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Learning loss intervention in primary school children: Differences in mathematics performance, confidence, and self-efficacy across term-time and a school holiday

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ABSTRACT

Children's academic performance has pervasive ramifications for their future prospects and life chances (Field, 2010). Yet, the influence of self-beliefs on children's mathematics performance has not been addressed with the additional consideration of learning loss after school holidays. Furthermore, previous findings from the learning loss literature are often confounded by methodological flaws (Cooper *et al*., 1996). A new measure of mathematics performance, confidence, and self-efficacy (MPAC-MSE) controlled for ability and cognitive functioning differences. A 3 x 3 mixed measures design explored differences in mathematics performance, confidence, and self-efficacy in 100 primary school children when assessed before and after a period of formal education, and again after a short school holiday, with a mathematical intervention, non-mathematical intervention, or no intervention. Main analyses found significant, disordinal interactions for mathematics performance and confidence, but not for mathematics self-efficacy. Simple effects illustrated how self-directed, diminutive engagement in a mathematical intervention led to significant increases in mathematics performance and confidence. These improvements were almost indistinguishable from those observed after an equivalent period of teaching. The non-significant fluctuations observed after a non-mathematical intervention or no intervention suggest that mathematics performance, confidence, and self-efficacy remain stable across a short school holiday. Implications for traditional and year-round education calendar structures are considered. Recommendations for further research include extending the testing period after returning to formal education from a school holiday and exploring parental attitudes and self-beliefs toward their involvement in home-based interventions for their children during longer school holidays.

Key Words	Learning Loss	Intervention	Primary School Children	Mathematics Performance	Mathematics Confidence	Mathematics Self-Efficacy

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INTRODUCTION

Children's Academic Performance

In England, regular assessments of children's academic performance inform teachers, schools, support services, and government departments of pupil progress. They determine specialist education provision and resource allocation, contribute to the monitoring and evaluation of a school's overall effectiveness via national performance league tables, and regulate further education and employment opportunities (DES, 1988; Mansell, James, & the Assessment Reform Group, 2009). With such pervasive ramifications for future prospects and life chances (Field, 2010), potential influences on children's academic performance have been of considerable interest for some time, however, there remains to be substantial gaps in the literature.

Learning Loss and Year-Round Education

In most English primary schools, 190 days of formal education are assigned to three main terms, which are separated by two-week breaks at Christmas and Easter. There are further one-week breaks in October, February and June, and a six-week summer break separates each academic year. As children are no longer required to assist with summer agricultural duties (Ballinger, 1988), this calendar structure is purportedly an outdated, part-time education that impedes the year-round process of learning (Glines, 1998). Implementing year-round education could ameliorate teaching provision by decreasing information loss through decay (Arthur *et al*., 2007), reducing recapitulation of previously learned material (Cooper, Nye, Charlton, Lindsay, & Greathouse, 1996), inciting better development of learning attitudes and key skills (Davies & Kerry, 1999; Speck, 1998), and suppressing the documented decline in children's academic performance between the summer and autumn terms, commonly labelled *learning loss* (Farrell, 1991; McCasland, 1992; Winters, 1995).

The current understanding of learning loss and the potential benefits of year-round education is predominantly derived from American research (Davies & Kerry, 1999). For example, compared with children learning in a traditional calendar structure, 11 year old children in year-round education showed four months' more mathematics growth and seven months' more reading growth across one academic year (Loyd, 1991). But, a meta-analysis reported that only a small number of studies included the aggregate number of days in the academic year, and none tested children on the last and first days of the academic years in question (Cooper *et al*., 1996). Researchers typically use scores from standardised tests, administered in May and October. Subsequently, these scores are inaccurate representations of children's performance between two academic years; using these scores inadvertently amalgamates periods of formal education into the summer break. This incites the potential overstatement and understatement of the effects of learning loss and teaching, respectively (Alexander, Entwistle, & Olson, 2007).

In addition to methodological problems, there are concerns regarding the generalisation of findings across continents. Unlike the traditional English academic calendar, American schools typically begin their academic year at the end of August. American formal education is then largely continuous, with a one-week break in spring, a two-week break for Christmas, and breaks of between one and three days' duration for public holidays. A final break of two to three months separates the academic years. Consequently, further research within the English education system would be an important contribution to the literature.

One project exploring the potential for year-round education in England trialled a 45-15 calendar structure comprising cycles of teacher-led formal education (40 days), self-directed learning (five days), and a break (15 days) (Davies & Kerry, 1999). Whilst overall positive evaluations were obtained from student, parent and teacher questionnaires, Davies and Kerry cautioned not to prematurely accept this structure as the optimal approach, and encouraged an exhaustive examination of alternative structures before significant amendments are made.

To address the issues discussed here, the optimal approach would be to defer the focus from summer learning loss to that of differences in children's performance across shorter breaks. Specifically, measures of performance recorded on the last day of the autumn term in December and the first day of the spring term in January could be compared. The Christmas break from formal education is of particular interest because it is of two weeks' duration and included in the English, American and year-round education calendar structures.

Mathematics Performance

There are remarkable, national and worldwide differences in children's mathematics performance (Cooper *et al*., 1996), which manifest from complex interactions between cognitive and social factors. For example, insufficient sleep is considered to be particularly detrimental, due to its association with behavioural problems and cognitive functioning deficits (Astill, Van der Heijden, Van IJzendoorn, & Van Someren, 2012), whilst the association between performance and social background may be due to differences in a child's home experiences, as determined by parental SES and education level (Alexander *et al*., 2001, 2007; Chin & Phillips, 2004; Day, Martin, Sharp, Gardner, & Barham, 2013; Field, 2010). Material possessions and enriching activities place children of a higher SES at an advantage in terms of their cognitive functioning and, consequently, their mathematics performance (Farah *et al*., 2006; Nunes *et al*., 2009; Sarsour *et al*., 2011). For example, deficits in a child's working memory (Alloway, 2006; Arthur, Bennett, Stanush, & McNelly, 1998; Kaufman, Reynolds, Liu, Kaufman, & McGrew, 2012; Sloutsky & Fisher, 2004) are associated with low SES and consistently poor performance in calculation-based and word-based problems such that overall academic progress is worse than their same-age peers (Bull & Scerif, 2001; Geary, Hoard, & Hamson, 1999; Passolunghi & Siegel, 2001; Wilson & Swanson, 2001).

The predominant focus of learning loss investigation and intervention has been the detriment of long school holidays to children's reading skills (Alexander *et al*., 2007; Cooper *et al*., 1996; Kim & White, 2008). Little research has explored mathematics performance fluctuations and the potential influence of affective factors, specifically across shorter school holidays. Short-term fluctuations and declines in children's self-competence, which mediates performance motivation (Eccles *et al*., 1993), form a gradual, declining trajectory throughout their time in education (Jacobs, Lanza, Osgood, Eccles, & Wigfield, 2002).

Potential changes in children's affect and self-beliefs during school holidays may impact upon their subsequent mathematics performance when they return to formal education; this possibility has yet to be considered within the context of learning loss, which may be owing to contradictory findings across the literature. Whilst Pajares and Miller (1994) advocated that children's attitudes were related to their achievement, Mortimore and colleagues (1988, in Nunes *et al*., 2009) had previously found that attitudes and achievement were largely independent of one another. Such discrepancies may have arisen from discreet differences in affective measures used and by content disparities between different measures of mathematics performance. These content disparities arise due to target sample age and diverse interpretations of mathematical skills and competence (Szücs & Goswami, 2013), which complicate interpretations and meta-analyses within the literature. For the purposes of this research, a mathematics performance measure should comprise tasks which are representative of nationally-taught skills within education. Additionally, controlling for differences in ability and cognitive functioning would facilitate universal comparisons of performance fluctuations.

Mathematics Self-Efficacy

Self-efficacy is the pervasive agency mechanism of belief in one's capability to control environmental events and personal functioning, such as performing a particular task (Bandura, 1991, 1993). But, individual ability is an unstable construct; changes to self-efficacy beliefs can result in performance fluctuations, irrespective of knowledge or skills (Bandura, 1993). Self-efficacy is developed through verbal persuasion, vicarious experience and physiological reactions, but is most susceptible to the influence of mastery experience (Bandura, 1986, 1997). Williams and Williams (2010) established cross-cultural support from 24 countries for Bandura's (1978, 1986) theory of reciprocal determinism, which purports that an individual's schema, comprising self-efficacy judgements and aspirations, is informed by their past performance. This schema then informs future performance through analytic thinking and goal setting (Bandura, 1993).

Thus, self-efficacy is not only a good predictor of mathematics performance, but is a better predictor than ability (Hacket & Betz, 1989). Specifically, high levels of self-efficacy are associated with resilience to failure, improved motivation, confidence, efficiency, and the consistent and competent use of analytic strategies, leading to better performance (Bouffard-Bouchard, 1990; Collins, 1982; Pintrich, 1999), particularly when working memory demands are high (Hoffman & Schraw, 2009) or when ability is perceived to be an acquirable skill rather than an innate quality (Wood & Bandura, 1989). High levels of self-efficacy can be induced through the promotion of positive beliefs and reduction of negative beliefs (Andrews & Debus, 1978; Schunk, 1984; Wilson & Linville, 1985), and with performance- and ability-related attributional feedback (Schunk, 1982, 1983; Schunk & Gunn, 1986). More recently, Falco, Summers and Bauman (2010) improved children's mathematics self-efficacy with a school counselling intervention that taught planning, goal-setting and strategy use.

The indirect influence of self-efficacy on behaviour through secondary means requires further investigation; particularly, how young children's mathematics performance may be vulnerable to self-efficacy fluctuations (Pajares, 1996, 1997). Over-confidence in young children may increase their effort and persistence, such that self-efficacy should only decline after repeated task failure and disappointment (Bandura, 1986), yet the accuracy, stability, and temporary failure resistance of their self-efficacy develop gradually over time (Bandura, 1977, 1997; Bong & Skaalvik, 2003; Gist & Mitchell, 1992). Pajares and Graham (1999) noted differences in children's mathematics self-efficacy over a period of six months, but concluded that the difficulty of their assessment measures may have confounded their findings. Declines in academic values and self-efficacy have also been identified across the summer transitional period between elementary and middle school, which has been ascribed to perceived parental goals (Friedel, Cortina, Turner, & Midgley, 2010), teacher goals (Anderman & Midgley, 1997; Gutman, 2006; Pintrich, 2000), and new peer groups (Wentzel, 1999).

Longitudinally, children's mathematics values and competence beliefs gradually decline as they progress through education (Jacobs *et al.*, 2002; Wigfield *et al.*, 1997); yet, little research has explored the potential influence of school holidays, when opportunities for developing and maintaining mathematics self-efficacy beliefs are reduced. Breaks from formal education may prompt the re-evaluation of and decline in self-efficacy beliefs in conjunction with performance declines (Bandura, 1978, 1986), yet this has not, to the best of the current author's knowledge, been considered previously by investigations pertaining to children's self-efficacy or learning loss, specifically in the domain of mathematics.

Mathematics Confidence

Confidence is the self-assessed belief in one's abilities (Kleitman & Gibson, 2011; Kleitman & Stankov, 2007), which may be more accurately aligned with performance than other self-beliefs (Boekaerts & Rozendaal, 2010; Morony, Kleitman, Lee, & Stankov, 2013; Stankov, Lee, Luo, & Hogan, 2012). When measuring confidence as a dimension of self-efficacy, judgements are made prior to task completion or of a hypothetical task that participants do not complete (Zimmerman, 1996). As a separate construct, however, judgements are recorded after task performance; unlike other self-beliefs, confidence involves different cognitive processes, such as metacognitive monitoring. To ascertain whether one's response to a task is correct, confidence encompasses beliefs about one's own abilities, one's capability to use known strategies appropriately and effectively, and task difficulty (Cramer, Neal, & Brodsky, 2009; Kleitman & Stankov, 2007; Kleitman & Gibson, 2011; Lai, 2011).

Cross-sectional (Eccles, Wigfield, Harold, & Blumenfeld, 1993) and longitudinal (Wigfield & Eccles, 1994) studies have identified higher levels of mathematics confidence in younger children, aged between six and seven years, than in older children of approximately nine years old. Mathematics confidence declines are evident at the point of transition to middle school before continuing to decline throughout the following academic year (Wigfield & Eccles, 1994). Using data from the Avon Longitudinal Survey of Parents and Children (ALSPAC) study, Nunes and colleagues (2009) found that children's mathematics confidence independently influenced their mathematics performance. Furthermore, a recent, large-scale study exploring mathematics self-beliefs of European and Asian students acknowledges confidence to be the strongest predictor of performance accuracy (Morony *et al.*, 2013): Whilst confidence could not account for a small amount of variance that was explained by self-efficacy, it accounted for most of the mathematics accuracy variance that all of the self-beliefs explained collectively.

Nunes and colleagues (2009) suggested that augmenting children's mathematics self-beliefs may improve their performance. However, the task of identifying and implementing such interventions was delegated to teachers. This is consistent with social cognitive theorists, who purport that this is most effectively achieved with mastery experience (Pajares, 1997). Recent research has shown that university students' learning can be better self-regulated by incorporating regular confidence measures (Kleitman & Costa, 2014), yet these findings need to be extended to determine how such measures may enhance younger children's learning (Morony *et al*., 2013). Consequently, the extent to which young children's mathematics confidence may fluctuate across school holidays and whether mathematics learning loss can be inhibited via the augmentation of mathematics confidence should be explored.

Aims and Hypotheses

The main aim of this research was to explore potential differences in primary school children's mathematics performance, confidence, and self-efficacy before and after a period of formal education and after a school holiday with either a mathematics intervention, a non-mathematics intervention, or no intervention.

Before and After Formal Education

It was predicted that mathematics performance, confidence, and self-efficacy scores would be higher after a period of teaching than before teaching.

Before and After a School Holiday

It was predicted that mathematics performance, confidence, and self-efficacy scores would be higher before a school holiday than after a school holiday. It was also predicted that mathematics performance, confidence, and self-efficacy scores would be higher for children in a mathematical intervention group than for children in a non-mathematical intervention or no intervention group. Finally, it was predicted that mathematics performance, confidence, and self-efficacy scores would be highest for children in the mathematical intervention group when assessed before a school holiday than for children in any other condition.

METHOD

Participants

A Measure of Mathematics Performance

Three teachers with Qualified Teacher Status (QTS), employed in a Derby City community primary school, were selected to participate via purposive sampling. They each received a five pounds high-street voucher as a gesture of appreciation for their time.

Main Study

The head teacher of a Derby City community primary school, operating under the traditional calendar structure, approved the invitation of 359 children, their parents/carers, and 14 teachers, across Key Stages One and Two to participate via purposive sampling. Children on roll with special educational needs, English as a second language, and free school meals eligibility (3.7%, 4.0%, and 3.7%, respectively) were below the national average. The researcher's children were excluded from participation, in addition to children and teaching staff in Foundation Stage Two, which operates under a different educational framework. Participation was voluntary and 65 children were withdrawn. Before data collection, 19 children were withdrawn by parents/carers and two teachers with a job-share arrangement opted out so their class of 29 children were also withdrawn. One child was withdrawn by their parent/carer before test two, 11 children were withdrawn by parents/carers before test three, and five children were withdrawn by parents/carers after all data collection. From the 294 participating children, two sub-samples were formed. Sub-sample one comprised 197 children (99 males, 98 females) aged between five years, three months and 11 years, one month (*M* age = seven years, 11 months), with complete data for test one and test two, to be used for reliability analyses. Sub-sample two comprised 100 children (49 males, 51 females) aged between five years, four months and 11 years, 0 months (*M* age = eight years, one month), with complete data from all research elements, to be used for the main analyses. A hamper of food and drink items was given to the teaching and administration staff after data collection was complete and all children received a certificate of achievement, regardless of intervention participation.

Design

Differences in mathematics performance, confidence, and self-efficacy before and after a period of teaching and after a school holiday, with a mathematical, non-mathematical, or no intervention, were explored using a 3 (time of assessment) x 3 (level of intervention) mixed measures design. The dependent variable of mathematics performance was derived from the sum of responses to 28 mathematics questions (MPAC), where correct responses were recorded as 1 and incorrect responses were recorded as 0. The dependent variable of mathematics confidence was derived from the sum of judgements recorded after children had completed each of the 28 mathematics performance questions (MPAC)**.** The third dependent variable of mathematics self-efficacy was derived from the sum of scored responses to the mathematics self-efficacy (MSE) measure.

Children were assessed across all three levels of the within-subjects independent variable of time of assessment: before a period of teaching; after a period of teaching; and after a school holiday. There were 17 days between each assessment and the latter two time points were the last day of the autumn term and the first day of the spring term, respectively. The between-subjects independent variable of level of intervention consisted of three levels; children were randomly allocated (http://www.random.org) to a mathematical or non-mathematical intervention group. Children from either group who returned, but did not complete, their designated intervention were deferred to the third level of no intervention.

To control for order effects, the mathematics performance and confidence (MPAC) questions were presented in a different order at each time of assessment and each class of children was allocated to one of two assessment orientations: mathematics self-efficacy followed by mathematics performance and confidence (MSE-MPAC); or mathematics performance and confidence followed by mathematics self-efficacy (MPAC-MSE).

Materials

Mathematics Performance

A multidimensional, ability-controlled measure was required to ascertain children's mastery of mathematics knowledge and skills. In accordance with the National Curriculum Mathematics Framework for Key Stages One and Two (DfE, 2013), 201 questions were drafted by the researcher. For currency handling questions, relevant permissions were sought for the reproduction of bank notes. Following inter-observer reliability analyses, 28 questions with the highest levels of consistency were incorporated into each of five assessment tiers, which corresponded with National Curriculum attainment sub-levels (DfES, 2011): Tier One (Sub-levels P5-8, 1c, 1b, and 1a); Tier Two (Sub-levels 2c, 2b, and 2a); Tier Three (Sub-levels 3c, 3b, and 3a); Tier Four (Sub-levels 4c, 4b, and 4a); and Tier Five (Sub-levels 5c, 5b, and 5a).

Mathematics Confidence

A 28-point self-report measure ascertained retrospective judgements of mathematics confidence for each of the 28 mathematics performance questions. One practice item was included to acclimatise children to the response format, which consisted of a four-point Likert scale accompanied by circles of increasing size. These scales represented confidence judgements from 0% to 100% as a simplified alternative for deployment with young children than the standard 10- or 100-point scales (Bandura, 2006). The following scoring system was implemented: not sure at all (0); a little sure (1); very sure (2); and totally sure (3). Previous research explored a similar measure of confidence ($\alpha = .90$), although they deployed an alternative response scale for 15 standardised mathematics items with 11 year olds (Kleitman & Gibson, 2011).

Mathematics Self-Efficacy

A mathematics self-efficacy (MSE) measure was devised to encompass the main contributing factors to self-efficacy (Bandura, 1986, 1997; Gardner, 2011): mastery experiences (13 items, 4 reversed); vicarious experiences (5 items, 2 reversed); verbal persuasion (7 items); and physiological feedback (3 items, 1 reversed). Twenty-six of the self-report measure's 28 items were simplified and adapted to pertain to mathematics self-efficacy from the children's self-efficacy scale (CSE) (Bandura, 2006), the patterns of adaptive learning scales (PALS) (Midgley *et al.*, 2000), and the motivation for reading questionnaire (MRQ) (Wigfield & Guthrie, 1997). These measures reported acceptable to excellent Cronbach's alpha reliability coefficients ($\alpha = .62$ to $.89$) for 22 items. The coefficients were not reported in the original publication for two CSE items, and one MRQ item ($\alpha = .40$) was removed from Wigfield and Guthrie's (1997) final measure. However, the latter item was adapted to generate two vicarious experiences items (demonstrating mathematics competence in the presence of peers). A further two vicarious experiences items were generated by the researcher to represent helping peers with mathematics problems and one's own mathematics self-efficacy being adversely affected by that of a peer (Bong & Skaalvik, 2003).

All items were presented in first-person tense to facilitate children's understanding. Practice items, one positive ("I like to eat strawberry ice cream") and one negative ("I don't like painting pictures"), were included to acclimatise the children to the response format. The MSE measure's four-point Likert scale responses were accompanied by squares of increasing size, which represented judgements from 0% to 100% as a simplified alternative for deployment with young children than standard self-efficacy measures (Bandura, 2006; Maurer & Pierce, 1998). The following scoring system was implemented: not at all like me (0); a little bit like me (1); a lot like me (2); and totally like me (3).

Intervention Measures: A Parent and Child Pack

Each child and their parents/carers received a sealed document wallet containing a research brief, an informed consent form, instructions, and a child activity booklet with a corresponding answer sheet. Five tiers of mathematical activity booklets comprised ability-appropriate mastery experiences in concordance with the mathematics performance measure, and five tiers of non-mathematical activity booklets comprised ability-appropriate word searches, mazes and colouring activities. To acknowledge the completion of each activity, there were 10 reward stickers featuring images of medals, stars and trophies, alongside praise statements, such as “Good Work!”, “Star Effort!” and “Well Done!” (http://www.schoolstickers.co.uk). A child’s certificate of achievement was included to recognise their effort and ability to complete all 10 activities.

Teacher’s Guide

To support teaching staff, a teacher’s guide comprised a demographic survey, a research schedule, and comprehensive instructions regarding the execution of assessment materials, including guidance for the DVD accompaniment and anonymity and consent protocols.

DVD Accompaniment

Two orientations (MSE-MPAC; MPAC-MSE) of a DVD accompaniment were produced using PowerPoint 2010. These were copied to DVD-R discs in Windows Media Video (.wmv) format for teacher use during assessments. Synthesised children’s voices controlled for literacy ability and standardised the delivery of assessment instructions and the mathematics self-efficacy (MSE) measure.

Demographic Survey

A demographic survey was devised for teachers to record the age, sex and mathematics ability level (according to the most recent teacher assessment) for each of the participating children in their class.

Procedure

A Measure of Mathematics Performance

Three teachers received a research brief inviting them to participate, outlining their right to withdraw, and explaining how their data would be used and stored. Informed consent was obtained, a unique participation code was generated for anonymity purposes, and instructions were provided. One teacher rated all 201 mathematics questions, a second teacher rated 122 questions, and a third teacher rated 79 questions. For each question, they identified which National Curriculum attainment level would be hypothetically awarded to a child for providing the correct answer. Upon returning their completed documents, each teacher was debriefed and thanked for their time.

Main Study

The school head teacher was provided with a research brief before preliminary *in loco parentis* consent was acquired for all Key Stage One and Two children.

Teachers were also briefed and informed consent was obtained individually. Two weeks prior to data collection, parents/carers received an information letter, which outlined the research aims, participation requirements, and how data would be stored and used. This also included a detailed explanation of the consent and withdrawal protocols, and an opt-out form to complete and return to their child's teacher at any time before the last scheduled date for data collection if they wished to withdraw their child. Each class teacher received a teacher's guide and demographic survey to complete for participating children. Survey completion took approximately 30 minutes and was returned to the researcher in a sealed envelope. The survey data were used to allocate children to the appropriate mathematics performance assessment tier.

On the morning of each assessment, the assessment materials were delivered to each classroom in archive boxes. Teachers seated children in their classrooms with their own stationery (pencil, pencil sharpener, rubber, and ruler). No calculators or counting aids were permitted. Then, teachers distributed assessment booklets to children according to their unique participation numbers, read aloud the child consent statement, and initiated playback of the DVD accompaniment on the interactive whiteboard. The DVD provided instructions and practice questions, before commencing the MSE and MPAC assessments. Teachers closely monitored children throughout and were instructed to remove any child who became distressed or verbally indicated their wish to withdraw.

Each MSE statement was simultaneously presented in the assessment booklets, on screen, and vocally to all children. A 10 second pause between each statement, enabled children to indicate in their booklets how much they believed each item was like them or not like them. During the MPAC assessment, children independently attempted each of the 28 mathematics performance questions and corresponding confidence scales in their booklets. A 20-minute timer was visually presented on the interactive whiteboard with visual and vocal prompts of time remaining at five-minute intervals. When the DVD instructed children to stop writing, teachers collected the assessment booklets and stored them in the archive box for researcher collection at the end of the school day. This procedure was repeated for each of the three assessment dates.

Parent and child packs were delivered to the classrooms on the last day of term. After teachers distributed the packs to the children at the end of the day, they were taken home for completion during the school holiday. Parents/carers were directed to read the research brief and sign the consent form. Children were instructed to complete one activity per day (five per week) from their allocated activity booklet, and to engage in each activity for no longer than 20 minutes. After completing each activity, parents/carers used the answer sheet to review the responses. Then, the children could choose one of ten reward stickers to affix to the page in their booklet. After completing five activities, a written praise statement was included in the activity booklet to acknowledge their effort and to encourage completion of the remaining activities. Upon finishing all 10 activities, children could complete and keep a certificate of achievement. The activity booklet and consent form were replaced in the pack, which was sealed and returned to school. Returned packs were stored securely within the classrooms until the end of the first week of term, when the researcher returned to collect them. A debrief letter was given to the head teacher to be read aloud during assembly. It included a statement for the children to thank them for their participation, remind them of how their data will be used and stored, and to speak to a trusted adult if they had any questions or unwanted feelings about the research. The letter also reminded the school that further correspondence would be sent later in the year to provide them with overview of the research findings.

RESULTS

A Measure of Mathematics Performance

Teachers' attainment level ratings for 201 mathematics questions were analysed for inter-observer reliability using Cohen's kappa coefficient and prevalence-and-bias-adjusted kappa ($\kappa(201) = .58$, $p < .001$, CI(95%) = .51 to .66, PABAK = .60). To explore differences in mathematics performance between ability sub-levels, the data (N=197) were analysed using a one-way between-subjects ANOVA. The mean and standard deviation of mathematics performance for the ability sub-levels are presented in Table 1. There was a significant main effect of ability sub-level ($F(2, 194) = 27.76$, $p < .001$, $\eta^2 = .22$, $1\text{-}\beta = .99$). Post-hoc Bonferroni tests indicated that mathematics performance scores were significantly higher for sub-level A than for sub-level B ($p < .001$) and sub-level C ($p < .001$), and significantly higher for sub-level B than for sub-level C ($p < .001$).

Table 1
The Mean and Standard Deviation of Mathematics Performance as a Function of Level of Ability

	C	B	A
M	11.18	14.11	16.87
SD	3.95	4.58	4.06
N	55	73	69

To explore differences in mathematics performance between assessment tiers, the data (N=197) were analysed using a one-way between-subjects ANOVA. The mean and standard deviation of mathematics performance for the assessment tiers are presented in Table 2.

Table 2
The Mean and Standard Deviation of Mathematics Performance as a Function of Level of Tiered Assessment

	1	2	3	4	5
Mean	14.09	14.70	12.74	16.79	15.25
SD	5.65	4.10	5.00	3.58	5.91
N	32	76	61	24	4

There was a significant main effect of tier ($F(4, 192) = 3.64$, $p = .007$, $\eta^2 = .07$, $1\text{-}\beta = .85$). Post-hoc Bonferroni tests indicated that mathematics performance scores were significantly higher for children allocated to tier four than tier three (p = .004), but there were no significant differences in mathematics performance between other tiers.

Main Study

Analytic Strategy

A baseline understanding for the main analyses was first established through the investigation of differences in children's mathematics performance, confidence, and self-efficacy before and after a period of teaching. Differences in children's mathematics performance, confidence, and self-efficacy were then explored before and after a short school holiday with either a mathematical intervention, non-mathematical intervention, or no intervention.

Mathematics Performance

Before and After Formal Education

Mathematics performance was higher after teaching (*M* = 16.17, *SD* = 4.82) than before teaching (*M* = 14.49, *SD* = 4.99). A paired-samples *t*-test showed that this difference was significant ($t(99) = -4.19$, $p < .001$, $d = .42$, $1\text{-}\beta = .98$) with a moderate effect, such that mathematical performance scores increased by six percent.

Before and After a School Holiday

To explore differences in mathematics performance between mathematical, non-mathematical, and no intervention groups before and after a school holiday, the data (*N*=100) were analysed using a 3x2 Factorial Mixed ANOVA. The mean and standard deviation of mathematics performance for time of assessment and level of intervention are presented in Table 3.

Table 3
The Mean (and Standard Deviation) of Mathematics Performance as a Function of Level of Intervention and Time of Assessment

	Time of Assessment		
Level of Intervention	Test Two	Test Three	Total (Intervention)
Math Intervention	15.29 (*5.73*)	16.56 (*5.30*)	15.93 (*5.31*)
Non-Math Intervention	16.69 (*4.26*)	17.26 (*3.87*)	16.97 (*3.77*)
No Intervention	16.55 (*4.32*)	16.00 (*4.34*)	16.27 (*4.15*)
Total (Time)	16.17 (*4.82*)	16.63 (*4.52*)	

Test Two=Before School Holiday
Test Three=After School Holiday

The main effect of time of assessment ($F(1, 97) = 2.22$, $p = .14$, $\eta^2 = .02$, $1\text{-}\beta = .31$) and the main effect of level of intervention ($F(2, 97) = .49$, $p = .61$, $\eta^2 = .01$, $1\text{-}\beta = .13$) were not statistically significant because there was a significant disordinal interaction effect ($F(2, 97) = 3.25$, $p = .04$, $\eta^2 = .06$, $1\text{-}\beta = .61$). This was explored further with simple effects analyses.

Paired samples *t*-tests showed that, after a school holiday, mathematics performance scores increased by five percent for the mathematical intervention group ($t(33) = -2.46$, $p = .019$, $d = .42$, $1-\beta = .59$). This difference reached borderline significance with a moderate effect after Bonferroni corrections ($\alpha = 0.017$). However, mathematics performance scores increased by only two percent for the non-mathematical intervention group ($t(34) = -1.09$, $p = .28$, $d = .19$, $1-\beta = .15$), and declined by two percent for the no-intervention group ($t(30) = 1.23$, $p = .23$, $d = .22$, $1-\beta = .17$). There was insufficient observed power for these smaller differences to reach statistical significance.

Mathematics Confidence

Before and After Formal Education

Mathematics confidence was higher after teaching ($M = 56.55$, $SD = 16.89$) than before teaching ($M = 49.70$, $SD = 18.11$). A paired-samples *t*-test showed that this difference was significant ($t(99) = -5.69$, $p < .001$, $d = .57$, $1-\beta = .99$) with a moderate effect, such that mathematics confidence increased by eight percent.

Before and After a School Holiday

To explore differences in mathematics confidence between mathematical, non-mathematical, and no intervention groups before and after a school holiday, the data (*N*=100) were analysed using a 3x2 Factorial Mixed ANOVA. The mean and standard deviation of mathematics confidence for time of assessment and level of intervention are presented in Table 4.

Table 4

The Mean (and Standard Deviation) of Mathematics Confidence as a Function of Level of Intervention and Time of Assessment

	Time of Assessment		
Level of Intervention	Test Two	Test Three	Total (Intervention)
Math Intervention	56.56 (*21.16*)	61.53 (*19.24*)	59.04 (*19.75*)
Non-Math Intervention	56.51 (*14.89*)	58.20 (*18.91*)	57.36 (*15.53*)
No Intervention	56.58 (*14.09*)	54.65 (*15.79*)	55.61 (*13.99*)
Total (Time)	56.55 (*16.90*)	58.23 (*18.15*)	

Test Two=Before School Holiday

Test Three=After School Holiday

The main effect of time of assessment ($F(1, 97) = 1.92$, $p = .17$, $\eta^2 = .02$, $1-\beta = .28$) and the main effect of level of intervention ($F(2, 97) = .34$, $p = .71$, $\eta^2 = .007$, $1-\beta = .10$) were not statistically significant because there was a significant disordinal interaction effect ($F(2, 97) = 3.01$, $p = .05$, $\eta^2 = .06$, $1-\beta = .57$). This was explored further with simple effects analyses.

Paired samples *t*-tests showed that after a school holiday, mathematics confidence increased by six percent for the mathematical intervention group ($t(33) = -3.34$, $p = .002$, $d = .57$, $1-\beta = .86$). After Bonferroni corrections ($\alpha = 0.017$), this difference was statistically significant with a moderate effect. However, mathematics confidence increased by only two percent for the non-mathematical intervention group ($t(34) = -.72$, $p = .48$, $d = .12$, $1\text{-}\beta = .08$), and declined by two percent for the no-intervention group ($t(30) = 1.02$, $p = .32$, $d = .18$, $1\text{-}\beta = .12$). There was insufficient observed power for these smaller differences to reach statistical significance.

Mathematics Self-Efficacy

MSE Measure Validation

Internal consistency of the mathematics self-efficacy (MSE) measure was explored using Cronbach's alpha. The data (N=197) were screened; the mean and standard deviation for each item is presented in Table 5 alongside the Kolmogorov-Smirnov tests of normality, which were violated for all items.

Initially, Item-Total Correlations were above ($r > .3$) for 12 items and above ($r > .2$) for 21 items ($\alpha = .75$). Sequential removal of eight items optimised both internal consistency (Q8 ($\alpha = .75$); Q22 ($\alpha = .77$); Q6 ($\alpha = .78$); Q20 ($\alpha = .79$); Q18 ($\alpha = .80$); Q17 ($\alpha = .81$); Q27 ($\alpha = .81$); Q24 ($\alpha = .82$)) and Item-Total Correlations ($r = .25$ to .53) for the remaining 20 items. Additional item removal would not have facilitated further improvements to the internal consistency.

Table 5
The Mean, Standard Deviation and Tests of Normality for the Measure of Mathematics Self-Efficacy (MSE)

Item	Mean (*SD*)	*D*
MSE1	2.19 (*1.01*)	.32*
MSE2	1.86 (*0.96*)	.20*
MSE3	1.60 (*1.08*)	.22*
MSE4	1.74 (*1.15*)	.22*
MSE5	2.59 (*0.79*)	.43*
MSE6	2.43 (*1.09*)	.45*
MSE7	2.15 (*1.05*)	.31*
MSE8	2.39 (*1.07*)	.42*
MSE9	1.76 (*1.14*)	.25*
MSE10	1.90 (*1.22*)	.31*
MSE11	2.26 (*1.03*)	.35*
MSE12	2.07 (*1.11*)	.30*
MSE13	2.17 (*0.99*)	.30*
MSE14	2.42 (*0.92*)	.38*
MSE15	2.24 (*1.05*)	.35*
MSE16	1.86 (*1.15*)	.27*
MSE17	1.48 (*1.29*)	.24*
MSE18	1.84 (*1.21*)	.26*
MSE19	1.92 (*1.11*)	.26*
MSE20	2.42 (*1.09*)	.45*
MSE21	2.3 (*0.95*)	.34*
MSE22	1.76 (*1.24*)	.25*
MSE23	2.3 (*0.97*)	.35*
MSE24	2.43 (*0.88*)	.36*
MSE25	1.72 (*1.18*)	.25*
MSE26	1.90 (*1.17*)	.28*
MSE27	2.38 (*1.06*)	.40*
MSE28	2.34 (*0.95*)	.35*

$^*p < .001$

Before and After Formal Education

Mathematics self-efficacy (MSE) was lower after teaching (M = 39.58, SD = 9.41) than before teaching (M = 40.87, SD = 9.08). A paired-samples t-test found this difference to reach borderline significance ($t(99) = 1.92$, $p = .058$, $d = .19$, $1\text{-}\beta = .48$) with a small effect, such that MSE scores decreased by two percent.

Before and After a School Holiday

To explore differences in mathematics self-efficacy (MSE) between mathematical, non-mathematical, and no intervention groups before and after a school holiday, the data (N=100) were analysed using a 3x2 Factorial Mixed ANOVA. The mean and standard deviation of MSE for time of assessment and level of intervention are presented in Table 6.

Table 6

The Mean (and Standard Deviation) of Mathematics Self-Efficacy as a Function of Level of Intervention and Time of Assessment

	Time of Assessment		
Level of Intervention	Test Two	Test Three	Total (Intervention)
Math Intervention	40.50 (*7.44*)	41.32 (*8.98*)	40.91 (*7.07*)
Non-Math Intervention	39.40 (*10.02*)	38.77 (*11.48*)	39.09 (*10.38*)
No Intervention	38.77 (*10.75*)	36.13 (*11.40*)	37.45 (*10.74*)
Total (Time)	39.58 (*9.41*)	38.82 (*10.77*)	

Test Two=Before School Holiday

Test Three=After School Holiday

There were small marginal and cell mean differences in opposing directions for the levels of intervention across the school holiday, but the main effect of time of assessment ($F(1, 97) = 1.46$, $p = .23$, $\eta^2 = .01$, $1\text{-}\beta = .22$), the main effect of level of intervention ($F(2, 97) = 1.08$, $p = .35$, $\eta^2 = .02$, $1\text{-}\beta = .23$) and the ordinal interaction effect ($F(2, 97) = 2.15$, $p = .12$, $\eta^2 = .04$, $1\text{-}\beta = .43$) did not reach statistical significance due to insufficient power.

DISCUSSION

Main Findings

Before and After Formal Education

It was predicted that mathematics performance, confidence, and self-efficacy scores would be higher after a period of teaching than before teaching. As expected, mathematics performance scores significantly increased with a moderate effect, yielding an improvement of 1.7 points. Mathematics confidence scores also significantly increased with a moderate effect, yielding an improvement of 6.9 points. Contrastingly, mathematics self-efficacy scores declined by 1.3 points, but this small effect only reached borderline significance.

Before and After a School Holiday

It was predicted that mathematics performance, confidence, and self-efficacy scores would be higher before a school holiday than after a school holiday. The marginal means indicated that mathematics self-efficacy scores were higher before a school holiday, whereas mathematics performance and confidence scores were higher after a school holiday. However, the main effect of time of assessment was non-significant for each of the dependent variables. It was also predicted that mathematics performance, confidence, and self-efficacy scores would be higher for children in a mathematical intervention group than for children in a non-mathematical intervention or no intervention group. The marginal mean scores of the mathematical intervention group were higher than those of the non-mathematical intervention and no intervention groups for mathematics self-efficacy and confidence. However, for mathematics performance children in the mathematical intervention group had the lowest marginal mean scores. The main effect of level of intervention was non-significant for each of the dependent variables.

Finally, it was predicted that mathematics performance, confidence, and self-efficacy scores would be highest for children in the mathematical intervention group when tested before a school holiday than for children in any other condition. There were significant disordinal interactions with small effect sizes for mathematics performance and confidence, explaining six percent of the variance. Simple effects analyses showed that, whilst the mathematical intervention group had the lowest mean scores for mathematics performance, they had the highest score increase after the school holiday. With a moderate effect, this increase of 1.3 points reached borderline significance. The mathematical intervention group had the highest mathematics confidence scores and the greatest score increase; with a moderate effect, their scores significantly improved by 4.9 points. For the non-mathematical intervention group, mathematics performance scores increased by 0.6 points and mathematics confidence scores increased by 1.7 points; these small effects did not reach statistical significance. Interestingly, for the no intervention group, their mathematics performance scores declined by 0.6 points and mathematics confidence scores declined by 1.7 points; these small effects also did not reach statistical significance. For mathematics self-efficacy, cell means indicated a small score increase for the mathematical intervention group, and small score declines for both the non-mathematical intervention and no intervention groups. The ordinal interaction with a small effect, did not reach statistical significance.

Implications

Coe (2002) proposed that interventions have only a small effect (Cohen, 1969; 1988) on performance due to its resilience to influence in comparison to other outcomes, extensive disparity within the population, and the education system's deployment of optimal strategies. However, in the current study the mathematical intervention, comprising rewards, feedback, and mathematics mastery experiences (Nunes *et al*., 2009; Pajares, 1996, 1997; Schunk, 1982, 1983, 1984; Schunk & Gunn, 1986), yielded a significant, moderate effect: Improvements in mathematics performance and confidence after a short school holiday were almost indistinguishable from those observed after an equivalent period of teaching. Performance sustention rather than improvement was anticipated because mathematics knowledge is particularly vulnerable to decay without adequate rehearsal (Geary, 1995), and intervention engagement was self-directed and of diminutive duration. Instead, the current findings support assertions that information retention is best facilitated via short, regular practice sessions rather than one intensive session (Rohrer & Taylor, 2006; Rohrer & Pashler, 2010). Extensions of the intervention measures, devised within the current study, may be of particular benefit to stem learning loss during the longer traditional summer holiday (Farrell, 1991; McCasland, 1992; Winters, 1995). Further research should address this postulation. The non-significant mathematics performance and confidence fluctuations observed for the non-mathematical intervention and no intervention groups offer support for the proposed changes to the academic calendar (Davies & Kerry, 1999). A school holiday duration of 17 days optimally allows children to pursue extra-curricular, non-academic interests without significantly impeding upon their mathematics performance and confidence.

The small, significant decline in mathematics self-efficacy (MSE) across the period of teaching is concordant with previous assertions of a gradual decline in children's self-beliefs throughout education (Eccles *et al*., 1993; Jacobs *et al*., 2002; Pajares & Graham, 1999; Wigfield *et al*., 1997). Falco and colleagues (2010) stated that "focusing on improving performance alone may not be enough to improve students' self-efficacy [...] when it comes to math" (p. 545). The mathematical intervention enhanced children's mathematics performance and confidence, but the brief reduction in opportunities for developing mathematics self-beliefs across the school holiday did not prompt the re-evaluation of and significant decline in MSE when children were reassessed upon returning to formal education (Bandura, 1978, 1986), as was anticipated. In comparison to the significant self-efficacy declines previously observed across the summer transitional period (Anderman & Midgley, 1997; Friedel *et al*., 2010; Gutman, 2006; Pintrich, 2000; Wentzel, 1999), the non-significant fluctuations observed in younger children across a short school holiday reflect the gradual development of MSE accuracy, stability, and resistance development (Bandura, 1977, 1997; Bong & Skaalvik, 2003; Gist & Mitchell, 1992).

Strengths, Limitations, and Recommendations

A measure of mathematics performance, confidence, and self-efficacy (MPAC-MSE) was successfully devised to control for ability and cognitive functioning differences. This facilitated precise assessments in direct rebuttal of methodological flaws and gaps within previous literature. However, financial and time constraints prevented extending the testing period after the short school holiday. Grenier (1975, in Cooper *et al*., 1996) found that, across the summer break, the mathematical computation skills of 12 year olds declined whilst their concept and problem solving skills improved. By continuing to test the children after returning to formal education, Grenier found that the children recovered computation skills within two weeks. Further research should adopt a similar method to explore potentially similar patterns of mathematics performance, confidence, and self-efficacy fluctuations for younger children within modern educational practise.

Whilst the current research sample included younger children than many previous studies in this field, several cases were deleted due to missing data. This was purportedly due to many children aged between five and six years old misconstruing the requirements of the MSE scale. Thus, adaptions to the MSE instructions, to include further practice opportunities, with a practical demonstration (Bandura, 2006) instead of or in addition to the DVD accompaniment, is highly recommended. These complications principally contributed to the reduced size of the final sub-sample of data, which comprised uneven intervention group sizes. This attenuated the observed power required for some of the smaller effects to reach statistical significance, such as the interesting but non-significant augmentation of mathematics self-efficacy for the mathematical intervention group during the school holiday. In conjunction with increased confidence, which may have increased children's effort and persistence (Bandura, 1986), this observation contrasted non-significant MSE declines for the non-mathematical intervention and no intervention groups across the school holiday, and the significant MSE declines observed for all three intervention groups across the period of teaching. By addressing the issues of power and exploring the impact across longer school holidays, it may transpire that MSE increases can be successfully induced using reward, feedback, and mastery experience (Nunes *et al*., 2009; Pajares, 1996, 1997; Schunk, 1982, 1983, 1984; Schunk & Gunn, 1986). This could be beneficial as a longitudinal intervention approach to stem the documented decline in children's self-beliefs throughout education within the traditional calendar structure (Jacobs *et al*., 2002).

Feedback after debriefing implied that a large proportion of children enjoyed completing their intervention booklets and many parents supported their child's participation. However, some parents and children perceived the mathematical intervention to be an unwelcome impingement upon the school holiday. Parental attitudes and involvement strongly influence children's attitudes and academic performance (Epstein, 1992; Onslow, 1992). Positive parent and child communication, encouragement to learn, and parental expectations and aspirations, augment children's mathematics self-efficacy and intrinsic motivation, thus enhancing performance (Fan & Chen, 2001; Fan & Williams, 2010; Hoover-Dempsey & Sandler, 1995; Jeynes, 2005). The current findings suggest that mathematical intervention engagement is not necessary during shorter school holidays. However, the sample's SES was predominantly middle-class and the mathematics performance of higher SES children may not be as susceptible to any pervasive effects of shorter school holidays as their lower SES peers (Alexander *et al*., 2001, 2007; Cooper *et al*., 1996; Day *et al*., 2013; Field, 2010). Davies and Kerry (1999) reported positive student and parent evaluations of a year-round calendar structure but, while the traditional calendar structure remains, further research should consider parental attitudes and self-beliefs toward supplementary interventions to augment children's mathematics performance and self-beliefs, particularly during the longer summer holiday.

Conclusion

The MPAC-MSE measure requires further validation within larger samples of primary school children aged between six and 11 years, and instructional amendments for children younger than six years. It does, however, show potential for supplementing investigations of mathematics performance, confidence, and self-efficacy in primary school children. Twenty minutes' engagement in a mathematical intervention for five days per week during a short school holiday led to significant increases in mathematics performance and confidence, which were almost equivalent to the improvements observed after an equivalent period of teaching. Without intervention, non-significant fluctuations in mathematics performance, confidence, and self-efficacy imply that these constructs remain stable across a short school holiday. These findings may proffer potentially important implications for English educational policy.

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