The construct of playful learning in primary mathematics: A literature overview

Linn Flaten

The University of Agder, Department of Mathematical Sciences, Kristiansand, Norway; linn.flaten@uia.no

This paper scrutinises the main scientific journals and books concerning early years mathematics education for the learning of playful mathematics in primary school. The search process resulted in 2633 studies which were then screened according to title and abstract before reading 61 studies in more detail. The resulting 13 studies were further examined to explore how the different mathematics education researchers characterised playful learning in mathematics. Based on these examinations, the paper provides a working definition of playful learning in primary mathematics education.

Keywords: Literature overview, mathematics teaching in primary school, play, playful learning.

Introduction

This literature overview aims to define playful learning (PL) in primary mathematics education (ME). When reading previous research literature, I discovered that early years ME researchers often do not define PL but view PL situations regarding teaching opportunities by stating what children learn, such as dealing with counting, operations on numbers, shape, and measuring (Ginsburg, 2006), geometrical thinking (Clements & Sarama, 2014), classification, seriation, conservation, one-to-one correspondence, estimating, quantitative concepts, number words, space-time orientations (van Oers, 1996) to name a few. Of course, what pupils may learn through play is highly important, as education has a learning perspective. However, I argue that PL does not depend on the specific mathematical content. In this literature overview, a total of 2633 studies were screened before reading 61 studies in more detail. When scrutinising the resulting 13 studies and identifying the ME researchers' common features of PL, my argumentation contrasts with the argument of Brooker et al. (2014), who concludes that a consensus on the definition of PL in early childhood never will be reached. Also, I argue that researchers studying the effectiveness of a PL approach and what mathematical content pupils learn when participating in PL situations could benefit from a definition of what constitutes PL in mathematics in the first place. Therefore, next, I draw on previous research providing insights into key concepts and a further rationale for conducting this literature overview, deliberately labelled an overview, rather than a review, because the interest is not in the studies' research findings. The aim is purely theoretical; to explore how ME researchers characterise PL to define PL in primary ME.

Background

As a pedagogical approach, PL is a broad construct capturing the interrelationship between play and learning (Hirsh-Pasek et al., 2009). It encompasses learning through free play, guided play and games (Fisher et al., 2012; Ginsburg, 2006). Free play is child-initiated and child-directed. Guided play is adult-initiated and child-directed. In both, the child is active and in the lead. The difference is the adult's passive role in free play, compared to an active role in initiating the activity in guided play (Fisher et al., 2012; Weisberg et al., 2013). Thus, the adult can create more learning opportunities by enhancing the children's engagement in the activities (for a review, see Fisher et al., 2010). The pupils are unlikely to get the full benefit from PL without teachers' engagement (Ginsburg, 2006). However, balancing adult and child participation can be challenging (Breive, 2019), with a risk of the activity becoming of the instructional type. Compared to free and guided play, direct instruction is adult-initiated and adult-directed (Fisher et al., 2012; Weisberg et al., 2013). Thus, guided play lies between free play and direct instruction, involving adult guidance while allowing children to direct the activity (Weisberg et al., 2015). However, there exist various perspectives and differences in opinions of play and learning. Some might even view the two as incompatible (Fisher et al., 2010). What defines PL is unclear (Samuelsson & Carlsson, 2008), as is the distinction between the three approaches (free play, guided play, and direct instruction) it overarches. Especially according to the degree of adult guidance where guided play falls on a continuum where the adults' involvement "varies according to the adults' curricular goals and the child's developmental level and needs" (Fisher et al., 2010, p. 343). In general, it is essential to differentiate between child-initiated (play-based) and adult-initiated activities (instruction or more school-like tasks). However, mathematics instruction can involve various instructional approaches (Sarama & Clements, 2009). It does not have to be direct instruction, and PL can also include different instructional approaches. The integration of play in the learning process is precisely why play in teaching has such great importance (Wood & Attfield, 2005), a potentially valuable educational tool also in primary school mathematics teaching and learning.

The relationship between mathematics and play can be seen as either "mathematics made playful" or "mathematising elements of play" (van Oers, 1996). Mathematics is made playful when it is the primary activity, e.g., games where counting or sorting activities are transformed into playful activities. Elements of play are mathematised when play is the primary activity, e.g., when the teacher tries to be responsive to the children's actions and introduce mathematical concepts to the activity. As such, in both conceptions of the relationship, the teacher may provide opportunities for further mathematics learning. Teachers' ability to respond to the opportunities during play is critical to enhance the children's mathematical thinking (van Oers, 1996), in line with Fisher et al. (2012) and Ginsburg (2006) regarding the adults' role in guided play. However, as play is challenging to define, it is also challenging to assess its quality (Samuelsson & Carlsson, 2008). Thus, it is difficult to draw clear lines between different types of play and between play and instruction. These demarcation difficulties may explain why existing research on play often has focused on mathematical content. Thus, a literature overview is needed to provide a working definition of PL in primary ME.

Methods

The literature overview, conducted in June 2021, was limited to searching six resources for studies of pupils aged 5-12, published in 2010-2021, with no limitations regarding research methods. The resources and the respective number of studies screened were: Educational Studies in Mathematics (ESM, 610), Journal for Research in Mathematics Education (JRME, 177), Journal of Mathematical Behaviour (JMB, 366), (The) Journal of Mathematics Teacher Education (JMTE, 248), The International Journal on Mathematics Education (ZDM, 784), European Early Childhood Education Research Journal (EECERJ, 127), Early Childhood Education Journal (ECEJ, 160), Nordic Studies in Mathematics Education (NOMAD, 87) and four conference proceedings from A Mathematics Education Perspective on Early Mathematics Learning between the Poles of Instruction and

Construction (POEM, 74). Reasons for choosing these journals and proceedings were: The first five journals are ranked A* and A in ME (Törner & Arzarello, 2012). EECERJ and ECEJ are dedicated to early childhood education in psychology and sociology. NOMAD captures the social pedagogical tradition in Scandinavia, relevant to my future research on PL in primary mathematics in Norway. PL has also been a reoccurring topic at the POEM conferences. The keywords were limited to *play* and *playful* but combined with *mathematics* for EECERJ and ECEJ. Both keywords proved influential as three papers only containing *play* were eventually included. The keyword play was expected to capture studies on games, which was investigated in four of the included papers. NOMAD was also searched for the Scandinavian countries' word for *play* ("*lek*"). Table 1 provides the collective screening based on *one* reason for each study's exclusion, with descriptions exemplifying the criteria. The search process resulted in 2633 studies that were screened by reading the title and abstract in phase one, with italicised numbers of excluded studies. In phase two, no papers were excluded based on criterion 3 as non-empirical studies were identified and excluded based on title and abstract. However, when in the slightest doubt of exclusion, the paper was read in more detail, e.g., when *play* appeared in the abstract, only to reveal in phase two that it was used without providing any features (criterion 2). Therefore, phase two included 61 studies, with bold numbers of excluded and included studies. For example, the search of JMB provided 366 studies (*157* + *181* + **9** + *16* + *2* + **1**), excluding *157*, *181*, *16* and *2* studies in phase one according to criterion 1 – 4, and reading ten studies in phase two of which **9** was excluded according to criterion 2 and **1** was included. The collective screening provided 13 studies ($n = 13$) scrutinised for features of PL. However, due to the mentioned limitations, there might be research that this overview does not capture.

Table 1: Results of the first (numbers in italic) and second (numbers in bold) screening phases

Reason for exclusion. Description exemplifying each criterion.	**EECERJ**	**ECEJ**	**ESM**	**JRME**	**JMB**	**JMTC**	**ZDM**	**NOMAD**	**POEM**
1) The school level. The pupils' age or school level was not stated or was not relevant.	*22* **3**	*22*	*113* **3**	*40*	*157*	*46*	*113* **3**	*27* **2**	*34*
2) The use of play or playful. E.g. used without providing features, in a different context (like the theatre) or words like dis*play* or inter*play*.	*25* **4**	*45* **6**	*412* **4**	*80*	*181* **9**	*178*	*632* **9**	*40* **1**	*24* **4**
3) The paper is not empirical. E.g., editorial, a review etc.	*17*	*6*	*71*	*53*	*16*	*24*	*25*	*17*	*7*
4) The subject. The study was not specific to mathematics.	*64*	*81*	*5*	3	*2*	*0*	*0*	*0*	*0*
Studies included ($n = 13$)	**2**	**0**	**2**	**1**	**1**	**0**	**2**	**0**	**5**

Results

The resulting 13 studies were all written in English and conducted in Norway (2), Sweden (2), England (1), Germany (1), Italy (1), Canada (2), the Netherlands (3), and Switzerland (1). I will now give an account of the 13 studies' perspectives when italicising the features of PL that they provide.

Gejard and Melander (2018) studied five-year-old children's geometrical learning and multimodal resources during block play. No clear definition of play was found to be provided in the article. However, they underline the importance of *balancing* the adult's and pupils' *control* in the activity. Further, they emphasised *active participation* in *collective* and *social* activities within a cultural setting where the pupils *negotiate* when displaying their understanding of the encountered geometry.

The role of teaching in a game setting was emphasised by De Simone and Sabena (2020) when investigating five-year-old children playing strategy games in a guided play setting where the teacher initiated the activity and supported the children in the reasoning processes. Thus, involving *interactive participation* where the "attention is on participating in the game (possibly on winning), and feeling pleasure and enjoyment are essential parts of the game" (De Simone & Sabena, 2020, p. 157). As such, it appears the researchers emphasised *interaction*, *communication* (of strategies) and *participation* and the children's perceptions like feeling *pleasure* and *enjoyment* in the PL situation.

McFeetors and Palfy (2017) investigated pupils' reasoning and strategies playing commercial games in a multi-aged grades five and six class. By implementing games dependent on logical reasoning, the authors aimed to "value reasoning as an integral part of thinking mathematically" (McFeetors & Palfy, 2017, p. 536). Overall, they emphasised providing an *engaging, authentic, collaborative,* and *social* context. Also, the teacher posed questions verbally and in writing to encourage pupils to express their reasoning and explore more sophisticated reasoning, which was recognised by the pupils as helpful and by the authors as vital for the advancement of pupils' reasoning in the play context.

In the following study, McFeetors and Palfy (2018) emphasised the participants' activity when 5th and 6th graders *interacted* while playing in pairs, prompted by adults' questions to emphasise *conversation* about strategic moves and strategies. The pupils were *encouraged to reflect* and build on their previous strategies. Games thought to foster *discussion* and which the pupils would find *appealing* was chosen. By being commercial games, they were perceived as *authentic*. Thus, *interaction, reflection* and *communication* in *authentic* game-playing contexts found *appealing* by the participants are features emphasised by McFeetors and Palfy (2017, 2018) in their two studies.

The participants' experiences were also emphasised by Vogt et al. (2018), indicating higher learning gains for pupils experiencing a PL approach. Activities that "are *fun, voluntary, flexible,* involve *active engagement*, have no extrinsic goals, involve active engagement of the child, and often have an *element of make-believe*" (Weisberg et al., 2013, in Vogt et al., 2018, p. 592, own italicisation).

Van den Heuvel-Panhuizen et al. (2013) investigated the role of a dynamic online game in 10–12-year-olds' early algebra problem-solving. They considered mathematical play in a game context as "that part of the process used to solve mathematical problems, which involves both *experimentation* and *creativity* to generate ideas, and using the formal *rules* of mathematics to follow any ideas to some sort of conclusion" (Holton et al., 2010, in van den Heuvel-Panhuizen et al., 2013, p. 285, own italicisation). Also, PL was aligned with mathematical processes by contributing to non-threatening environments making it safe for pupils to present incorrect solutions and confront misconceptions.

Helenius et al. (2016) identified features that linked mathematics to play, the interacting components being *creative*, *participatory*, and *rule negotiation*. The *creative* aspect involved the 6-year-olds' modelling of a situation, where they *incorporated some elements of reality and altered others* when posing and solving problems they encountered. Furthermore, playful mathematics activities were dependent on *participation* and contributions from others in a *collaborative, social* context "both at the local level of the immediate situation and also at the societal level which determines the rules and values that affect immersion in reality" (Helenius et al., 2016, p. 146). Thus, the participants engaged in the free play situation and a more comprehensive societal reality, excluding individual play as mathematical. In these situations, the participants abided by *rules* which could be changed and *negotiated*, thus "forming the boundaries of the play situation" (Helenius et al., 2016, p. 147). The criteria were independent of the mathematics content and identified as interactional.

Two studies by van Oers (2010, 2014) were included in the overview. Building on the study from 2010, van Oers (2014) considered mathematising as "the activity of producing structured objects that allow further elaborations in mathematical terms through problem solving and (collective) reasoning/argumentation" (p. 112). Productive mathematising was defined as a "playful activity that has its roots in young children's playful participation in cultural practices" (van Oers, 2014, p. 112). Thus, productive mathematising could be interpreted as PL activities when contrasting productive mathematising to re-productive activities or instruction. The characteristics of the play activity were that the activity was *rule-driven* with a high level of *involvement* and some *degree of freedom* given to the pupils. According to van Oers (2014) the activity could contain elements of instruction if it was meaningful, contributing to the children's participation, and balancing "creative construction and sensitive instruction" (p. 121). Thus, the degree of freedom might vary "as long as the activity as a whole remains a playful activity, i.e. is based on personally acknowledged rules, is engaging, and preserves some degree of freedom" (van Oers, 2014, p. 121). The level of involvement included the motivation to keep the activity going, to *engage*, *collaborate* and be *creative*.

Black et al. (2019) built on the characteristics by van Oers (2010) when they investigated a six-year-old boy's expression of his emotion-cognition experience, who described the playful activity as "fun" and the school mathematics experience making him "tired".

Also, Tubach and Nührenbörger (2016) adopted the characteristics of van Oers (2014). They investigated play as a promising approach to link the informal with the more formal mathematics learning in the transition from kindergarten to primary school.

Hundeland et al. (2020) studied the quality of a kindergarten teacher and five-year-olds' mathematical discourse, emphasising *active* children *in the lead* of the PL activity. They referred to Hirsh-Pasek et al. (2009), who stated that "playful learning, and not drill-and-practice, *engages* and *motivates* children in ways that enhance developmental outcomes and lifelong learning" (p. 4, own italicisation).

Incorporating inquiry and playfulness studying five-year-olds engaging in PL activities in kindergarten, Breive et al. (2018) stated that playfulness "has to be founded in *rules* acknowledged between the players, the activity has to be *engaging* and the activity has to emphasise the *player's* *possibilities to deliberately play in his/her own way*" (p. 185, own italicisation). Furthermore, adult guidance provided children with the needed will to ask questions and construct mathematical ideas.

Discussion

Even though not explicitly revealed, several of the excluded papers incorporated PL as an approach to mathematics learning without providing features of PL or clarifying what it constitutes, which is a finding in agreement with other research (e.g., Helenius et al., 2016; Samuelsson & Carlsson, 2008).

Researchers providing features of PL in mathematics do so frequently in terms of *interactional*, *participatory*, and *social* situations. These situations are characterised by *involvement* (van Oers, 2014) and *participation* (Helenius et al., 2016), allowing pupils to *engage*, be *creative*, and *collaborate* when *negotiating* and *discussing* the encountered mathematics. To keep the activity going by *engaging*, *collaborating* and being *creative* are included in the level of involvement by van Oers (2010, 2014), whereas *creativity* was singled out as a separate criterion by Helenius et al. (2016). Several of the researchers provided features of PL independent of the specific mathematical content and more related to mathematical processes in guided play (e.g., Breive et al., 2018; van Oers, 2010, 2014), free play (Helenius et al., 2016) and games activities (e.g., De Simone & Sabena, 2020; McFeetors & Palfy, 2017, 2018; van den Heuvel-Panhuizen et al., 2013).

Further, the PL situations are characterised by researchers as involving *authentic* (McFeetors & Palfy, 2017, 2018), *cultural* activities (van Oers, 2014) with an imaginative *element of make-believe* (Vogt et al., 2018) or *incorporating and altering elements of reality* (Helenius et al., 2016). Also, PL activities are rule-driven (van Oers, 2014), potentially involving negotiation of implicitly or explicitly expressed *rules* (Breive et al., 2018; Helenius et al., 2016; van den Heuvel-Panhuizen et al., 2013).

Several researchers also argue for a need for a mutual understanding and coordination of participants' perspectives of what is engaged in, talked about, experienced, and learned (e.g., Breive et al., 2018; Gejard & Melander, 2018; McFeetors & Palfy, 2017, 2018). It is especially crucial regarding the adults' role in PL situations, which should provide the pupils with the opportunity to be in the lead (Hundeland et al., 2020) and to play in their own way (Breive et al., 2018). Thus, PL situations are characterised by balancing the adult's and children's control (Gejard & Melander, 2018) in activities where creative construction and sensitive instruction provide a degree of freedom to the children (van Oers, 2014). This feature, mentioned by several researchers, could collectively be termed as participants *right of co-determination*, an element allowing pupils a degree of freedom to be *creative* and influence the activity, which may also contribute to the pupils' *feeling of enjoyment*.

Based on this literature overview, common features of PL among ME researchers are identified. Following the identified features, I thus define PL in primary school mathematics as *situations where participants with a right of co-determination actively participate in a rule-driven, imaginative, cultural mathematics activity while discussing the encountered mathematics.* Since the 13 studies included all three approaches, the definition applies to PL as an overarching construct of learning mathematics through free and guided play and games (Fisher et al., 2012). The features of *collaboration*, *interaction*, *creativity*, *emotions* and *authenticity* are not mentioned explicitly. However, following the previous argumentation, the definition encapsulates these features. There are aspects of *collaboration*, *interaction* and *creativity* encompassed when pupils are given a *right to co-*

determination when engaging in PL activities *discussing* the encountered mathematics. Also, *creativity* is encompassed by the *imaginative* feature, allowing participants to influence the activity, which may also lead to feelings of *enjoyment* and *pleasure*. Thus, the features align PL with mathematical processes rather than with mathematical content. The participants coordinate their perspectives when posing their suggestions and developing the activity while trying to solve the encountered mathematics tasks. However, emotions are highly subjective and can vary within the same activity. By intending to provide a working definition applicable for teachers and researchers assessing or investigating the quality of play (Samuelsson & Carlsson, 2008), emotions are not mentioned explicitly. Also, the *authentic* feature (of games) is encompassed by the *cultural* feature in the definition. Notably, there can also be a varying degree of fulfilment of the different features, as in the scrutinised studies. As such, the definition includes a familiar resemblance of features of PL, without necessarily each situation exercising all features to the same extent. Also, since the taken approach has its limitations, it will be interesting to test and, if needed, refine the definition when researching primary mathematics teaching claimed to be playful.

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