield important results for youth in facilities. Indeed, Oudekerk et al. (2013) reported that the majority of youth that eventually earned a high school diploma did so during the incarceration period. The authors also reported that academic achievement in adolescence was the strongest individual predictor of academic attainment in early adulthood.

A recent synthesis revealed that only one research-based math intervention has been conducted since 1970 among committed or detained youth (Wexler, Pyle, Flower, Williams and Cole, 2014). This study, conducted in 1980 by Kane & Alley, examined the effect of peer tutoring on math achievement of 38 youth. In contrast, Wexler et al. identified 15 intervention studies focused on literacy (reading and writing). This contrast in focus is inexplicable, given the literature on math achievement in facilities, and the critical importance of math literacy to adult outcomes, following release.

This review provides the field a starting point and a direction for research and subsequent math intervention. If quality instruction is to be delivered to committed youth from diverse backgrounds with significant academic needs, mathematic assessment within facilities must be specific enough to identify areas of academic deficiency. Once the field has identified areas of deficit, targeted interventions will then allow researchers to determine whether intervening results in meaningful outcomes for these youth.

Conclusion

Despite the limitations present in many of the reviewed studies, patterns emerged that were consistent with the hypothesis that youth math skills in juvenile facilities were at least as low as reading skills. Further, certain groups of youth, including minorities and youth with disabilities, performed lower on measures of mathematics achievement than White youth and peers without identified educational disability. While youth in juvenile facilities demonstrate low math achievement, there is preliminary evidence that they can make meaningful academic gains during the commitment period. A research focus on accurate assessment of math achievement and math skill deficits in juvenile facilities can provide a starting point for efficient, effective mathematic intervention.

Study

Purpose. The purpose of this descriptive study was to measure and report the comprehensive math achievement of youth in short- and long-term juvenile facilities. The study was conducted in Tennessee, which along with 20 other states and the District of Columbia, requires Algebra 1 as the first high school level math requirement in a math sequence leading to graduation.

All youth in long- and short-term settings were assessed using a nationally-normed standardized measure of math achievement in order to determine broad math achievement and establish sample comparability to previous literature. Participants were also administered a standardized math assessment that measured specific areas of math achievement and a diagnostic measure of pre-algebra readiness, and information was gathered related to participant Algebra I completion.

In order to develop a clear picture of the math achievement and algebra readiness of these youth, demographic information was collected from study participants and group differences were examined related to setting type (long- or short-term), ethnicity, race, gender, age, and special education status.

The current study relied on data collection by trained research assistants, in order to minimize the possibility of incorrect data, and measured fidelity of assessment administration across measures. Reliability procedures were also used in order to record data. By following these procedures, this study aimed to avoid some of the limitations present in much of the previous research conducted with youth in juvenile facilities.

Research Questions. This study adds to the existing literature by addressing the following research questions:

1. How do youth in juvenile correctional settings perform on two nationally normed and standardized measures of mathematical achievement?
    a. Does math achievement vary by setting type?
    b. Does youth math achievement on standardized measures vary across race, gender, Algebra I credit, or special education status?
2. How do youth in juvenile justice settings perform on a specialized assessment of algebra readiness called the Diagnostic Test of Pre-Algebra Readiness (DT-PAM, 2010)?
    a. Does algebra readiness, as measured by the DT-PAM vary by setting type?
    b. Does algebra readiness vary across race, gender, Algebra I credit, or special education status?
3. Do the youth in juvenile facilities experience success in Algebra 1?

a. Does Algebra I completion vary according to demographic factors (i.e.: race, gender, age, special education status, or setting type)?

Hypotheses. Based on previous assessment research conducted in juvenile facilities and described in the literature review, I hypothesized that youth in long- and short-term facilities would demonstrate standardized math achievement deficits, and youth in short-and long-term settings would demonstrate similar math score deficits. I expected youth with disabilities to score lower on overall standardized achievement than their nondisabled peers, and minority youth to score lower than their White peers. Although previous published research has not investigated specific area of math achievement deficits among youth in juvenile corrections, I expected that on average, participants would demonstrate an algebra readiness deficit, and youth with disabilities and minority youth would demonstrate a significantly greater math weakness in algebra readiness than youth without disabilities and White youth.

I hypothesized that few youth that participated in the study would have academic credit for Algebra 1. I expected that younger youth, youth with disabilities, and Black and Hispanic youth would have the lowest rate of Algebra credit, and that older youth, youth without disabilities and White youth would have higher rates of Algebra 1 credit.

Chapter II

METHOD

Terms

The students that participated in this study are referred to as committed, if they were recruited from a long-term setting; or detained, if recruited from a short-term setting.

Internal Review Board Approval

I sought approval from the Vanderbilt University Internal Review Board (IRB) prior to commencing the study. Additionally, this study was approved through the Tennessee Department of Children's Services (DCS) Research Review Board. Both the Vanderbilt IRB and the DCS Research Review Board approved all study procedures.

Sample

In this study, I recruited approximately 27 males and nine females from three long-term, single gender facilities in the state of Tennessee. Additionally, I recruited 21 youth from a mixed-gender, short-term detention center. While participants recruited from short-term detention could have been either gender, very few females were actually detained in the short-term setting, and no study participants from the detention center were female.

Long-term facilities.

Consent. Participants from long-term facilities were recruited in two ways. In my initial recruitment effort**,** facility administration sent consent packets to parents or guardians of all the youth aged 13-17 who were expected to remain in the facility for the following 6 weeks.

The consent packets contained:

1) A consent letter introducing the study.

2) An informed consent form which described the study time commitments, benefits, and potential risks to student participants. The parents/ guardians were informed that they were able to withdraw their student from the study at any time without an explanation and without consequences. My contact information was provided for the parent for questions regarding the screening or study participation.

3) A release form to examine educational records to determine Algebra I and special education status, and

4) A researcher addressed, stamped envelope.

Parental consent was also recruited during "Family Day" events held at two of the three long-term facilities (one male, one female). In both facilities, Family Day was a day selected by the facility in which parents visited to see their children and engage with facility staff. Lunch was served to the families and games and activities were provided to engage the families. I attended Family Day and explained the study to parents, one on one, as they passed information booths about family services. Parents were provided the packets described above, without the stamped envelope, and given the option of consenting to have their child participate in the study. In all, five girls were recruited at Family Day at the female facility, and ten males were recruited through the Family Day at the male facility. The remaining long-term participants were recruited through mailings.

Student assent. Following parental/guardian consent, private meetings were held at the long-term centers to obtain student assent. The student investigator or trained research assistants described the purpose of the study, time commitments, benefits, potential risks, and answered any questions individually with potential participants. Participants were informed that they could withdraw from the study at any time. The only criterion for study inclusion was that youth not be expected to be removed from the facility in the six weeks following the mailing of consent packets.

Adult student consent. For adult students aged 18 in long-term facilities who were not expected to be moved from the facility in the following six weeks, consent packets were read aloud and provided to adult students in a one-on-one setting.

Short-term facilities.

Consent*.* For youth aged 13-17 in the short-term facility, we received a consent waiver from the Vanderbilt University IRB, since this research was not feasible if informed consent of the subjects' parents or guardians was required prior to study commencement. Youth in detention stay less than two weeks, on average. Waiting for parental consent to be returned could eliminate the possibility of conducting this research within this population of youth. The research involved no more than minimal risk to the subjects; the waiver or alteration did not adversely affect the rights and welfare of the subjects, and youth assent was requested prior to youth participation. In order to provide parents notice of the study, facility administrators sent study information letters to parents and guardians of students expected to remain in facility for five days. The letters provided a name and number of a study contact to notify if the parent wished to opt their child out of the study. At least forty-eight hours after the letter was mailed, youth were assented.

Student assent. Student assent procedures for youth in short-term detention were identical to those procedures used for youth in long-term facilities. Only those youth whose parents or guardians had been mailed letters describing the study, and who had not opted out were assented to participate in the study.

For this study, no racial, gender, or ethnic group was excluded. I expected to have some study attrition due to youth assent and subsequent refusal. Participant demographic data is presented in Table 1. These data served as the independent or predictor variables for this study.

Table 1

Participant demographics

Demographic	%	N
Gender		
Male	84.21%	48
Female	15.79%	9
Ethnicity		
AA	68.42%	39
W	24.56%	14
H	1.75%	1
ME	1.75%	1
NA	1.75%	1
M	1.75%	1
Age		
13	3.51%	2
14	3.51%	2
15	7.01%	4
16	26.31%	15
17	33.33%	19
18	26.31%	15
Setting Type		
Long-term	63.16%	36
Short-term	36.84%	21
Special Education Status		
Eligible	31.15%	18
Not Eligible	66.67%	38
Missing	1.75%	1
Algebra I Credit		
Yes	73.68%	42
No	26.31%	15

*AA= African American, W= White, ME= Middle Eastern, NA= Native American, M= Mixed Race

Study Measures

The Arithmetic Subtest of the Wide Range Achievement Test 4 (WRAT 4). Trained study personnel assessed the standardized math achievement of the youth in both short- and long-term settings using the Arithmetic Subtest of the WRAT 4 (2006). The WRAT 4 is a commonly used, brief achievement test measuring arithmetic computation. The measure was normed on a stratified representative sample of over 3000 individuals of ages 5–94 years, and the Arithmetic Subtest has a reported split-half reliability of .79 to .89. The measure is valid, correlating at .67 against the Woodcock Johnson III Broad Math Subtest. Assessment administration requires 15-20 minutes. Raw scores were converted to age-based standard scores and percentiles. I examined overall means and group differences by long- or short-term setting type, race, gender, age, Algebra I status and special education status.

KeyMath 3. In order to assess areas of mathematic strengths and weakness related to algebra, an algebra readiness instrument was used called the KeyMath 3 (Connoly, 2007). The KeyMath 3 is a norm-referenced measure that provides accurate diagnostic information that can be used to develop intervention. The KeyMath 3 is aligned with the National Council of Teachers of Math (Connoly, 2007). In particular, the Numeration and Algebra subtests, which are derived from the Basic Concept Cluster, measure skills relevant to algebra readiness and demonstrate reliable scores. Fractions, decimals, percentages, exponents, multiples and factors are all covered under the umbrella of the Numeration Subtest, which demonstrates a .95 reliability. The Algebra subtest measures understanding of ratio and proportion, order of operations, and ability to work with equations, among other skills relevant to success in algebra, and demonstrates a reliability coefficient of .87. These two subtests take about 15 to 30 minutes each to administer. Finally, The Applications Content Area Test is made up of the Foundations of Problem Solving and Applied Problems subtest. These areas of competency are essential to problem solving proficiency and higher math skill, so both these subtests were administered. Individually, these subtests demonstrate strong reliability, and taken together, the Applications Measure demonstrates a .93 reliability coefficient among youth in grades 6-12.

The KeyMath 3 series uses basal and ceilings in test administration, so that an examiner can limit assessment to a student's functional range. Total test administration time took around 45 minutes, and yielded valid and reliable information in relation to academic deficit in areas that support algebraic success.

The Diagnostic Test for Pre-Algebra Mathematics (DT-PAM). Study personnel also assessed the youth using The Diagnostic Test for Pre-Algebra Mathematics (DT-PAM, 2010). The DT-PAM is designed to provide diagnostic information on the competencies of individual students in various areas of basic math that support success in algebra. This information may be used to direct instruction and intervention. The DT-PAM takes about 45 minutes to administer and was scored at Vanderbilt University according to publisher directions. The score report contains raw scores for 21 competency areas.

On the whole, the DT-PAM is reliable, based on 972 8^{th} grade students from four Massachusetts school districts. The reliability coefficient for a sample of 424 youth was .928. The measure is also valid, based on two criterion related validity studies. In the first analysis, 169 scores from the Massachusetts Statewide Examination of 8th grade math (MCAS) and the DT-PAM were analyzed, with a resulting Pearson product-moment correlation of .935. In the second analysis, 207 scores from both measures were correlated at .790. A third correlation study with an *n* of 159 resulted in a correlation of .59, but the authors indicated reliability issues in that MCAS administration. In terms of construct validity, the DT-PAM correlates with the

COMPASS Pre-Algebra, a commonly used measure of pre-algebra skills, at .719 and with the PLAN Math at .756.

The DT-PAM measures 21 areas of pre-algebra competency in a 50 item test, and while the test on the whole is valid and reliable, reliability measures of specific areas of competency are mixed. The median reliability for the competency area scores is .47 (Cronbach's alpha). Sixteen out of 21 competencies demonstrated reliabilities between .4 and .6, and the full range was from .12 to .61, based on data from the 972 8th grade students in four norming groups. While the authors of the measure indicate that the reliabilities are adequate to assess the strengths and weaknesses of groups of students, in terms of detained and committed students, reliabilities for individual construct areas were not sufficient to report in this study. Therefore, only the global DT-PAM score was reported in this study.

Taken as a whole, the measure assesses many competency areas that may be related to algebra success, including fraction and decimal sense (Siegler et al., 2012; Wu, 2010), vocabulary, order of operations, equation writing, proportions and ratios (Bottoms, 2003) and problem solving (Fuchs et al., 2014).

Although standard scores were not available for this measure, the publishers indicate that that the norming sample demonstrated a mean score of 23.2 with a standard deviation of 10.41 among 580 eighth grade students who were administered the test in one day.

Algebra 1 Experience. Algebra I status was analyzed as a predictor variable along with gender, special education status, race, and age. It was also analyzed separately as an outcome variable. For youth participants in long-term facilities, I requested information regarding whether or not the student possessed an Algebra I credit from facility administration at the end of testing days. For youth in short-term facilities, who did not have educational records available, these data were collected via self-report prior to testing.

Together, these measures provided information on the overall math achievement of youth in correctional facilities, specific youth skill deficits related to algebra, and youth achievement in Algebra 1.

Procedures and Study Design

Long-Term Facility Assessment Procedures. Following parental informed consent and minor student assent or adult-student informed consent, study participants were interviewed regarding their ethnicity, gender, and age. Study personnel administered the three assessments at a time and date arranged by facility administration to avoid instructional interruption. The youth were provided privacy from other students during the KeyMath 3 test administration. The WRAT and the DT-PAM were paper and pencil tests that were able be administered in a small group setting with other research participants. These measures were administered over one to two days, depending on student preference. Students were offered breaks between measures and small edible reinforcers for completing tests. Following student assessment, data relating to student special education status and Algebra I status were gathered from facility administration.

Short-Term Setting Assessment Procedures. For youth in short-term settings, youth assenting to participate in the study were interviewed regarding their ethnicity, gender, age, Algebra I credit and special education status. Following this interview, students in the short-term facility were administered the study measures in a manner identical to the youth in long-term facilities, as described above.

Assessment Training and Inter-Observer Agreement (IOA). The WRAT 4 Arithmetic Subtest and KeyMath 3 test administrators were trained in a one hour block, then provided the opportunity to practice test administration on each measure at least three times. Following instruction and practice, each test administrator was "checked out" by a trained WRAT 4 or KeyMath 3 administrator.

The authors of the DT-PAM provide recommendations for test administration in the DT-PAM Manual (APR Testing Services, 2010). In order to provide a standardized administration, I created a script that DT-PAM administrators read aloud to students. Test administrators were trained on the script, motivating the students to do their best work, and answering student questions before or during the test. Administrators were informed that there was no time limit for the test, and student calculators were not to be used.

Thorough measurement of IOA and procedural fidelity on study measures assured that test administration was conducted properly and risk to participants was minimized. Nearly one-fifth of all sessions (31/171 or 18%) were observed for appropriate testing procedures by a research assistant trained to collect procedural fidelity during the study. Fidelity of test administration was measured at 100%. All WRAT 4, KeyMath 3, and DT-PAM answer sheets were checked for reliability.

Once scoring was complete, one-quarter of score data from both measures were entered into the spreadsheet a second time by an independent research assistant in order to assess reliability.

Data Storage and Privacy Risks. De-identified data sheets were securely stored in a locked file cabinet in a locked office, and de-identified computer files were stored on a password-protected university server. These data will be maintained five years by the investigators.

Data Analysis. This study was exploratory and descriptive in nature. As such, several types of analyses were used in order to fully explore the data for variance by demographic category. Once data were collected from student participants, they were entered into a spreadsheet along with setting type, special education status, gender, Algebra I credit, ethnicity, and age by youth identification code. First, I analyzed group differences according to setting type, in order to determine whether scores by setting type could be combined to provide an overall descriptive report.

To answer my first two research questions, I conducted preliminary analysis by running descriptive statistics on KeyMath 3 subtest scale scores, WRAT 4 Arithmetic Subtest achievement standard score, and DT-PAM raw score. Score mean, standard deviation, and range were reported for youth overall, youth by setting type, special education status, ethnicity, Algebra I credit, and gender. Independent sample t-tests were used in order to determine whether groups demonstrated score differences by special education status, ethnicity (between African American and White students), Algebra 1 status, and gender. Given the extremely small sample sizes of Native American (n = 1), Hispanic (n = 1), and Mixed Race (n = 1) youth, group comparisons were made only between African American and White students.

In order to answer my third research question regarding whether students with and without an Algebra I credit varied by setting, special education status, ethnicity (between African American and White students), gender, and age, chi-square analyses were used.

Following a report of descriptive data and demographic group differences, six multiple regression analyses were used in order to estimate the relationships between the independent variables and the six outcome variables. In order to run the analyses, setting was recoded as a binary variable with 0 for long-term and 1 for short-term; gender was a binary variable coded 0 for males and 1 for females; Black, Hispanic, and other race were binary variables for the student's race with White as the reference group; special education status (sped) was a binary variable with 1 for students receiving special education and 0 for a student not receiving special education; and age was a control variable centered on the sample mean. $y_1 = \beta_0 + \beta_1 SETTING_{1i} + \beta_2 GENDER_{2i} + \beta_3 BLACK_{3i} + \beta_4 HISP_{4i} + \beta_5 OTHERRACE_{5i} + \beta_6 SPED_{6i} + \beta_7 AGE_{7i} + e_i$.

Finally, I examined the correlations between the measures in order to develop a deeper understanding of how the measures related to one another.

Chapter III

RESULTS

Data Analysis

Data analyses were conducted using SPSS (version 24.0). First, before combining the samples by setting type, I examined group differences by setting using independent sample t-test for scores, and chi-square analyses, in order to determine whether youth differed significantly by age, race, gender, or special education status according to setting.

Table 2 provides the results of the independent samples t-test for the comparison across setting. In this analysis, the youth did not differ by setting type on any of the assessed measures of achievement. In this comparison, as well as group comparisons across other independent variables, the Benjamini-Hochberg multiple testing correction (Benjamini & Hochberg, 1995) was administered to *p*-values across contexts, in order to reduce false discovery rates. The corrected *p*-values are noted in the tables below.

In calculating effect sizes for small sample sizes for the analysis below and all other t-test analyses, I took caution to avoid overstating the effect. In order to minimize bias, I used Hedges *g* (Hedges & Olkin, 1985) as a slight adjustment to Cohen's *d*. These data are reported in the tables below.

Table 2

Results of t-test and descriptive statistics by setting type

Variable	*M* (*SD*)		*t*	*g*	*p*
	Short-Term	Long-Term			
KeyMath 4					
Numeration	6.43 (2.42)	5.86 (2.57)	.82	.22	.42
Algebra	6.67 (3.02)	5.81 (2.95)	1.06	.29	.29
Foundations	6.29 (2.35)	5.56 (2.32)	1.14	.32	.43
Applied	6.89 (2.85)	5.86 (2.39)	1.41	.40	.27
WRAT	80.76 (10.82)	81.61 (13.18)	-1.02	-.06	.80
DT-PAM	22.29% (.13)	27.86% (.23)	-.25	-.005	.33

Note: *g* = Hedges *g*

There were also no significant differences between the groups based on age, $\chi^2(5, N = 57) = 10.14$, $p = .71$; race, $\chi^2(5, N = 57) = 5.94$, $p = .31$; or special education status, $\chi^2(5, N = 57) = 1.81$, $p = .41$. Since the youth demonstrated no difference in scores, age, race, or special education status, the scores for youth in the two settings were combined to provide overall descriptive information.

The youth did differ by gender $\chi^2(5, N = 57) = 6.23$, $p = .013$; and by Algebra I credit, $\chi^2(5, N = 57) = 11.65$, $p = .001$. Since all the females who participated in the study were housed in a single long-term girls' facility, group differences could not be avoided for this independent variable. The Algebra I completion rate was also subject to limitations, as discussed in more depth below.

To answer my first research question, I conducted preliminary analyses by running descriptive statistics on KeyMath 3 subtest standard scores (Numeration, Algebra, Foundations of Problem Solving, and Applied Problem Solving), WRAT 4 Arithmetic subtest standard score, and DT-PAM raw score (percentage correct) for the combined sample. Score means, standard deviations, and range are reported in Table 3 below.

Table 3

Overall score descriptives

	N	*M*	*SD*	Range
KeyMath 4				
Numeration	57	6.12	2.5	1-11
Algebra	57	6.15	2.97	1-12
Foundations	57	5.82	2.30	1-11
Applied	57	6.20	2.61	1-12
WRAT Arithmetic	57	81.30	12.34	55-116
DT-PAM	57	25.84%	.20	4%-82%

Note: *N* = sample size; *M* = Mean; *SD* = standard deviation; Foundations = Foundations of Problem Solving; Applied = Applied Problem Solving; WRAT= Wide Range Achievement Test; DT-PAM= Diagnostic Test of Pre-Algebra Readiness.

Descriptive data and group differences were calculated for youth by special education status, gender, Algebra I credit, and ethnicity. In addition to the analyses described above, I analyzed the demographic differences of youth with Algebra I credit versus youth without Algebra I credit.

Youth that were not in special education scored significantly higher than youth that were in special education on the KeyMath 3 Numeration, Algebra, and Applied Problem Solving subtests. White youth scored significantly higher on the KeyMath 3 subtests for Numeration, Foundations of Problem Solving, and Applied Problem Solving than their African-American peers. Finally, youth with Algebra I credit scored significantly higher on the DT-PAM. Tables displaying these results, along with the respective effect sizes and significance, are displayed in Tables 4-7.

Table 4

Results of t-test and descriptive statistics by special education status

Variable	M (SD)				
	Special Education	Not Special Education	*t*	*g*	*p*
KeyMath 4					
Numeration	4.78 (2.48)	6.76 (2.27)	-2.96	-.83	.013*
Algebra	4.39 (2.57)	7.00 (2.83)	-3.32	-.88	.01*
Foundations	4.94 (1.98)	6.26 (2.42)	-2.01	-.61	.13
Applied	4.89 (1.91)	6.97 (2.56)	-3.07	-.86	.015*
WRAT	76.50 (11.73)	83.82 (12.02)	-2.14	-.62	.13
DT-PAM	17.7% (0.18)	30.00% (0.20)	-2.20	-.61	.08

$^*p < .05$

Table 5

Results of t-test and descriptive statistics by gender

Variable	*M* (*SD*)		*t*	g	*p*
	Female	Male			
KeyMath 4					
Numeration	5.00 (1.73)	6.27 (2.60)	1.40	.50	.20
Algebra	5.11 (1.45)	6.31 (3.16)	1.11	-.48	.29
Foundations	6.11 (2.71)	5.77 (2.29)	-.40	.09	.69
Applied	5.44 (1.33)	6.38 (2.75)	1.00	-.45	.41
WRAT	76.89 (5.97)	82.13(12.99)	1.18	-.43	.24
DT-PAM	19.77% (0.21)	26.94% (0.12)	1.00	-.11	.33

*$p < .05$

Table 6

Results of t-tests and descriptive statistics by ethnicity

Variable	M (SD) African American	M (SD) White	*t*	g	*p*
KeyMath 4					
Numeration	5.46 (2.33)	7.57 (2.10)	-2.98	-.91	.013*
Algebra	5.49 (2.92)	7.50 (2.25)	-2.34	-.72	.057
Foundations	5.21 (2.11)	7.43 (2.34)	-3.29	-1.00	.01*
Applied	5.59 (2.41)	7.64 (2.44)	-2.72	-.82	.025*
WRAT	79.23 (11.17)	86.64 (13.75)	-2.00	-.75	.13
DT-PAM	23.87% (0.21)	30.00% (0.20)	-1.00	-.29	.33

*$p < .05$

Table 7

Results of t-test and descriptive statistics by Algebra I credit

Variable	M (SD)				
	Has Credit	Lacks Credit	*t*	*g*	*p*
KeyMath 4					
Numeration	6.36 (2.52)	5.27 (2.40)	-1.50	.45	.21
Algebra	6.40 (2.93)	5.33 (3.06)	-1.20	.37	.30
Foundations	5.90 (2.23)	5.60 (2.69)	-.43	.13	.69
Applied	6.31 (2.65)	6.00 (2.60)	-.39	.11	.70
WRAT	82.79 (12.34)	77.13 (11.45)	-1.55	.46	.21
DT-PAM	30.00% (0.21)	14.13% (0.10)	-2.79	.88	.035*

* $p < .05$

In order to determine whether youth differed by demographic status on Algebra I credit, chi-square analyses were conducted for the categorical data of Algebra I completion. Algebra I completion did not differ significantly by age, χ^2 (5, N = 57) = 8.61, p = .13; by gender, χ^2 (1, N = 57) = 1.42, p = .23; or by African-American or White ethnicity, χ^2 (1, N = 54) = .046, p = .83. However, Algebra I completion varied by special education status, χ^2 (1, N = 56) = 7.10, p = .008; and by setting type, χ^2 (1, N = 57) = 9.72, p = .002.

Following the analyses of group differences, multiple regression analyses were used in order to estimate the relationships between the independent variables (setting type, gender, special education status, algebra credit, race, and age) and each outcome variable (WRAT, DT-

PAM and KeyMath 3 Numeration, Algebra, Foundations of Problem Solving and Applied Problem Solving).

Regression analyses estimating the relationship between the predictor variables and the outcome variables KeyMath 3 Algebra, Applied Problem Solving and DT-PAM were significant. The predictor variables Setting, Special education status, Gender, Age, and Race predicted about 25% of the variance on the KeyMath 3 Algebra subtest and the DT-PAM, and about 28% of the variance in the KeyMath 3 Applied Problem Solving subtest. Each of these full models was significant; however, only one predictor was significant in each of these models.

Special education status was a significant predictor for each of the KeyMath 3 subtests. Because the Beta coefficients were all measured in standard deviations, they could be compared to one another. Special education status had the largest Beta coefficient (-.30) for the dependent variable KeyMath 3 Algebra. A one unit standard deviation increase in Special education status led to a .30 standard deviation decrease in predicted KeyMath 3 Algebra score. Similarly, a one unit standard deviation increase in Special education status led to a .40 standard deviation increase in predicted KeyMath 3 Applied Problem Solving score. The Beta coefficients for race were the next largest in both these models, and were nearly significant themselves: KeyMath 3 Algebra, $\beta = .25$ ($p = .07$) and KeyMath 3 Applied Problem Solving, $\beta = .23$ ($p = .07$). Algebra I completion was the only significant predictor of the outcome DT-PAM score.

Tables 8, 9, and 10 provide the Beta weights and *p*-values for equations $y_1 = \beta_0 + \beta_1 SETTING_{1i} + \beta_2 GENDER_{2i} + \beta_3 BLACK_{3i} + \beta_4 HISP_{4i} + \beta_5 OTHERRACE_{5i} + \beta_6 SPED_{6i} + \beta_7 AGE_{7i} + e_{i.,}$ resulting in significant models.

Table 8

Demographic predictors of KeyMath Algebra (*N* = 56)

Predictor	B	SE(B)	β	*t*	p	95% CI for ρ
Setting	-1.35	.99	-.22	-1.36	.20	-3.35-.65
Gender	.074	1.14	.009	.07	.90	-2.21-2.36
Special education status	-1.96	.93	-.30	2.10	.02*	.40-3.81
Algebra credit	1.42	1.04	.22	1.36	.18	-.67-3.50
Race	.76	.39	.25	1.92	.07	.06-.04
Age	.17	.32	.07	.51	.11	.61--.51

Note: R^2 = .253; *p < .05

Table 9

Demographic predictors of KeyMath Applied Problem Solving (*N* = 56)

Predictor	B	SE(B)	β	*t*	*p*	95% CI for ρ
Setting	-1.13	.83	-.22	-1.36	.18	-2.81-.54
Gender	.15	.95	.02	.16	.88	-1.76-2.06
Special education status	-2.19	.78	-.40	-2.81	.007**	-3.76-.62
Algebra credit	.79	.87	.14	.90	.37	-.96-2.53
Race	-.60	.33	.23	-1.83	.07	-.06-1.27
Age	.26	.28	-.13	.92	.37	-.83-.31

Note: R^2 = .28; **p < .01

Table 10

Demographic predictors of DT-PAM score (*N* = 56)

Predictor	B	SE(B)	β	*t*	*p*	95% CI for ρ
Setting	-.005	.07	-.01	-.07	.94	-.14-.37
Gender	.03	.08	.05	.38	.71	-.13-.18
Special education status	-.05	.06	-.11	.73	.47	-.17-.08
Algebra credit	.15	.07	.34	-2.16	.04*	.01-.29
Race	.04	.03	.22	1.64	.11	-.01-.10
Age	.03	.02	.20	1.39	.17	-.01-.08

Note: $R^2 = .25$; *$p < .05$

Finally, I examined the correlations between the measures. All of the measures were correlated with each of the other measures, $p < .01$.

Table 11

Correlations between outcome variables

	1	2	3	4	5	6
1. KM Numeration	---					
2. KM Algebra	.86**	---				
3. KM Foundations	.68**	.71**	---			
4. KM Applied	.83**	.83**	.74**	---		
5. WRAT	.86**	.81**	.65**	.77**	---	
6. DT-PAM	.74**	.78**	.59**	.68**	.77**	---

** $p < .01$

Chapter IV

DISCUSSION

The purpose of this descriptive study was to measure and report the comprehensive math achievement of youth in short- and long-term juvenile facilities and investigate specific math skill deficits among committed and detained youth. As described in the literature review, math assessment in juvenile facilities has been examined in the peer-reviewed research for four decades. However, little research has investigated specific areas of mathematical deficit among this population of youth. Given the critical importance of math literacy to high school completion and future independence (James, 2013; Mathematical Sciences Education Board, 1995), a sharper focus into the math achievement of this vulnerable population was necessary.

Before providing information on study findings, it was important to compare the demographics of this sample to national demographic estimates of the larger population. In terms of race, this sample was disproportionately African American. While the OJJDP (2014) estimated that about 40% of youth in juvenile facilities nationally in 2011 were African American and 32% were White, in this sample 68% of youth were African American and 24.6% were White. Youth from other ethnicities were practically unrepresented, with just one youth reporting Hispanic ethnicity, one reporting Middle Eastern ethnicity, and one reporting Native American Ethnicity. The makeup of the sample could have been a result of a small sample size, or it could reflect the overall makeup of juvenile facilities in the region. Because the state of Tennessee does not publicly report statewide youth demographics for youth in custody, it is difficult to determine, and further study would be required in order to fully answer this question.

Youth gender mapped much more closely on the national data reported by the OJJDP (2014), which indicated that that there were about eight times as many males as females in the juvenile facilities in the United States. This study's sample was about 16% female (*n* = 9) and all females were recruited from a single facility. Nationally, and in this sample, girls were far less likely to be committed and detained than boys.

The special education status of the sample also mapped closely to the national estimates as reported by Quinn et al. (2005). Quinn and colleagues determined that about 33.4% of youth in long-term juvenile facilities were qualified for special education. In this sample, which was mixed long- and short- term, 31.2% were eligible for special education, according the facility administration in long term settings, or student self-report in short-term settings. These rates were almost triple the identification rate within the general population (U.S. Department of Education, 2015), and support Quinn et al.'s position that students with disabilities are overrepresented in juvenile facilities.

In regard to research results, I had three main research questions, which generated nine main findings. My first two research questions asked how study youth scored on measures of math achievement, and whether achievement varied according to demographic variables. First, in a study of group differences, youth in short and long-term settings did not demonstrate a difference in any assessed measure of math achievement. These findings were consistent with earlier research conducted by Krezmien et al. (2008) regarding achievement across juvenile settings. The youth also did not differ in age, special education status, or ethnicity. Because the groups did not vary by assessed achievement, these subsamples were combined in order to provide overall descriptive information regarding math achievement. The youth did differ on Algebra I status (whether credit had been received), and this finding is discussed in more detail below.

Second, on average, the youth assessed in juvenile facilities performed poorly on standardized measures of math achievement and algebra readiness. The sample's standard score (SS) on basic arithmetic skill, as measured by the WRAT 4, was in the low average range. The sample, with a mean age of 16 years, demonstrated a mean grade equivalency of 5.1 on the WRAT. These findings were similar to those of earlier studies assessing math skills in youth facilities (Beebe & Mueller, 1993; Ficke et al., 2006; Grigorenko et al. 2013; Krezmien et al., 2008; Lansing et al., 2014; Marshall et al., 1978; Perkins et al., 2014).

In terms of specific youth skills related to algebra as measured by the KeyMath 3, the sample scored in the below average range across skills. Grade Equivalence (GE) scores were in the late fourth grade, early fifth grade for all subtests. The KeyMath 3 subtests measured skills that undergird algebra success like fractions, decimals, percentages, exponents, multiples (Numeration subtest) and skills relevant to algebraic understanding like ratio and proportion, order of operations, and ability to work with equations (Algebra subtest). The Problem Solving subtests measured skills related to the planning and application essential to solving math problems.

Based on previous assessment research conducted in juvenile facilities, I hypothesized that youth in long- and short-term facilities would demonstrate similar achievement, and as a combined sample, would demonstrate deficits in standardized math achievement. These hypotheses were proved true. The present sample performed in the below average range on two standardized measures of math achievement. The youth in this sample struggled to understand math concepts necessary to support algebra competence. While this study aimed to identify specific areas of math weakness, overall findings indicated that youth were below average across a range of skills and likely require intensive and comprehensive intervention.

Third, the results of these analyses indicated that youth were at least as prepared as the DT-PAM norming sample to take Algebra I. The DT-PAM assesses many competency areas that may be related to algebra success, including fraction and decimal sense (Siegler et al., 2012; Wu, 2010), vocabulary, order of operations, equation writing, proportions and ratios (Bottoms, 2003) and problem solving (Fuchs et al., 2014). Although standard scores were not available for this measure, the publishers reported a mean score of 23.2 with a standard deviation of 10.41 among 580 eighth grade students who were administered the test in one day. Youth in this study sample were also administered the measure in one day, but were older on average than the norming sample. On average, the youth in the study sample scored a higher mean, and demonstrated greater variability in their scores than the youth in the norming sample. Because standard scores were not available for this measure, interpretation of the DT-PAM score was somewhat limited. Further analyses examining the correlation between the study measures indicated that the DT-PAM was significantly correlated with both the WRAT and the KeyMath 3 subtests ($p > .001$). These analyses, discussed in more depth below, indicated that youth performance was fairly consistent across measures.

Fourth, while youth math achievement on math achievement tests did not vary by gender or setting, African American youth and youth in special education scored significantly lower on measures of mathematic achievement than their White peers and their peers not identified for special education services in t-test analyses. Additionally, youth with Algebra I credit scored significantly higher on the DT-PAM.

African American youth scored significantly lower than White youth on three of the four KeyMath 3 administered subtests. These subtests (Numeration, Foundations of Problem Solving, and Applied Problem Solving) all measured knowledge and skills necessary for algebra success.

Similarly, youth in special education scored significantly lower than youth not in special education on two of the same measures of math achievement (KeyMath 3 Numeration and Applied Problem Solving) and the KeyMath 3 Algebra subtest.

While study youth demonstrated differences on areas assessed by the KeyMath 3, the youth did not differ by race or special education status in terms of basic arithmetic skills, as measured by the WRAT, or Algebra I readiness, as measured by the DT-PAM. The youth also did not exhibit group differences on the Algebra subtest of the KeyMath 3. These results suggest that although this sample of detained and committed youth possessed broad math achievement deficits, African American youth and youth in special education demonstrated even weaker achievement in the basic skills that undergird algebra success and in the specific area of math problem solving, as measured by the KeyMath 3. These findings support the development of specific intervention for vulnerable youth, and echo the findings of earlier studies examining group differences based on race (Baltodano et al., 2005; Krezmien et al., 2008; Lansing et al., 2014; Grigorenko et al., 2013), and special education status (Krezmien et al., 2008; Baltodano et al., 2005; Zabel & Nigro, 2001).

Fifth, in regression analyses, the full models predicting scores on the KeyMath 3 Algebra subtest, KeyMath 3 Applied Problem Solving subtest, and the DT-PAM were significant; however, only one predictor was significant in each of these models.

Special education status was a significant predictor for each of the KeyMath 3 subtests. Although Race was the next largest predictor after Special education status, Special education status uniquely and significantly explained the variance in math achievement on these measures. With the information gleaned from t-test analyses, it became clear that among this youth sample that scored well below grade level across measures of math achievement, youth in special education were especially unprepared to take and pass Algebra I.

Algebra I completion was the only significant predictor of the outcome DT-PAM score. This sixth finding echoed the t-test analyses conducted on group differences in DT-PAM score, which indicated that students with an Algebra I credit outperformed those without one on the DT-PAM. This result was not surprising on its own, as students who have established proficiency in Algebra I would be expected to score relatively better on an Algebra I readiness assessment. It was surprising however, that Algebra I status did not significantly contribute to the remaining outcome measures, particularly the KeyMath 3 Algebra and Problem Solving subtests.

Algebra I status was used as both a demographic predictor of outcome and in separate analyses, as a measure of achievement. A surprising seventh finding was that most youth in the sample had already earned an academic credit for Algebra I. The vast majority of youth (over 70%) had an Algebra I credit. While these rates of Algebra I credit completion were encouraging on one hand, they were also somewhat problematic, when considered alongside youth achievement data for this sample. In an examination if group differences based on Algebra I completion, youth with Algebra I credit only differed from youth without an Algebra I credit on DT-PAM score. The groups had similar achievement on standardized measures of math achievement. It was surprising that youth with below average math skills across standardized measures demonstrated proficiency in Algebra I coursework in such large numbers. While it is possible these youth were provided accommodations to support learning despite deficits, it is also possible that for some students, an Algebra I credit masked significant skill deficits in math.

In considering Algebra I as a measure of achievement, I also examined group differences between students who had an Algebra I credit versus those that did not. In my eighth study finding, students with an Algebra I credit did not differ based on age or race, but did differ based on setting and special education status. Youth in long-term settings were significantly more likely to have an Algebra I credit, and in one long-term facility, every youth (n = 23) assessed was reported to have an Algebra I credit. Data relating to where Algebra I credit was earned (prior to facility admission or during the period of commitment) were not gathered for this study, but it is possible that youth in long-term settings completed Algebra I in the stable facility school placement, while the youth in short-term settings, who were taking the bulk of their math courses in their community schools, could have been subject to factors (like detention, truancy, or out of school suspension) that impacted progress in Algebra I coursework.

Youth in special education also had significantly lower rates of Algebra I completion. This finding illuminates the regression analysis described above, which indicated that special education significantly explained youth scores on measures of math achievement which support algebra success. While study youth demonstrated math achievement deficits across measures and demographics, youth in special education were particularly vulnerable to low math achievement, and for this sample, lower achievement was related to lower rates of Algebra I completion. For this subsample of youth, intervention into skills that support algebra appeared to be of critical importance.

Finally, I examined the correlation of each measure used in this study with the other measures. Since the DT-PAM had not previously been correlated with the WRAT or the KeyMath 3, this analysis could have provided important information about this measure related to this study. Each of the measures was significantly correlated with each of the other measures, reinforcing the position that the measures indeed assessed the same broad construct. This result also indicated that youth performed consistently across measures, despite demonstrating a DT-PAM score closer to the norming group mean.

Overall Summary of Findings

Math literacy is critical for youth moving into the workforce. In this study and in others, researchers have demonstrated the below average math achievement of youth in juvenile facilities. This math achievement deficit may undermine youth earnings post-high school, and threaten future independence (Mathematical Sciences Education Board, 1995). This situation is untenable for the youth who experience it, and math intervention is critical. The purpose of this study was to examine relationships within the data to identify possible relationships between predictors and outcomes, and generate hypotheses that could be subject to more rigorous future examination. This study demonstrated that for this sample, academic deficits were pervasive and not limited to specific categories of math skill. Students in special education and African American students were particularly at risk for deficits related to problem solving skills that support, and African American students struggled with the numeration skills that support Algebra success.

Algebra I completion in long-term youth facilities may warrant further analysis as well, as youth performed poorly on measures of math achievement, but demonstrated proficiency in coursework. This surprising result could indicate that some facilities have found tools to accommodate low math skills that warrant further investigation or that Algebra I credit masks critical academic deficits. Students in special education were less likely to have completed Algebra I, and could require additional support in order to be successful.

Implication for Researchers, Practitioners, and Policymakers

Implications for researchers. There is evidence that most youth in short and long-term juvenile settings underperform their non-committed peers in the area of mathematics. The assessments described in this study provide important information regarding standardized math achievement performance as well as specific deficits relating to algebra readiness of youth in juvenile facilities.

In order to address these deficits, future research should focus on the delivery of math intervention in juvenile facilities. Intervention aimed at improving basic arithmetic, numeracy, and problem solving could increase the mathematic functioning of youth in facilities, and could lead to higher levels of math achievement. Intervention could also be focused on particular subgroups of students, especially students in special education, who demonstrated significantly greater academic deficits in the skills that support algebra, and were less likely to have earned a credit for Algebra I than their peers without disability. Math intervention research in juvenile facilities is scarce, but critical.

Most youth in this study had already taken and passed Algebra I, despite demonstrating below average math achievement. Future research should continue to examine whether higher math credit is associated with enhanced post-high school outcomes, while also taking into account math achievement. In other words, researchers should ask whether it is achievement that is associated with enhanced outcomes, or just the possession of the high school credit. Either finding could have potential implications for practice and policymakers.

Additionally, given the mounting evidence that these youth are significantly behind in math achievement, researchers might consider whether other math skills, related to independent living, might be associated with improved outcomes post high school.

Implications for practitioners. This study has important implications for teachers and administrators of facility schools. On average, youth held in juvenile facilities perform lower on measures of math achievement, as demonstrated by this and earlier studies. African American youth and youth in special education generally score lower than their White counterparts and youth not in special education on math achievement, and might especially benefit from math intervention. Practitioners should intervene early and consistently on the math skills of all youth in juvenile settings, and should progress monitor deficit areas to ensure intervention efficacy.

Implications for policymakers. Finally, this study has important implications for policymakers. There is growing evidence that math achievement is tied to future independence. Youth in juvenile facilities are more likely to experience any number of factors that undermine independence, including reduced academic achievement. While researchers in other fields have focused on evidenced based practices to reduce recidivism in youth programs (Lipsey, Howell, Kelly, Chapman, & Carver, 2010), policymakers focus increased resources on improving the academic achievement of youth in juvenile justice settings.

Policy makers should also consider the overwhelming evidence that youth in juvenile facilities are significantly behind in math skill, and determine where resources should be delivered in order to supply the greatest benefits to this vulnerable population post high school. This study focused on Algebra I readiness, but there may be other math skills related to independent living that might be as useful, or more useful, to these youth.

Limitations of Current Research

While this study provided an initial understanding of the math achievement and algebra readiness of youth in juvenile facilities, there were also limitations that must be addressed. The first limitation, and perhaps the most significant, was the sample size of the study. The sample was low enough that true effects might not have been detected in the sample. Indeed, in some group comparisons, especially related to independent variables Ethnicity and Special education status, the resulting effect sizes were large, but insignificant. It is quite possible that a larger sample would uncover more significant differences among these youth.

The entire study sample numbered only 57 youth, and various subsamples were much smaller than that. Youth in short-term settings numbered only 21, while youth in long-term settings numbered 36. Only nine girls participated in the study, and all of these girls were housed in one long-term facility. Additionally, only 14 youth reported that they were White. Because of the issues related to limited sample sizes, all group comparisons and regression analyses should be interpreted with caution.

Because this study was exploratory in nature, multiple analyses were conducted in order to discover group differences among the youth in the sample. The purpose of these analyses were to examine relationships within the data to identify possible relationships between predictors and outcomes, and generate hypotheses that could be subject to more rigorous future examination. Although I accounted for multiple significance testing in my analyses, it is possible that some significant effects are due to type I error, and results should be regarded as preliminary and unreliable unless they can be rigorously tested and replicated in future studies.

Another limitation of the current research was the use of self-report in data collection. Because youth in short-term settings did not reliably have school records available, students were asked to self-report whether or not they had completed Algebra I and whether or not they were in special education. It is possible that some youth in the short-term setting did not answer these questions accurately, and as such, the results presented here may be flawed.

Despite these limitations, this study provides an important focus into the math achievement of youth in juvenile facilities. First, this study reinforces a growing body of literature by documenting the critical math achievement deficits among this most vulnerable population of youth, and also goes beyond the available research by digging into specific skill deficit areas. This study also provides initial evidence that youth in juvenile facilities are demonstrating proficiency in Algebra I coursework, while performing below average on measures of math achievement. This finding is paradoxical and incites questions regarding intervention and accommodation in Algebra I coursework in juvenile facilities and in the community schools where these youth originate.

This study provides an initial understanding of the broad math achievement deficits of one sample of committed and detained youth. Overall, the youth performed similarly to other youth samples from the population on the broad measure of mathematic achievement. Previous research had not identified specific areas of math weakness among this population, but this study provides evidence that for this sample, the areas of math deficit were pervasive, and certain youth, including youth with disability, were especially vulnerable. Youth committed or detained to juvenile settings are vulnerable to a multitude of factors that limit independence, including low achievement. However, there is some evidence that academic improvement may improve outcomes for these youth (Blomberg, Bales, and Piquero, 2012). Within the academic realm, math literacy is critical, as research indicates that higher math proficiency is associated with increased income and independence after high school (James, 2013).

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