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ORIGINAL ARTICLE

Playful maths! The influence of play-based learning on academic performance of Palestinian primary school children

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Abstract
This study explores the relationship between play-based learning and achievement in mathematics in Palestinian elementary school children. Forty teachers from eight schools received training in play-based pedagogies and follow-up support visits from programme staff (intervention group); four matched schools served as the control group. Grade-appropriate tests were administered to all students in two consecutive school terms. A total of 859 students (458 females, 401 males) and 832 students (477 females, 355 males) completed maths tests in term 1 and 2, respectively. Results revealed that the intervention group attained higher test scores than the control group in both terms ($P < 0.01$). Furthermore, in term 2 an interaction effect between group and gender was found ($P < 0.05$), with girls in the intervention group achieving the highest scores. Our finding suggest that play-based learning approaches may enhance academic achievement.

Keywords Learning · Teaching · Play · Palestine · Mathematics · Academic success

1 Introduction

The last decade has witnessed a general shift in educational pedagogy aimed at enhancing the educational experiences of young children (Bennett & Tayler, 2006). Government policies internationally are promoting child-centred pedagogies (e.g. Government of Ireland, 1999). Enacting a child-centred approach allows children to become active participants in their learning processes rather than passive recipients of knowledge (Dewey, 1906). Education is centred on their needs and abilities and the teacher takes on the role of facilitator in the learning process rather than the provider of knowledge (de la Sablonnière et al., 2009). Through

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engaging in active learning approaches such as hands-on learning where pupils learn by doing (Dewey, 1906), student-centred instruction where pupils are viewed as active agents in their own learning (Government of Ireland, 1999), play-based learning where learners are facilitated to explore and engage with their environment and interact socially with others (Cornelli Sanderson, 2010; Zosh et al., 2018), and co-operative learning which involves the combined efforts of learners working together (Johnson et al., 1998), children participate in 'real world' tasks which promote the development of deep levels of understanding (Biggs, 2011). This far exceeds surface knowledge, rote learning and memorising skills required to perform well in traditional assessments (de la Sablonnière et al., 2009). Active educational approaches have been found to promote greater class participation among students; contribute towards building a society of effective and efficient problem solvers through engaging children in higher order thinking; and support the development of students' performance skills by building on their strengths and needs throughout the process (Darling, 1994; Darling-Hammond, 1994).

Play is widely recognised as a means of engaging children actively in their learning, particularly in early years education; however, the effectiveness of play as a pedagogical approach has been disputed in the research literature. Overall, there is consensus on the effectiveness of play to promote children's development in areas such as socialisation, enjoyment, problem solving, physical and emotional development as well as their overall wellbeing (Ghafouri & Wien, 2005; Hunter & Walsh, 2014). However, many debate the effectiveness of play for academic learning (Zosh et al., 2018). Zosh et al. (2018) argue that much of this disagreement can be attributed to the difficulty in defining play. Through reviewing the literature on play and learning Zosh et al. (2018) conceptualise play as a spectrum ranging from free play to guided play, games, and playful instruction. Movement through the spectrum is dependent on who initiates the play (child/ adult), who directs the play (child/ adult) and whether there is an explicit learning goal. During free play the child instigates and leads the play without guidance, input, or support from an adult and there is no extrinsic goal (Zosh et al., 2018). Guided play, while being led by the child is initiated by the adult who creates the context, scaffolds the activity, and provides effective feedback focussed on a learning outcome (Alfieri et al., 2011; Zosh et al., 2018). Playful instruction is a more structured form of playful learning as it aims to achieve an explicit learning outcome while being both initiated and directed by the adult (Zosh et al., 2018).

In recent years, the effect of various types of play on children's academic performance has been examined (Kotsopoulos et al., 2015). In their meta-analysis of 164 studies, Alfieri et al. (2011) compared the effectiveness of unassisted discovery learning, assisted discovery learning and explicit instruction. They found that assisted discovery approaches led to better learning outcomes than unassisted discovery learning or explicit instruction (Alfieri et al., 2011). In their review of 74 studies examining play for academic achievement, Pyle et al. (2017) also report that guided play (both teacher-directed and mutually directed play) has been found to best support children's general academic learning, and contributes to their oral language, reading, writing, scientific and mathematical skills. Much of the existing literature focuses on play in pre-school settings with little reference to play beyond the early years in primary education (Hunter & Walsh, 2014). Primary school aged children are; however, included in the studies by Bustamante et al. (2020) and Habgood and Ainsworth (2011) in which the authors evaluate the effectiveness of two distinct types of playful learning on academic outcomes. Bustamante et al. (2020) evaluated the effectiveness of a life-sized science and maths board game (Parkopolis) located in a children's museum on children's STEM skills. 749 children aged between 3 and 7 years engaged with Parkopolis. Although the authors note that most of the children were preschool age (3–5 years), they conclude that such playful learning experiences can augment developmentally appropriate STEM concepts children learn in early childhood and primary school (Bustamante et al., 2020). Habgood and Ainsworth (2011) developed a digital game to teach Maths to 7–11–year–olds. In this study, the authors highlight the effectiveness of intrinsic integration i.e. delivering academic content through the fun elements of the game (see Habgood and Ainsworth (2011) for a more detailed definition). Both Bustamante et al. (2020) and Habgood and Ainsworth (2011) emphasise the importance of guided interactions with the teacher or caregiver during the learning process to bring about learning in STEM/ mathematics.

Science of learning illustrates that children learn best when they are actively (minds-on) engaged in meaningful (linked to prior knowledge and transferrable to the real world) learning which occurs in socially interactive environments (Hirsh-Pasek et al., 2015). Zosh et al. (2018) contend that guided play achieves best academic outcomes because it harnesses the features of an optimal learning environment as well as joy (positive affect) and iteration (construction of new knowledge through hypothesis testing (Piaget, 1962)) "more so than any other types of play" (Zosh et al., 2018, p 4). Joy, intrinsic motivation and iteration are inherent characteristics of play (Krasnor & Pepler, 1980; Piaget, 1962) and have been found to result in advanced executive functioning and academic achievement (Diamond, 2014). Lazonder and Harmsen (2016) found in their meta-analysis that iteration is enhanced through guided play because adult support brings about more advanced hypothesis testing and experimental design resulting in more advanced learning for the child. Therefore, to optimise learning, children must engage in playful learning in which they are facilitated with fun child-centred opportunities to explore and discover while being scaffolded, guided, supported and provided with effective feedback towards a learning outcome (Alfieri et al., 2011; Hirsh-Pasek et al., 2009).

Since playful learning has been found to be more engaging and developmentally appropriate for children than didactic teaching strategies (Alfieri et al., 2011; Balfanz et al., 2003; Sarama & Clements, 2006) it is beginning to receive a central position in policy and curriculum development internationally. Play underpins curriculum development in countries such as Australia (Sumsion et al., 2009), Canada (Lynch, 2015), China (Pan & Li, 2012), Greece (Tafa, 2008), India (Hegde & Cassidy, 2009), Ireland (Gray & Ryan, 2016), Japan (Hegde & Cassidy, 2009), New Zealand (Synodi, 2010), Norway (Synodi, 2010), Singapore (Ling-Yin, 2006), South Korea (Kim, 2004), Sweden (Synodi, 2010), United Arab Emirates (Baker, 2014a) and the United Kingdom (Tafa, 2008).

However, although playful learning pedagogies have been well endorsed in government policies in many parts of the globe, much of the literature discusses the many perceived barriers to implementing play as pedagogy in primary education (Hunter & Walsh, 2014). Lack of provision, insufficient resources, space constraints, confusion around the role of the teacher, parental expectations, emphasis on academic achievement, and cultural practices and beliefs are some of the constraints affecting the quality, frequency and duration of play as pedagogy (Fung & Cheng, 2012; McInnes et al., 2011; Moyles, 2014; Pyle et al., 2017). Key stakeholders in early childhood education settings in Hong Kong, and India expressed that large class sizes and space constraints restrict children from moving around, resulting in pupils sitting quietly, working on written assignments rather than engaging in play-based learning (Fung & Cheng, 2012; Hegde & Cassidy, 2009) Additionally, teachers explained that schools lack appropriate play materials such as blocks, board games, and writing materials (Hegde & Cassidy, 2009).Pyle et al. (2017) report that similar concerns have been expressed by stakeholders in a range of diverse countries (e.g. China, Canada, Ireland, U.A.E.). Global evidence is demonstrating that primary school teachers are experiencing tensions between competing demands of play-based approaches and curricular demands (Brooker & Edwards, 2010; Wood, 2014). Existing research is also highlighting that teachers lack understanding of how children learn through play (Gray & Ryan, 2016). It has been widely reported that many teachers view the concepts of play and learning as distinct constructs (Baker, 2014a; Lynch, 2015; Pramling Samuelsson & Johansson, 2006; Vong, 2012). Fung and Cheng (2012) and Baker (2014a) have reported that teachers find it difficult to identify how play activities can lead to learning. Fung and Cheng (2012) also report parental preferences for didactic instruction over play which is echoed in studies conducted in Canada (Lynch, 2015), India (Hegde & Cassidy, 2009), South Korea (Kim, 2004), and the United Arab Emirates (Baker, 2014b). In their recent review of play-based learning, Pyle et al. (2017) highlight that this distinct view of play and learning may inhibit teachers' abilities to implement play-based pedagogy in the classroom.

In addition to competing policy demands, and a lack of familiarity and understanding of play-based pedagogical approaches in primary education, a deficiency in training provision has also been identified as impeding the effective use of play-based approaches to learning (Hyvonen, 2011; Moyles, 2014; Pui-Wah & Stimpson, 2004). Teachers acknowledge that throughout their educational programmes, they have been educated on a spectrum of pedagogical styles including play however, it emerges quite strongly in the literature that teachers feel they need additional training and professional development on how to use play as a vehicle for learning in the classroom (Fung & Cheng, 2012; Pyle et al., 2017). In many studies, teachers recognise the value of play but lack professional support and resources to use it in practice (Fung & Cheng, 2012; Pui-Wah & Stimpson, 2004; Pyle et al., 2017). This combined with the barriers mentioned above highlight the lack of implementation of play as a pedagogy to teach academic content in primary classrooms internationally.

Given the emphasis government policies are placing on the role of play in primary education, teachers are obliged to change their perceptions towards teaching academic content through play (Wallerstedt & Pramling, 2012). However, this can only be achieved through the provision of appropriate training on play-based approaches which fosters an understanding of the benefits of play, validates the relationship between play and learning and illustrates the supportive role of the teacher in the process (Alfieri et al., 2011; Pramling Samuelsson & Carlsson, 2008).

1.1 Education in Palestine

A long history of social and political conflict and upheaval in Palestine resulted in a lack of educational resources and facilities so that academic achievement levels and school attendance rates were among the lowest in the world (UNESCO, 1991). The education system failed to meet the needs of students and pressed them to leave school and enter the work force at a young age (Al-Ramahi & Davies, 2002; Khales & Meier, 2013). The ratification of the United Nations Convention on the Right of the Child (UNCRC), by the State of Palestine in 2014 placed children's rights at the centre of social and political agendas. All children now have a right to free primary education and restrictions are placed on the employment of children (UNESCO, 1991). In recent years, pedagogic practice in Palestinian primary schools has undergone great reform to improve the quality of their education system towards meeting economic and social needs (Shinn, 2012). However, teaching methods in Palestine remain very much teacher centred, with didactic pedagogies and lecture type teaching where students passively acquire knowledge (Al-Ramahi & Davies, 2002; Khales & Meier, 2013). Textbooks classified according to student age contain the official material to be taught in schools and emphasis is largely on meeting official requirements of a subject-based curriculum rather than the learning process (Khales & Meier, 2013). Maths is one of the core curricular subjects in which this textbook based, didactic type teaching is prominent in Palestinian primary schools (Al-Ramahi & Davies, 2002). To meet social and economic needs, as well as the needs of the children a change from this passive learning approach towards a child-centred playful learning approach is recommended (Shinn, 2012). This necessitates a change in both students' and teachers' attitudes and behaviours. Therefore, it is important that extensive professional development training and support are provided to teachers to deepen their knowledge and instructional expertise (Khales & Meier, 2013).

Despite the many identified benefits of playful learning for both academic and developmental learning, there is a dearth of research on the effects of this pedagogy on primary school academic outcomes (McGuinness et al., 2014). As it is essential to validate the relationship of play and learning—particularly in the primary school setting, if primary school educational professionals and key stakeholders are to buy-in to using this pedagogy (Pramling Samuelsson & Carlsson, 2008), this study aims to examine the relationship between play-based learning and students' mathematic achievement in Grades 1–4 in Palestinian primary schools. Since mathematics has been identified as one of the core curricular areas in which students engage in passive learning in Palestinian classrooms (Al-Ramahi & Davies, 2002), this study will focus on teaching mathematics concepts through play. Finally, reflecting the research highted above, in the current study playful learning can be defined as 'an experiential, participatory and guided approach, which enhances the teaching and learning process. Through play-based learning children …actively engage with their peers and leaders in educational games and activities' (Right To Play, 2017). This paper addressed the following research question: Do primary schoolchildren who are taught mathematics using play-based learning pedagogies attain higher scores in maths tests compared to those taught using traditional practices?

2 Methods

2.1 Study design

This non-randomised parallel group study was conducted in the 2018/19 school year. The population of interest is children attending primary schools in Palestine. This paper analyses data collected as part of a project examining the impact of play-based learning in Palestinian schools (Turshan, 2019). The purpose of the original study was to examine the extent of the relationship between play-based learning methodologies and acquiring numeracy skills / mathematic subject knowledge of students. Data were originally collected for internal monitoring and evaluation process and to provide reports to funders.

2.2 Setting

The Transforming Attitudes, Approaches and Learning Outcomes Across the Middle East (TAALOM) project was implemented by the NGO Right To Play (Right To Play, 2020). Primary schools were recruited from the Qabatiya district of Palestine. Schools were located in rural areas, considered to be of moderate socioeconomic status. In this paper, we use data collected during term 1 (September—December 2018) and term 2 (February–April 2019) of the school year

Table 1 Characteristics of included schools

School	Gender	Total students in school	Grades in this study
Intervention group			
School A	F	237	2, 3, 4
School B	Mixed	259	3, 4
School C	F	337	3, 4
School D	Mixed	281	3, 4
School E	M	388	1, 2
School F	F	256	1, 2
School G	M	614	1, 2
School H	F	371	1
Control Group			
School I	M	431	1, 2, 3, 4
School J	F	325	1, 2, 3, 4
School K	F	388	1, 2, 3, 4
School L	F	367	1, 2, 3, 4

2.3 Participants

Students in grade 1–4, and their teachers, from 12 primary schools participated in the study. A letter was sent from the Ministry of Education to the school principals, to invite their school to take part in the project. This was followed up with contact from [masked for review] to explain the detail of the project. Grades 1–4 were used in the present study as they are collectively considered the "preparatory stage" of compulsory basic education in Palestine. Eight schools were selected as the intervention group (16 classes in total, four at each grade level) and four schools matched by contextual reference, e.g. teacher qualification, student's academic success, served as the control group (16 classes, 4 at each grade level). There were a similar total number of students in both groups; with 415 students in the intervention group and 444 in the control group completing the term 1 exam. These schools were selected by the Ministry of Education and [masked for review] as they were located in a marginalised areas and had not received any training from [masked for review] previously. Control schools were required not to have previously received training in play-based learning methods. The control group continued with usual practice for the duration of the programme. Table 1 provides an overview of the characteristics of the included schools. 85% of teachers were female, aged 25–45 years with 5–15 years' teaching experience.

2.4 Variables and data sources

The primary outcome was test scores in mathematics assessed during a school-based test at the end of each semester (i.e. December 2018 and May 2019). Tools were purposively developed to assess attainment of learning outcomes of the Palestinian mathematics curriculum for each grade level. The tool was developed by a panel of education supervisors,[1]

[1] Educational supervisors, called "inspectors" in some countries, are employed by the Ministry of Education to conduct school visits where teachers are observed, mentored and supported. A report is then provided to the Ministry of Education.

including a supervisor with expertise in mathematics education ($n = 5$, 60% female). An external consultant facilitated a series of workshops where the panel reviewed the mathematics curriculum for grade 1–4 and subsequently developed school-based tests for each level. Feedback was sought from the Ministry of Education and Higher Education and revisions were made. Appendix 1 summarises the curriculum outcomes that were assessed for each grade level. A sample of one of the maths tests are also provided in Appendix 2. The tests included 15–20 questions that assessed the children on the learning outcomes covered during the semester. The tests were specific to each grade level. Types of questions included identifying missing numbers on a number-line, ordering numbers, rounding numbers, completing operational sums (addition, subtraction, multiplication, division), counting in multiples of a numbers, identifying and naming shapes and angles, colouring a fraction of a set, identifying the fraction of a shape that is coloured, stating the place value of digits, creating graphs and solving data questions, and problem solving. Educational supervisors administered the test during normal school hours. The supervisors were not masked to group assignment.

2.5 Play-based learning programme

Right To Play works in 15 countries worldwide to protect, educate and empower children to rise above adversity using the power of play (Right To Play, 2020). Teachers attending the intervention schools received training in the use of play-based learning methods from Right To Play staff (intervention group). The type of play utilised in the programme is considered "guided play and games" in that the teacher is involved in initiating the activities which are focussed on learning outcomes. Teachers used a "Reflect-Connect-Apply" strategy to assess their students learning and guide them accordingly on their learning journey. This strategy involved discussions within the guided play activities in which teachers facilitated the children to *reflect* on their experiences, *connect* those experiences to their prior knowledge and *apply* their new learning to their daily lives and in their future learning. The play-based learning programme is underpinned by the creation of a positive child-centred learning environment.

Teachers received 16 days of training over three years. The training aimed to provide teachers with the knowledge, skills and attitudes necessary to teach the national numeracy curriculum objectives using child-centred, play-based approaches. About 40 teachers from the eight intervention schools attended the compulsory training. These training events were delivered as experiential learning workshops and covered topics such as: child-centred pedagogy, play-based learning approaches; positive learning environment; Reflect-Connect-Apply methodology, inclusion, child protection and gender; positive discipline; life skills (see Table 2 for an overview of the workshop topics). Teachers also received a manual outlining some general ideas to support numeracy teaching, the Curriculum Framework developed by Right To Play and examples of games and play-based activities. The activities are linked to the four numeracy strands (Number sense, Measurement, Spatial Sense and Data Management) and are divided into three learning stages (Early Numeracy, Emerging Numeracy and Expanding Numeracy) to reflect a student's learning journey across primary school. Key objectives, prior knowledge, equipment needed, discussion points, activity instructions, as well as ideas for assessment, variation, extension, adaption and inclusion are outlined for each activity. Each activity begins with a discussion to access the students' prior knowledge. The children then engage in guided play which incorporates the reflect-connect-apply approach to teach the mathematical concept (see Appendix 3 for examples of activities provided to teachers). Teachers were encouraged to adapt the games and activities to meet the needs of the children and their own teaching requirements. Equipment was provided to schools, such

Table 2 An overview of content in the teacher workshops

Area	Topics
Play-based learning foundations *This introductory area of learning provided the foundation for further professional development relating to PBL*	• Building community • Child development • Play-based learning • Reflect-Connect-Apply Practical play-based learning experience • Engaging children • Core principles of a positive learning environment
Play-based learning in practice *This area of learning supported teachers to examine their curriculum and apply PBL approaches*	• Universal truths of learning • Knowing your curriculum • Literacy and numeracy • Planning and demonstrations • Reflect-connect-apply (advanced) • Modifying games for the curriculum • Working with large groups
Creating a positive learning environment for play-based learning *This area of learning supported teachers to build a safe and effective environment for all students when enacting PBL*	• Child-centred learning • Inclusion • Child safety • Positive behaviour management • Gender equality • Family engagement

as beanbags marked with letters, numbers and mathematical symbols. Teachers also received approximately 640 follow-up visits to their schools to provide mentoring and support. This included lesson observations followed by feedback and discussion with the teacher. Observation sheets were completed. Areas agreed for development were then followed up during the next visit. Data for the current study were collected in year 3 of the programme.

2.6 Analysis

Analysis were conducted using SPSS version 26 (SPSS Inc, Chicago, UL). Descriptive statistics were run to present mean and standard deviations for variables of interest. Preliminary examination of the data showed that the data was skewed, which is a typical observation with test score data of this kind. We conducted the analysis for the main effect using a Mann Whitney U test and a significant difference was found. Given that many statisticians support the use of parametric statistics in these conditions (Blanca et al., 2017; le Cessie et al., 2020), and the need to examine interactions and control for covariates, we proceeded with the reporting of parametric tests in this paper. The main outcome measure, i.e. test scores, was examined using a Factorial ANOVA with group and gender as fixed factors, and grade as a covariate.

3 Results

A total of 859 students (458 females, 401 males) completed the examination in semester 1, while 832 students completed the exam in semester 2 (477 females, 355 males). Further detail of the subject numbers by grade and group can be seen in Table 3. There was attrition

Table 3 Participant characteristics

		Intervention				Control			
		Term 1 exam		Term 2 exam		Term 1 exam		Term 2 exam	
		n	%	*n*	%	*n*	%	*n*	%
Gender	F	249	60.0%	227	59.0%	209	47.1%	250	55.9%
	M	166	40.0%	158	41.0%	235	52.9%	197	44.1%
Grade (n)	1	103	24.8%	111	28.8%	115	25.9%	107	23.9%
	2	115	27.7%	107	27.8%	107	24.1%	114	25.5%
	3	104	25.1%	84	21.8%	114	25.7%	118	26.4%
	4	93	22.4%	83	21.6%	108	24.3%	108	24.2%
Total number		415		385		444		447	

F, female; M, male; n, number of participants

in term 2 as not all children presented for the second assessment in term 2. We believe these are data missing completely at random (MCAR) and therefore imputation is not requited (Bennett, 2001).

Figure 1 shows test scores by group and gender for each semester. The mean score for the intervention groups in term 1 and term 2 was 85.8 (SD = 19.8) and 85.9 (SD = 17.3), respectively. Corresponding scores from the control group in term 1 and 2 were 71.1 (SD = 24.9) and 69.2 (SD = 25.0). There was a significant main effect for group, with the intervention group attaining higher test scores in term 1, F (1, 854) = 87.1, $P < 0.001$), (85.8 vs 71.1) and semester 2, F (1, 827) = 115.6, $P < 0.001$, (85.9 vs 69.2). The main effect for gender was not significant (Term 1 $p = 0.25$; Term 2 $p = 0.91$). The mean score for the intervention group in term 1 was 86.1 (SD = 19.7) for females and 85.3 (SD = 20.0) for

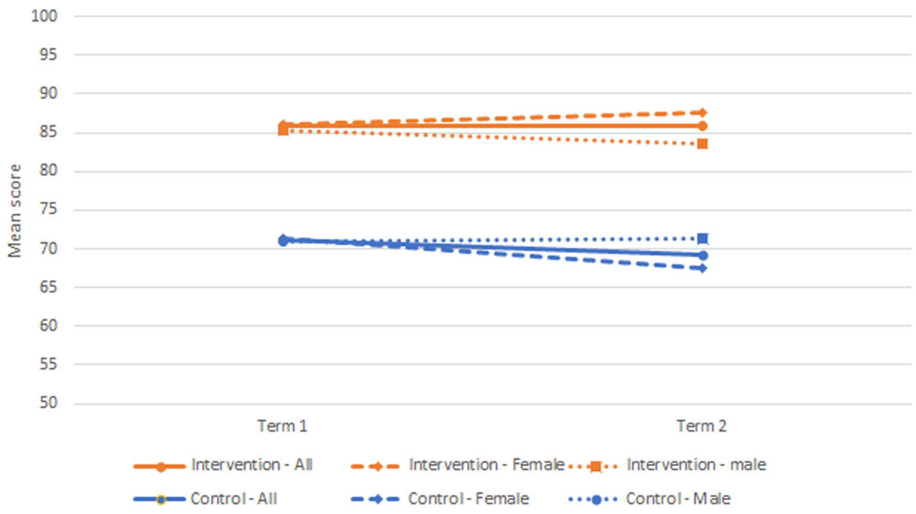

Fig. 1 Mean scores in term 1 and term 2

males. Corresponding term 1 scores for the control group was 71.3 (SD = 24.8) for female students and 70.9 (SD = 25.1) for male students. There was no interaction effect between group and gender for the term 1 examination scores, F (1,854) = 424.3, p = 0.348). However, in term 2 there was a statistically significant interaction between group and gender on test score, whilst controlling for grade, F (1,827) = 6.75, p = 0.01; intervention females M = 87.6 (SD = 14.9), intervention males M = 83.5 (SD = 20.1), control females M = 67.6 (SD = 25.4), control males M = 71.3 (SD = 24.5). Girls in the intervention group achieved similar scores to the boys in term 1 and attained higher scores in term 2.

4 Discussion

The study sought to examine the relationship between play-based learning and students' achievement in mathematics in Palestinian primary schools. The main effect observed for group indicates a significant difference in the test scores attained by the intervention group versus the control group in both term 1 and term 2 assessments. Students in schools where teachers received training in play-based pedagogies attained higher scores. Much of the research thus far has focussed on early childhood setting, this paper therefore augments the body of evidence regarding the association between play and academic achievement in the primary school setting.

One of the challenges to comparing this work to other studies is the various ways in which "play-based learning" is defined in the literature and operationalised in practice. Recently Zosh et al. (2018) proposed a multidimensional definition of play that creates a spectrum ranging from free play (no guidance or support) to guided play and games (including purposeful adult support while maintaining playful elements) (Zosh et al., 2018). The pedagogies implemented in the present study range along the spectrum of play conceptualised by Zosh et al. (2018) from guided play to "playful instruction" as the activities are initiated by the teacher with an explicit learning goal in mind, and depending on the activity, they are directed by the teacher and/or by the child (Zosh et al., 2018). A similar approach was utilised in the "Big Math for Little Kids" play-based programme implemented for 4–5–year–old children from low-income communities in New York over 2 years (Lewis Presser et al., 2015). The programme demonstrated a positive impact of mathematic knowledge. A recent scoping review of the literature on play-based pedagogies in kindergarten education noted evidence for a positive impact on various elements of mathematical learning, including measurement, logico-mathematical thinking, number sense and spatial skills (Pyle et al., 2017). Of note is that the above-mentioned research involved children in early childhood (prekindergarten and kindergarten). A related teaching method–physically active learning–has been used more widely with children of primary school age and proven successful in enhancing both learning and health outcomes (Martin & Murtagh, 2017a). Several programmes have focussed specifically on mathematical learning and point to the potential for play -based learned to be extended beyond early years setting.

The effect of group on test scores was different for male and female students in term 2, but not term 1. Girls in this study achieved similar scores to the boys in term 1 and higher scores in term 2. This may suggest that girls particularly benefited from learning the term 2 mathematical concepts using play-based approaches. While there is some evidence that girls and boys perform differently in specific content domains in international Maths assessments, with girls outperforming boys in data, boys excelling in number and both performing similarly in shape and measure (Mullis et al., 2012), it is unclear if the results of the current study are affected by this as a combination of content domains were taught across both terms. Despite male bias in school mathematic textbooks in Palestine (Karama, 2020), eighth grade female students in Palestine score slightly higher in international assessments of maths than their male counterparts (Mullis et al., 2008, 2012). Given the underachievement of male students in Palestine compared to the international average of males in these studies, further investigation of the underlying causes of this gender disparity in response to play-based learning is warranted. Exposure to play-based learning in the current study demonstrated a similarly positive effect on test scores for both girls and boys in term 1. Analysis of large international datasets demonstrates that, on average, males and females differ very little in mathematics achievement, despite more positive math attitudes and affect among males (Else-Quest et al., 2010). Previous studies which have evaluated gender differences in play, have consistently reported that boys express more negative affect, particularly aggression during play than girls (Fehr & Russ, 2013; Russ, 2003). In their longitudinal study, evaluating the relationship between the processes involved in play and mathematics achievement, Wallace and Russ (2015) found that children whose play contained more imagination and more positive affect in particular, achieved better outcomes in mathematics assessments. Although our study did not evaluate the children's engagement in playful instruction, in line with previous research, it is possible that the girls in our study may have engaged in more positive affective elements during their play than the boys which could explain why girls performed better in the term 2 mathematics assessment. However, further research is needed to evaluate children's engagement in playful instruction to identify differences, if any, between the genders and the effect these may have on their achievements in mathematics.

A unique aspect of the present study is the challenging context in which the programme was implemented. Palestine is a highly marginalised area with high levels of poverty. Ongoing conflict and political unrest in the region has had a detrimental impact on education. This has led to low standards in children's critical thinking and life skill development (Ministry of Education & Higher Education, 2017). The Palestinian Ministry of Education recognises the importance of these issues through a strategic goal to develop a student-centred teaching and learning pedagogy and environment (Ministry of Education & Higher Education, 2017). Apart from the positive impact of play-based learning on academic achievement that the present study alludes to, previous research has demonstrated the positive impact of game-based pedagogies on student enjoyment and teacher satisfaction (Martin & Murtagh, 2017b). Teacher satisfaction and student enjoyment have been found to influence teacher decisions to implement such child-centred pedagogies (Benes et al., 2016; Lubans et al., 2008). Additionally, student enjoyment has been found to maintain student interest and engagement (Dishman et al., 2005). Since attendance at school is a priority (UNESCO, 1991) such outcomes are likely to be of even more importance in terms of child welfare and development in conflict/marginalised settings and are worthy of further investigation in relation to the programme discussed here.

We have identified several further research recommendations in relation to this work. A randomised controlled trial—or a pragmatic evaluation of existing programmes—should be conducted to examine the effectiveness of the play-based programme on mathematical learning and academic achievement. Evidence points to additional benefits of play beyond academic learning, including social-emotional development and general cognitive development (Pyle et al., 2017). The potential for Right To Play's play-based learning programme to influence social development should be investigated in further research. Such study would be complemented by qualitative research to explore teachers' and students' perspectives of the play-based approach in Palestinian schools.

Similar to the current study, much of the research to date on academic benefits of play have focussed on the importance of teacher-directed and mutually directed play with an active teacher role (Danniels & Pyle, 2018). The spectrum-based view of play allows us to question if different types of play might prove optimal for different learning outcomes (Zosh et al., 2018). In their study, evaluating the relationship between symbolic representation in pretend play and mathematics achievement, Hanline et al. (2008) found that practice with symbolic substitution in pretend play transfers to symbolic representation skills later required for mathematics and literacy. Wallace and Russ (2015) also reported that divergent thinking fluency developed through pretend play also later translated to mathematics achievement. Since these longitudinal studies demonstrate that processes inherent in free play such as symbolism, divergent thinking, affect, etc. can be transferred to academic skills, future research should explore whether the use of free play in academic lessons such as mathematics can evoke improvements in academic success similar to the current study.

Several possible pathways have been suggested for the link between play and academic achievement. This association is likely to be influenced by enhanced concentration and on-task behaviour, improved classroom room behaviour and enriched student–teacher relationships. School contentment is strongly related to academic achievement (Sigfsdttir & Allegrante, 2009). Future research should explore the potential pathways and mediating factors that can explain–and perhaps maximise–how play-based approaches can influence learning, test scores and academic achievement.

4.1 Limitations

This study has limitations that may have impacted the findings and the overall generalisability of the results. First, a purposive sample was selected for the study, and it is therefore unclear if the sample is representative of the provincial or national school population. Second, the nature of the design means that causality cannot be determined. We do not have data on baseline academic performance of the intervention and control groups. Third, controlling for clustering at class and school level was not possible due to the nature of the data available. Fourth, the educational supervisors were not masked to group assignment when administering the tests. Lastly, while the mathematics assessment was designed by a group of experienced education supervisors, the validity and reliability of the instrument has not been established so the results may need to be interpreted with caution. Future similar studies should assess the validity and reliability of the mathematics assessment tool.

5 Conclusion

This non-randomised parallel group study revealed differences in examination scores for maths between intervention and control groups, with the intervention group attaining higher scores across the school year. This data suggests a link between play-based learning approaches and academic achievement; a controlled trial or pragmatic evaluation is warranted to confirm effectiveness of the programme. Such novel pedagogical approaches have the potential to influence educational policy developments within Palestine and other Arabic-speaking countries in the Middle East region.

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Data availability Available from the authors upon request.

Code availability Not applicable.

Declarations

Conflicts of interest Elaine Murtagh and Rosemarie Martin declare no conflicts of interest. Jamil Sawalma is employed by Right To Play.

Appendix 1

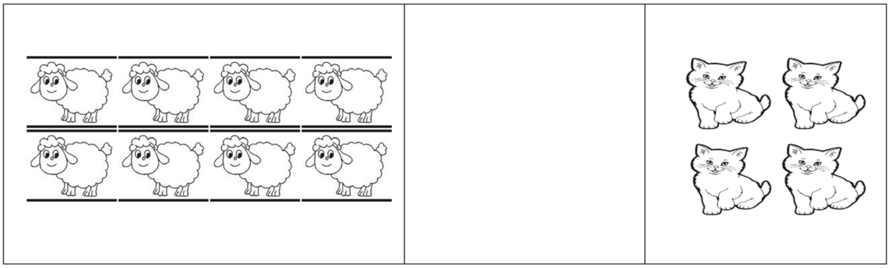
Curriculum outcomes assessed in the examinations

Grade	Semester 1	Semester 2
1	• Proficiency in reading numbers and writing and representation and compare them within the number 20	• Mastering the addition and subtraction within the number 99
	• Proficiency in the addition and subtraction within the number 9	• Distinguish between square, rectangle, triangle, cube, parallelogram, rectangle and ball
2	• Classifies the numbers to odd and even numbers within 99,999	• Creates sentences multiplying numbers (2 3 4 5 10) and uses multiplication facts to solve life problems
	• Read data represented by pictures and represent other data in pictures as well	• Represents the following fractions: half, quarter, third, five
3	• Represent the numbers and determine the decimal value of the numbers in 9999 in different ways	• Give the division facts corresponding to multiplication facts of the numbers (2 3 4 5 6 7 8 9)
	• Distinguish between types of angles and draw it	• Distinguish between the concepts of space and perimeter in a simple way
4	• Represent numbers and determine the decimal value of numbers within millions in different ways	• Proficient in reading decimal and decimal numbers and writing and comparing them
	• Distinguish between fractional and fractional number and non-real fractions	• The conversion between units of measurement is used to solve life issues

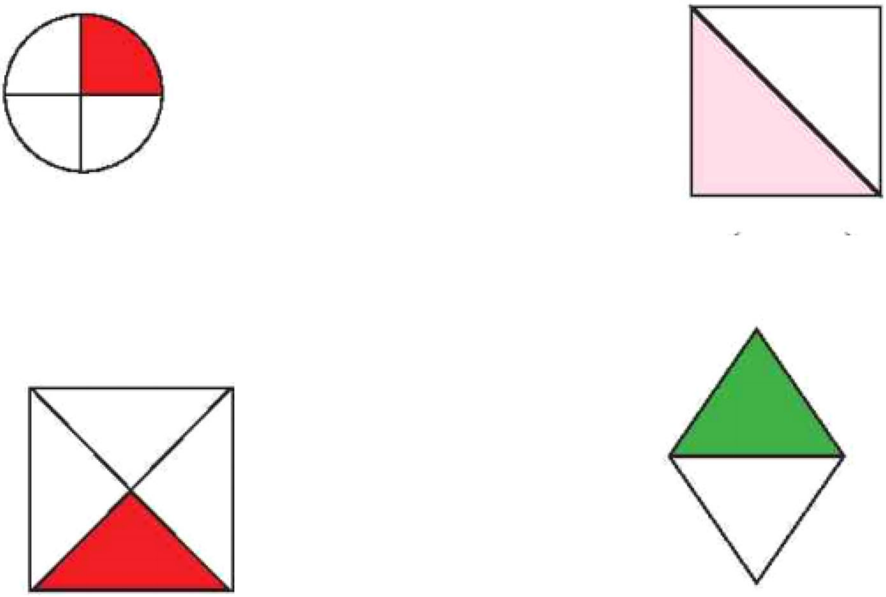
Appendix 2

Sample maths assessment (translated from Arabic)

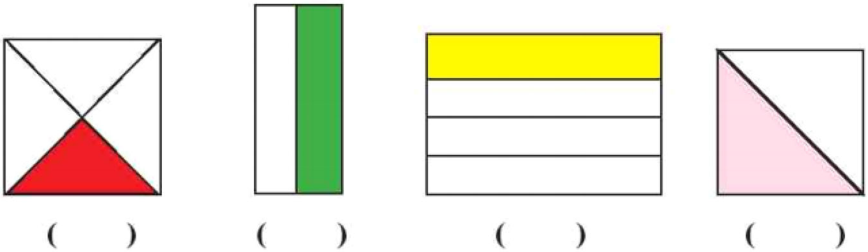
- Select a quarter (1/4) of the group



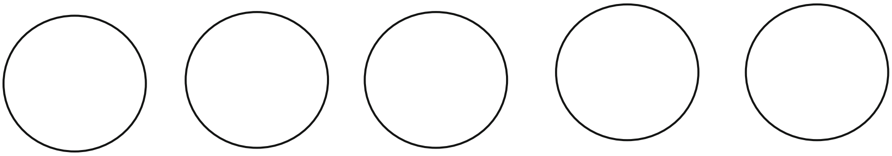
- Connect between the fraction and what it represents



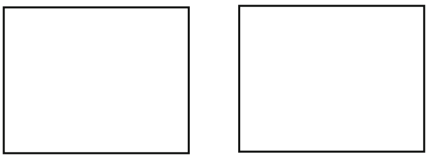
- Write the fraction represented by the shaded part



- Draw shapes representing the following multiplication



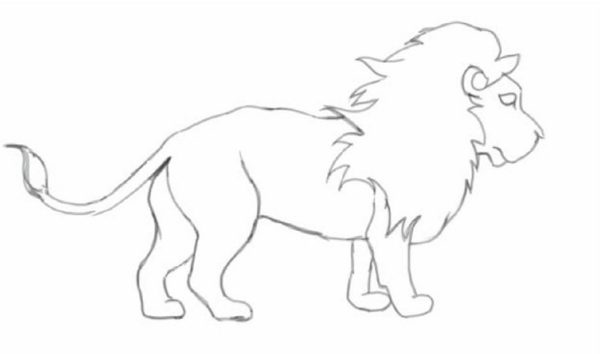
5 x 3 =



2 x 3 =

- Express the following with multiplication sentence

□ X □ = □



Appendix 3

Example 1: Measurement: Weight   Stage: Early

Weight Watchers

Key Learning

To estimate, measure, weigh and compare objects, choosing and using appropriate non-standard or standard units and measuring instruments

Goal of the Game

Students race to find and weigh the heaviest object

Prior Knowledge

Before participating, students should:

- Be familiar with terminology to speak about and measure weight
- Have some understanding about how to use and read a weigh scale

What You Need

Equipment:

- Sports or gym equipment (such as ropes, cones, balls, etc).
- Weigh scales (as many as are available, ideally one per group)

No. of players:

- 6 or more

Opening Discussion

- Show a weigh scale and ask: What is this? Do you remember how to use it?
- What do we use it for? What are we trying to find out about when we use it?

How to Play

1. Explain to students that they are going to have a race to find and weigh the heaviest object.
2. Divide students into small groups of 3 – 4 (or slightly larger if you have access to fewer weigh-scales).
3. Invite each group to find a station to work at (a table or classroom desk will do) and distribute the weigh scales, one per group.
4. Explain and demonstrate that:
5. Each group will move around the room or outside quickly, but carefully, to find 5 items that they want to weigh
6. Once the team has collected their 5 items they should hurry back to their station and weigh them, one at a time, to determine which item is the heaviest. Students should record the weight of each item.
7. When a team has identified which item is the heaviest they must yell, "Done!" and this will stop the race.
8. Each group will share the name and weight of their heaviest item, starting with the group that finished first.
9. Invite each team to come to the front of the room to show how they weighed their item and to show the others in the class how heavy it is.
10. Repeat the race again and ask student to find new items.
11. The game ends at your discretion.

Observation and Assessment

- Which items are the students choosing to weigh?
- Are they using the weigh scales properly?
- Are students using the correct terminology to talk about the weight of their items?
- Are the weights accurate?
- What items are the discovering are the heaviest from their collections?

Discussion

Reflect

- What item did you find that was heaviest? How much did it weigh?
- What items did you find that were not very heavy?
- What to do you notice about all the heavy items?
- What do they have in common?

Connect

- If you look around the classroom right now, what do you think is the heaviest item in it?
- What do you think is the heaviest item in your home? How can you tell?

Apply

- If you want to measure the weight of rice or sugar at home, but you don't have kitchen scale, what is something you can use to help you get a good sense of its weight?

Variation

- Before beginning to weigh the items, students can be asked to estimate how much they think the item will weigh.
- The game can be played alternatively to discover which item is the lightest.

Extension

- Students can test some of their ideas for weighing items at home and bring in a list that orders 5 items from lightest to heaviest.

Adaptation

This game could also be used for *Number Sense:*

- *Early: to* give the number that is 1 more or less than any given number, and 10 more or less for multiples of 1

Inclusion

- Students with mobility challenges can remain at the station and make suggestions which items should bring back. They can also be assigned the role of "Master Weigher" where they have to help the others students in their group to do the weighing.
- Students with visual or physical challenges can be paired with a student with whom they can walk to gather items.

Example 2: Strand: Data Management Stage: Emerging

CLASSROOM BASKETBALL

Key Learning

To answer a question by collecting, organizing and interpreting the data and using tally charts, frequency tables, pictographs, pie charts and bar graphs to represent results

Goal of the Activity

An activity where students shoot paper basketballs with their right and left hands and represent the data in bar graphs

Prior Knowledge

Before participating, students should:

- Have some familiarity with how to use different graphic organizers to represent the results.

What You Need

Equipment

- Paper basketballs made from crumpled paper (10 for each pair of students)
- Buckets (or anything that can hold small objects such as a trash basket)
- Paper
- Pens/Pencils

No. of Players:

- 6 or more

Opening Discussion

- Have you played basketball before?
- Can you shoot with your right hand? Your left hand?
- If you had 10 throws, how many baskets do you think you can make with your right hand? Your left hand?

How to Play

1. Divide students into pairs.
2. Ask the students to spread out and find some space in the classroom.
3. Place a bucket around 3 meters away each pair. Pairs of students can share buckets to reduce the number of buckets that you will need.
4. Explain and demonstrate that:
   - In pairs, they will have a basketball shooting competition with their partner.
   - Each student will shoot 10 paper basketballs into a bucket with their right hand and then 10 paper basketballs with their left hand.
   - Partners will need to keep track of and record how many times their partner makes the basket with each hand on a piece of paper.
   - The partners will then switch roles.
   - After around 5 minutes, you will say "Stop", and the pairs will return to their seats.
5. Lead the class in an RCA discussion, using the questions below as a guide.
6. Using the data of at least two students, demonstrate to the class how to create a bar graph on the board showing right hand versus left hand.
7. Explain to the students that when comparing data you can use bar graphs. The purpose of this bar graph is to compare data sets. Review data on the bar graph with the class. Ask questions such as "How many left hand throws did X get?"
8. Discuss the graphs and have students verbally give sentences describing and comparing the data of the students.
9. Ask students to return to their partners and graph both their own and their partner's data for both right and left hand from the basketball competition.

Observation and Assessment

- Are students taking turns tossing with their right and left hands?
- Are their partners recording the data accurately? How are they recording the data?
- Do students understand the idea of a bar graph? Are they able to apply your example to their own?
- Are students working together to create a bar graph? How are they doing?

Discussion

Reflect

- How many throws did you make with your left and your right hand?

Connect

- How could we compare the results between partners? Amongst the whole class?
- How could we show our results visually? What kinds of graphic organizers could we use?
- Are you familiar with a bar graph? Have you seen one before?

Apply

- How would we represent the data of each pair on a bar graph?
- What information would we have to include on the bar graph?
- After all bar graphs have been completed ask: which person/pair in the class had the most baskets?

Variation

- Add other activities that can be easily graphed such as shooting erasers into a goal, throwing an object at a target, knocking down bottles with a ball, etc.

Extension

- Students could also try ten throws using both hands and create another bar on their graph for that data.
- Students can represent the same data using a different means, such as a pie chart.

Adaptation

This activity could also be used for *Data Management:*

- *Expanding:* to answer a questions by identifying what data to collect, organizing presenting and interpreting data in tables, diagrams, tally charts, frequency tables, pictographs.

Inclusion

- Students with visual challenges can be grouped in a team of 3 and play the game with the other students. Their team members can give them verbal feedback when they are shooting.

Example 3: Strand: Spatial Sense Stage: Expanding

WHO DID IT?

Key Learning

To find the volume and the surface area of 3-dimensional shapes

Goal of the Game

To solve a mystery by applying their knowledge of spatial sense to recognize and describe key properties of shapes, find the volume and surface area of 3-dimensional shapes and identify names, vertices, edges, and faces of the shapes

Prior Knowledge

Before participating, students should:

- Be able to identify key attributes of 3-dimensional shapes
- Be able to measure the volume and area of 3-dimensional shapes

What You Need

Equipment:

- *Who, Where, and When* worksheet – one set for each group
- Tape measures
- Paper
- Pens/pencils

No. of players:

- 6 or more

Opening Discussion

- Have you ever been involved in a Mystery?
- Have you ever wanted to try to solve one?

How to Play

1. Explain to students that today they are going to work in teams to try to solve a mystery – a shape mystery. They will have to use many of their numeracy skills to do it.
2. Divide students in teams of 4.
3. Provide the teams with 5-10 minutes to talk about and review:
   - key properties of 3-dimensional shapes
   - calculations of surface area and volume of 3-dimensional shapes.
4. Distribute the *Who, Where and When* worksheets to students.
5. Explain that:
   - A crime has been committed and there are 4 suspects.
   - The students' job is to use their detective numeracy skills to use the errors made in the solutions, to determine:
     - Who the victim is
     - Who the culprit is
     - The day of the crime
     - The location of the crime.
   - Before beginning to figure out the answer, each group will make accusations and guess who, where and when.
6. Provide groups time to analyze the errors by the four suspects and to try to solve the crime.

   Note to Teacher: The victim is the W; the criminal is the V; the crime took place on Thursday on the playing fields. DO NOT REVEAL TO STUDENTS

Observation and Assessment

- Are the students applying their skills to solve the mystery?
- How familiar are they with the formulas of volume and area?
- Are they applying the formulas correctly?

Discussion

Reflect

- Ask each group: What was your solution?
- Who was the victim?
- Who committed the crime?
- When did it happen?
- Where did it happen?
- Were you accurate in who you accused at the beginning?

Connect

- How did you figure it out? What process did you follow to solve the mystery? Why did you think to approach it that way?
- Did your knowledge of 3-dimensional shapes help you in identifying the location and the day of the crime?

Apply

- How could you use the formulas for surface area and volume? Why might it be important to know them?

Variation

- If students need support provide a cue card or list of questions that help groups detect an error in the description of key attributes of 3-dimensional shapes.
- Make the mystery more challenging to solve by increasing the number of suspects and errors that they made.

Extension

- Students can work in groups to create their own mysteries to share with each other.

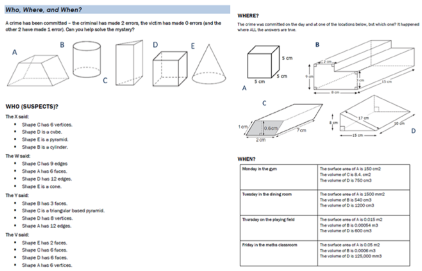
Adaptation

This activity could also be used for *Spatial Sense:*

- *Emerging:* to compare 3-D figures according to their key properties

Inclusion

- Students with visual challenges can be supported by a student who reads the instructions out loud and writes on their behalf.



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