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EFFECT OF MATHS-INTEGRATED PE GAMES ON COGNITIVE ABILITY

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ABSTRACT

The aim of the study was to examine the effect of educational games, based on physical education and math exercises, on cognitive ability. The study was designed using the quasi-experimental model. A total of 45 fourth-grade students participated in the study. During the implementation, 16 educational game sessions designed with mathematical exercises were applied to the experimental group. The Raven Standard Progressive Matrices Test (RSPM) was applied prior to and following the implementations. The RSPM scores of the control group did not show statistically significant progress ($t=-1.67$), while the experimental group showed statistically significant progress ($t=-5.85$; $p<0.01$). Considering the gender variable, RSPM scores increased significantly in male students ($t=-4.03$; $p<0.01$) of the control group whereas the change in scores of female students of the control group did not indicate a significant difference ($t=0.42$). Both for male ($t=-4.98$; $p<0.01$) and female ($t=-3.00$; $p<0.05$) students composing the experimental group, the scores obtained from the RSPM test were found to have increased at a statistically significant level. It is concluded that integrated physical education classes may contribute positively to cognitive skills development and may decrease gender differences.

Keywords: Interdisciplinary teaching; Physical Education; Mathematics; Educational games; Cognitive ability; Gender differences.

INTRODUCTION

The interdisciplinary teaching model, which synthesises and integrates instructional content concerning different subject fields within the scope of educational practices and curricula, is aimed at students gaining educational attainments through reasoning with a holistic perspective and learning field-specific skills and knowledge around a common topic (Jacobs, 1989). The model contributes to the development of higher-order thinking skills like problem solving, analysing, synthesising and evaluating, as well as encompassing a number of advantages to improve such elements of teaching as transferring learning, multidirectional development, social interaction and increasing academic motivation (Erickson, 1995). Although discipline-based teaching models remain one-dimensional due to their information-oriented approach, researchers (Brandt, 1991; Fink, 2003; Repko, 2009) state that the interdisciplinary model supports meaningful learning experiences with an integrated viewpoint among subject fields.

When the interdisciplinary model is considered within the scope of physical education (PE) classes, the low number of applied studies leaves the literature limited in evaluating the model's success. This causes the integrated physical education practices to remain unenlightened, although studies theoretically supporting the use of play and PE classes within the interdisciplinary teaching model are not very novel (Chen *et al*., 2011).

Considering previous studies that include both integrated physical activity (PA) settings in classrooms and integrated PE classes, positive results are seen in terms of increased PA levels (Oliver *et al*., 2006; Bartholomew & Jowers, 2011; Erwin *et al*., 2011; Holt *et al*., 2013; Murtagh *et al*., 2013; Carlson *et al*., 2015; Daly-Smith *et al*., 2018), learning and academic outcomes (Derri *et al*., 2010; Chen *et al*., 2011; Donnelly & Lambourne; 2011; O'Hara *et al*., 2011; Hraste *et al*., 2018;) and student engagement and academic motivation (Hatch & Smith, 2004; Mahar *et al*., 2006; Chen *et al*., 2011; Vazou *et al*., 2012; Cheon & Reeve, 2015).

It is also obvious that many of the studies above, according to the literature, investigated the integration of PA based on classroom settings while a small number of studies investigated the integration of other subjects into PE classes. In this context, bringing movement and physical activity into theoretical classes and an inactive classroom environment could turn out to be advantageous in terms of increased PA level, learning outcomes and the motivational climate.

However, in educational circles careful thought must be given about how bringing theoretical subjects into PE would result in such factors while PE classes are already active, enjoyable and attractive for children without theoretical applications. Marttinen *et al*. (2017) also report in their review study on the integration of PE that there are a limited number of empirical studies on determining which subject fields and educational practices are congruent with the PE course. Therefore, claiming that the interdisciplinary model is useful for learning processes only theoretically is an overgeneralisation for PE. It is critical to find an answer to the question, "In which practical examples does the interdisciplinary teaching model succeed or fail in PE?" through empirical research in order to come to a judgment in evaluating the success of the interdisciplinary teaching model in PE (Chen *et al*., 2011).

On the other hand, although maths is the most frequently used discipline by researchers within the scope of integration of both PA settings and PE classes, empirical investigations on cognitive outcomes of the integration settings have been neglected by researchers who focused intensively on the PA level of students in the classroom (Marttinen *et al*., 2017). Nevertheless, some positive evidence exists in research that has addressed the issue of cognitive abilities of students within the scope of an integrated curriculum. For example, Palmer *et al*. (2013) found that acute exercises with pre-schoolers have positive effects on sustaining attention, while Reed *et al*. (2010) reported that integrated PA settings in the classroom with maths, language, arts and social study classes increased fluid intelligence scores derived from the Raven Standard Progressive Matrices (RSPM) test.

Additionally, other studies in literature support the notion that a physically active classroom environment, contributes to the cognition and attention processes of students (Donnelly & Lambourne, 2011; Schmidt *et al*., 2016; Daly-Smith *et al*., 2018). However, Daly-Smith *et al*. (2018) reported that there was no support for enhanced cognition or academic performance due to limited repeated studies within the scope of integrated PA in classroom settings. In addition to this, the focus of related studies that investigate cognition, attention or intelligence has also been on PA settings in the classroom instead of PE classes (Reed *et al*., 2010; Donnelly & Lambourne, 2011; Palmer *et al*., 2013; Schmidt *et al*., 2016; Daly-Smith *et al*., 2018).

PURPOSE OF THE STUDY

Considering all the previous mentioned facts, the aim of the present study is to examine the effect of integrated games based on physical education classes that are designed through synthesising with maths, on the cognitive skills of pupils. This research also includes the investigation of gender differences in terms of cognitive ability arising from integrated PE games with maths.

METHODOLOGY

Research model and participants

The present study was conducted using the quasi-experimental model based on a pre-test post-test design with experimental and control groups, using a quantitative approach. While determining the study group, a number of criteria were followed in accordance with related literature as follows:

1) Individuals are at an age where they play or take part in game activities and are cognitively able to understand the strategies and rules of games that require concrete operational thinking, motor skills and social competence (Piaget, 1962; Vygotsky, 1967; Smilansky & Shefatya, 1990; Frost *et al.*, 2012).
2) Individuals are at an age where they are still open to having experiences for cognitive development to a certain extent (Piaget, 1972; Paus, 2005; Romine & Reynolds, 2005).
3) Individuals are at an age where they are able to solve maths problems (subtraction, addition, multiplication and division) and acquire the ability of reversibility and using mental actions and operations in a logical manner (McDevitt & Ormrod, 2004).
4) Individuals are in a grade where the curriculum is appropriate in terms of maths skills and PE applications. The remarks of three teachers (maths, physical education, classroom teacher) were considered in order to determine this criterion with an interview.

In the light of these criteria and the literature discussed, individuals in the fourth grade, aged 9–10 years, were selected as the study group. Following the principles of the random cluster sampling method, two different classrooms were chosen randomly as the experimental and control group among five classrooms at a private primary school located in İzmir. After four students were excluded from the study because of their absence at least once from class (3 students from the control group, 1 student from the experimental group), a total of 45 students in the fourth grade (control group n=21; experimental group n=24) were included in the study. As for the gender variable, the control group was made up of 11 boys (52.38%) and 10 girls (47.62%), while the students in the experimental group were made up of 15 boys (62.50%) and 9 girls (40.0%). In addition, 2 physical education teachers participated in the study and presented PE classes for both the intervention and control groups. Moreover, one primary school classroom teacher and one maths teacher took part in the study to support the research team as experts in terms of educational game design, curriculum appropriateness and programme design.

Data collection tool

The measurement instrument used in the study is Raven’s Standard Progressive Matrices Test (Raven *et al.*, 1998), which is designed to measure cognitive abilities of individuals. The test that can be applied individually or in groups, consists of five sets of items named A, B, C, D and E. Each set includes 12 patterns with the same principle but increasing difficulty. Each correct answer is worth one point and the possible maximum score is 12 in each set and 60 in total. The items, included within the test, ask the candidate to find the missing piece on presented matrices that include visual geometric figures and patterns that progress in accordance with a certain logical system. The individual is given six to eight choices depending on the difficulty level of the test battery to complete the missing piece (Raven *et al*., 1998).

The RSPM is used to investigate educative aspects of general intelligence, reasoning ability and cognitive ability. The educative aspect of general intelligence is defined as the ability to enhance novel insights, discern the hidden meaning of a concept and find relationships in a logical sense (Raven *et al*., 1998). While the test is to measure fluid intelligence within the scope of general ability, the measurement field includes general cognitive abilities, such as reasoning, analytical scrutinising, problem solving, regular thinking, visual-spatial perception and cognitive flexibility (Carpenter *et al*., 1990).

The present study specifically employed the 36-item form of the test, including the A, B and C forms designed for participant groups aged 11 years and younger. Raven *et al*. (2004) state that the mental ability of children aged 8–11 makes them ready for solving sets A and B completely and set C partially and claim that individuals in this age group can be evaluated over the 36-item form consisting of A, B and C sets. The different studies that have been conducted by Turkish scholars show that RSPM reliability ranges between 0.88 and 0.91 in the Turkish population (Şahin & Düzen, 1994; Tunalı, 2007).

Ethical clearance

Ethical permission for the study was obtained from Ege University Scientific Researches and Publication Ethics Committee prior to initiating the study (Protocol No: 503). In addition, administrators and teachers of the intervention school were informed about details of the study at a common meeting and researchers guaranteed that the usual educational activities would not be disrupted due to the study. Also, all parents and participant children were informed about the researchers, purpose and process of the study by means of consent forms. A total of forty-nine consent forms were signed by parents.

Procedure

Before starting the intervention of the study, Raven's Standard Progressive Matrices Test was conducted with both groups in the classroom one day prior to the beginning of the intervention as a pre-test. The practical process continued for eight weeks and 16 games (four-operation board, mathematical reaction, memory running, formulised stop, number train, missing number and figures, number memory) were practised in total with two educational games put into practice each week.

Educational games were synthesised with mathematical patterns, designed by the researchers with the support of three teachers (physical education, maths and classroom teacher) according to the physical education and maths curricula. Educational games have competitive characteristics at team or individual level in the present study and these games include motor activities, such as running, throwing, jumping, catching, etc.

Moreover, maths activities in educational games consist of four operations: measuring, sequential calculation, evaluating figures and basic geometric forms. Similar activities and games that were used in other studies were included that focused on integrated units of PA or

PE and maths (Hatch & Smith, 2004; Chen *et al*., 2011; Wade, 2016; Hraste *et al*., 2018). All intervention classes were presented by a physical education teacher.

These classes were observed by a researcher from a blind part of the playground to track whether the educational games were presented by the teacher as previously planned. Students were informed about the rules of the games prior to each practice. Thirty minutes of a physical education class, planned to last 40 minutes in total, were allocated for educational games. The remaining 10 minutes of the classes were allocated to warming up (5 minutes) at the beginning of the classes and cooling down (5 minutes) activities at the end of the classes.

Students in the control group attended similar educational games, however, mathematical designs were excluded for the control group. Control classes were conducted by another physical education teacher and observed by a researcher from a blind part of the playground to track whether the educational games were being presented as previously planned. Following the practical process, the measurement tool was reapplied to all the students participating in the study as a post-test one day after the last intervention. Attendance checklists for both classrooms' students were provided by teachers.

Game Sample 1: Mathematical reaction

Before the game, the teacher identifies some colours for odd and even numbers. Each student is also identified with a number by the teacher. The students create a circle in the play zone at the beginning and the teacher is located in the middle of this circle during the game. She/he loudly sets a four-operation problem (like 12+7) and throws coloured balls into the air at the same time, which coincide with the identified numbers of the students. The student (in this case number 19) who correctly calculates his/her number according to the four-operation problem is required to catch a ball with the correct colour in the air and hit other students with the ball to gain point/points. The other students run away after they have calculated the four-operation problem and see that the related number does not belong to them.

They also try to avoid being hit by number 19. If the student (number 19) catches the ball by solving the four operations correctly, he/she would gain one point at first. Then, if he/she successfully hits another student with the ball one more point is gained. On the other hand, students would lose a point if they run away without solving four operation problems or the student in question (number 19) drops the ball onto the floor without catching it.

Game Sample 2: Memory running

Students are split equally into teams and each student is given a number by the teacher. At the beginning of the game, each team starts to jog around the basketball court in the hall and they practise some motor skills at stations (slalom, sprint, slide steps, stance walk and stretching practices) during the run. While running and practising motor skills during a game, the teacher loudly calls out a number in any time. The students who have the number called out by the teacher, come to the middle of the hall where memory cards (4x4 squares – 2 pieces) are placed on the floor. All cards have geometric figures on one side and each geometric figure can be seen on the cards. The students can open two cards to see these geometric figures. If the figures match each other, the students gain one point. If not, they have to close the cards again and return to their teams for running and practising motor skills, while the teacher calls out new numbers for the next students. The game continues until all cards match and the team that matches more cards wins the game.

Data analysis

The collected data were analysed using the SPSS 24.0 package program. Four students were excluded from the study because of their absence at least once during interventions (3 students from the control group, 1 student from the experimental group). Finally, the data of 45 students were captured in the data set.

The Shapiro-Wilk test was performed to test the normal distribution of the data. The data were found to be distributed normally and the data set was subjected to t-tests parametric analysis methods. An independent t-test was applied to investigate RSPM score differences at the baseline and at the end of the intervention between groups. The dependent t-test was applied to determine any differences in RSPM scores in groups regarding pre-test and post-test scores.

In addition, a dependent t-test was applied to investigate gender differences. The level of statistical significance was considered to be a minimum of $p<0.05$ in the evaluation of the results. Effect sizes were calculated considering Cohen's d-value (Cohen, 1988). In this regard, practical significance of d-values were considered at three levels as small (0.20-0.49), medium (0.50-0.79) and large (0.80+) (Cohen, 1988).

RESULTS

The Shapiro−Wilk test showed the values of significance ranged between 0.157 and 0.661 for each group and skewness values were between -0.172 and 0.178 and kurtosis values were between -0.695 and -1.20 (Table 1).

Table 1. **SHAPIRO-WILK NORMAL DISTRIBUTION TEST RESULTS**

Testing	Statistic	df	p	Skewness	Kurtosis
Control Group Pre-test	0.967	21	0.661	-0.102	-0.777
Control Group Post-test	0.933	21	0.157	0.178	-1.200
Experimental Group Pre-test	0.968	24	0.617	-0.172	-0.906
Experimental Group Post-test	0.964	24	0.520	0.159	-0.695

From this perspective, p-values of over 0.05 (Mertler & Vannatta, 2005) and skewness and kurtosis indices close to 0 within ±2 limits (Tabachnick & Fidell, 2013) are accepted as proof of the existence of a normal distribution.

Table 2. **INDEPENDENT GROUPS t-TEST RESULTS**

Groups	Testing	Mean±SD	t-value	p	ES
Control Group Experimental Group	Pre-test	12.43±3.87 14.67±5.23	-1.64	0.11	–
Control Group Experimental Group	Post-test	13.19±3.66 17.96±4.38	-3.98	0.00**	0.99

SD=Standard deviation ES=Effect size

An independent t-test was applied to test whether the control and experimental group's RSPM scores differed at baseline. There was no statistically significant difference between the RSPM scores of the control (12.43±3.87) and the experimental group (14.67±5.23). On the other hand, independent t-test results of the post-test that were applied to determine intergroup differences at the end, show that there was a statistically significant difference between the RSPM scores ($p<0.01$) of the control group (13.19±3.66) and the experimental group (17.19±4.38). The effect size of the difference ($d=0.99$) was found to be large (Cohen, 1988) (Table 2).

***Table 3*. DEPENDENT GROUPS t-TEST RESULTS**

Group	**Testing**	**Mean±SD**	**t-value**	**p**	**ES**
Control Group	Pre-test Post-test	12.43±3.87 13.19±3.66	-1.67	0.11	–
Experimental Group	Pre-test Post-test	14.67±5.23 17.96±4.38	-5.85	0.00**	0.52

SD=Standard deviation ES=Effect Size

A dependent t-test was applied to investigate whether the control group had a developmental effect, which could occur due to the normal development process of children. In this regard, no significant difference was seen between the pre-test (12.43±3.87) and post-test scores (13.19±3.66) of the control group students ($p>0.05$). Furthermore, dependent t-tests were applied to compare the experimental group's pre-test and post-test RSPM scores to determine in-group improvement. The difference between the pre-test (14.67±5.23) and post-test (17.19±4.38) scores of the experimental group students was found to be statistically significant ($p<0.01$). The effect size of the difference ($d=0.52$) was found to be at a medium level of practical significance (Cohen, 1988) (Table 3).

***Table 4.* DEPENDENT SAMPLES t-TEST RESULTS ACCORDING TO GENDER**

Group	**Gender**	**Testing**	**Mean±SD**	**t-value**	**p**	**ES**
Control Group	Boys	Pre-test Post-test	11.82±4.12 13.55±4.16	-4.03	0.00**	0.42
	Girls	Pre-test Post-test	13.10±3.66 12.80±3.19	0.42	0.68	–
Experimental Group	Boys	Pre-test Post-test	15.13±5.30 18.60±4.08	-4.98	0.00**	0.73
	Girls	Pre-test Post-test	13.89±5.32 16.89±4.88	-3.00	0.02*	0.59

SD=Standard deviation ES = Effect size

The results of the dependent groups t-test performed on a group basis considering the gender variable, show that significant differences were found between the pre-test (11.82±4.12) and post-test scores (13.55±4.16) of the boys in the control group ($p<0.01$). The effect size of this difference ($d=0.42$) was found to be small (Cohen, 1988). The difference between the pre-test (13.10±3.66) and post-test scores (12.80±3.19) was not significant for the girls in the control group. On the other hand, both boys ($p<0.01$) and girls ($p<0.05$) in the experimental group showed a significant difference in the pre-test and post-test RSPM scores (Table 4). The effect size level was found to be medium for both boys ($d=0.73$) and girls ($d=0.59$) (Cohen, 1988).

DISCUSSION

The evaluation of the findings in terms of the experimental and control groups shows that mathematics exercises synthesised with educational games, based on the interdisciplinary teaching model, affected general mental ability development positively. Increased learning motivation caused by the use of the interdisciplinary teaching model (Yıldırım, 1996; Chen *et al*., 2011; Vazou *et al*., 2012;), the fact that the model provides a holistic perspective towards concepts and problems around learning experiences (Erickson, 1995) and the fact that learning experiences offered by the model reinforce sense-making and permanency (Placek, 2003; Eisner, 2009), all indicate the causal background of the results obtained in favour of the experimental group. Moreover, since play offers an enjoyable learning environment for students in the age group in question, another factor to increase motivation for learning and participation is considered to be the use of educational games.

Although only cognitive outcomes were investigated, the results may also be related to both cooperative and competitive PE games and enjoyment which may have supported psychological needs of the students (competence, autonomy and social relations) and their motivation in the scope of Self-Determination Theory (Ryan & Deci, 2000). In this regard, the interdisciplinary teaching model and educational games used in the practices are implementations that increase participation in the learning environment and promote the development of mental abilities. To this end, in the face of the implementations solely focused on cognitive processes that have become the deadlock of education systems, it is believed that the interdisciplinary model used in physical education lessons would contribute to the establishment of an educational construct that can generate a “buffering effect”, and that could promote cognitive development processes without neglecting the experiences in the affective and psychomotor domains.

Reed *et al*. (2010) reported that integrated PA settings in the classroom with maths, language, arts and social study classes increased the fluid intelligence scores of students as derived from the Raven Standard Progressive Matrices (RSPM) Test. Instructional settings integrating maths activities with movement and exercise within the scope of PE lessons, have been shown to contribute positively to learning mathematical skills, to children’s attitudes towards classes and social interaction, while students make progress in learning motor skills (Chen *et al*., 2011). In another study, following a physical education class on shot putting techniques in athletics, higher-level mathematical calculations like parabola, correct angle, velocity and acceleration were performed successfully in maths and physics classes through previously recorded images and videos. As a result, the study emphasised that high school students’ in the 10th grade, the skills of sense-making, transferring and integrating information improved and their motivation increased as well (Hatch & Smith, 2004). Furthermore, studies investigating PA practices in school and classroom settings have reported that PA settings make a positive contribution to cognitive and academic attainments, such as attention, concentration, task-oriented motivation and academic achievement (Mahar *et al*., 2006; Reed *et al*., 2010; Donnelly & Lambourne, 2011; Palmer *et al*., 2013).

The meta-analysis study conducted by Marttinen *et al*. (2017) stated that studies dealing with integrated model classes focused on achievements, such as skill learning and PA levels, whereas the number of studies measuring academic and cognitive achievements is limited, especially in PE. In this regard, the evaluation of the success of the interdisciplinary model in physical education around general cognitive skills in the current study is seen as an important contribution to the related literature. Moreover, while practices using the interdisciplinary model mostly focus on teaching exercise, drills, subjects and skills, it should be considered that the present study used educational game activities.

While there is a large body of literature indicating the benefits of the interdisciplinary model used in physical education classes, there are few studies describing the arrangements and practices that yield results in terms of educational achievements (Chen *et al*., 2011; Marttinen *et al*., 2017). In the present study, it was found that games designed on the basis of PE could produce positive results in terms of cognitive skills. However, there is still a need for related studies to extend their practices to be descriptive. As a matter of fact, the integrated model has several disadvantages, including the difficulty of class management and having a grasp of more than one subject field, not being economical (time, energy, cost) and including incompatible subject fields, which may negatively affect educational achievements and processes (Thorburn & Collins, 2003; Eisner, 2009).

Regarding the gender variable, only male students were found to make statistically significant progress in the control group whereas both male and female students made progress according to their pre-test results in the experimental group. In the study of Lynn *et al*. (2004), it was shown that the Raven Standard Progressive Matrices Test scores obtained by males were higher than those of females and that this difference progressed in favour of males particularly in the developmental process.

The problems included within the test concern the abilities to rotate the mental representations of particularly two- or three-dimensional objectives in the mind and to evaluate them logically. At this point, the measurement of skills, such as organising visual-spatial relations, perceiving shapes, colours and sizes, abstraction, reasoning and arithmetic perception becomes prominent in the test content and the reason behind males getting higher scores on the test is due to the fact that the test focuses on related skills (Johnson *et al*., 2008). In the associated literature, several studies reported that males show better scores in skills, like visual-spatial perception, reasoning about shapes and designs, arithmetic and mathematical perception, abstraction and logical inference than females (Neisser *et al*., 1996; Härnqvist, 1997; Keith *et al*., 2008; Keith *et al*., 2011; Lejbak *et al*., 2011; Ziada *et al*., 2019; Jiang *et al*., 2020).

On the other hand, Hutchison *et al*. (2019) reported no gender difference in basic numerical skills except for number-line tasks, however, they also mentioned that gender differences may still exist due to cultural differences. In terms of visual-spatial perception and mental rotation processes, a one-point difference is reported between males and females at the age of 8–10. This difference is reported to reach up to five points in favour of males between the ages of 10 and 15 (Keith *et al*., 2011). These differences are believed to possibly stem from the different roles attributed to men and women in social life. As a matter of fact, it is claimed that men evolved through the cognitive processes of visual-spatial perception and mental rotation associated with hunting, whereas women specialised in visual memory for remembering shapes and objects while storing and collecting food (David, 1998; New *et al*., 2007).

It is suggested that changing expectations may also play a role in the difference between genders. Studies have indicated that defining the tasks given to women as men-related jobs and women-related jobs affects women's mental rotation performance negatively, while telling them the opposite improves their performance (Sharps *et al*., 1994; Newcombe, 2007). Similarly, in the findings obtained from the present study, the difference found between males and females in RSPM scores may be associated with social roles and expectations and the fact that the related skills are more commonly used by males. This could explain the progress that was made in the related skills by the female students in the experimental group as much as males.

Another study consistent with this conclusion and similar to the experimental design used in the study was conducted by Toronto University (Feng *et al*., 2007). In this study, male and female participants were made to play video games, including mental rotation questions. The results of the study showed that females made greater progress than males in the related skills, while the total score of males remained higher. The results showed that playing video games reduced gender differences in mental rotation skills (Feng *et al*., 2007). In this regard, we may interpret the results in our study and related literature that when an experimental opportunity is given to females by eliminating gender stereotypes, they are as successful as males in skills in which males were thought to be better, thereby beating social stereotypes.

CONCLUSION AND IMPLICATIONS

The present study examined the effect on cognitive processes of mathematical exercises synthesised with educational games within an experimental design, best practices of the model were found to make positive contributions to cognitive skills of students. The fact that the study focused on higher-order mental skills like analysis, synthesis and evaluation rather than academic achievement outcomes in mathematics, increases the significance of the results obtained. Moreover, it could be seen that educational practices can be effective in going beyond the limits brought about by the effects of social expectations and roles in terms of gender.

While meeting the expectations of the cognitive development-oriented structure of the education systems, best practices that could fulfil the needs of students in other developmental domains are important for raising children and young people in a healthy way. In this context, it is recommended that stakeholders of education use the interdisciplinary teaching model in the educational processes that also consider psychomotor, affective and social development domains, in addition to the cognitive domain. In future studies, performing detailed practices that test the attainments of affective and psychomotor domains in addition to cognitive attainments, would be advantageous by providing a multidimensional evaluation opportunity.

Conducting more research on different age groups may be beneficial to see the effects of integrated PE classes with a wider perspective. It is recommended to strengthen and diversify theoretical grounds of future studies, as the current study is limited in that it investigated cognitive progress of students in the scope of an interdisciplinary teaching model and a standardised cognitive test (RSPM). Moreover, qualitative methods, such as evaluating student and teacher opinions and observing the planning and intervention process of the experiment, should be included in the research process for a more detailed description. Since the number of practical studies in the literature is inadequate, there is still a need to conduct studies to shed light on the effects of the interdisciplinary teaching method on educational processes.

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