*Iran J Public Health, Vol. 50, No.5, May 2021, pp.938-948*

**Original Article**

# The Effect of STEAM-Based Physical Education Classes on Middle School Students' Attitudes toward Physical Education Classes and Self-Directed Learning Abilities

***Dae-Jung Lee**

*Department of Physical Education, Jeonbuk National University, Jeollabuk-do, Korea*

***Correspondence:** Email: dleownd23@hanmail.net

**(Received 09 Jun 2020; accepted 20 Aug 2020)**

**Abstract**

**Background:** Efforts have often been made to improve physical education (PE) classes in response to rapidly changing societies. We applied science, technology, engineering, arts, and mathematics (STEAM) education to PE classes. The purpose was to examine the effect of STEAM-based PE lessons on self-directed learning abilities, a core competency of the 21st century, and on attitudes toward PE classes related to PE alienation and avoidance.

**Methods:** To achieve this purpose, six out of eight classes at a middle school in Jeollabuk-do province, Republic of Korea were selected in 2019. The experimental and control groups, consisting of 87 and 88 students, respectively, were chosen from among 238 first-grade students by utilizing convenience sampling. The experimental group attended PE classes based on STEAM for 14 weeks, whereas the control group attended traditionally teacher-centered PE classes. We used a multivariate analysis of variance (MANOVA). Statistical significance was set at $P<0.05$.

**Results:** The experimental group displayed significant differences in all the sub-factors of attitudes toward PE classes and all the sub-factors of self-directed learning abilities, compared to the control group ($P<0.05$). PE classes based on STEAM appear to have a positive effect on students' attitudes toward PE classes and their self-directed learning abilities.

**Conclusion:** PE is struggling to solve students' alienation and avoidance problems, despite numerous efforts. Thus, discussions have been conducted on how the STEAM philosophy can be implemented in the field of PE. Results suggest that efforts to combine STEAM education and PE are needed.

**Keywords:** Attitudes; Education; Learning abilities; Physical education

## Introduction

Since the study of sports pedagogy began, efforts have been made to improve physical education (PE) classes in response to rapidly changing societies. Various teaching methods have been applied to PE classes to solve problems associated with teacher-directed learning. In this study, we attempt to apply STEAM (science, technology, engineering, arts, and mathematics) principles to PE classes as part of these efforts, for two specific reasons:

First, the creation of a PE class that satisfies all students is required. Since Carlson's study in 1995, there has been growing interest in the problem of students who avoid PE and are alienated from it (1). Alienation in PE classes occurs in two ways. The first involves students just sitting in class aimlessly throughout the lesson because they are not interested in PE itself. The second involves students participating in the class at the beginning and then losing interest halfway through, whereafter they just sit in class aimlessly or become indifferent to class activities (2). The first form of alienation is related to internal factors, such as students' lack of physical function or a lack of interest in physical activities. The second form of alienation can be attributed to external factors such as teachers' teaching methods and skills. To solve these problems, dynamic teaching methods and STEAM programs need to be applied to PE classes (3).

Second, there is a need for teaching and learning methods that can increase the core competency of self-directed learning in the 21st century. The aptitude demanded by an increasingly knowledge-based society is that of a person who does not merely hold exponentially increasing knowledge and information but can creatively solve the complex problems they face by themselves, or in a cooperative relationship (4). Accordingly, specialized and customized education is required to accommodate the diversity of students, where they can take a more active role in self-directed, student-centered lessons, instead of just unilaterally receiving standardized curriculums presented to them by teachers (5). School education has trained students to passively accept the flow of segmented activities, regardless of individual experiences, through an institutionalized schedule (6). In other words, students' learning is directed by others. In PE, the students are expected to follow the teacher's posture exactly, leaving little room for the enhancement of self-directed learning abilities. Teacher-centered PE classes that have less interaction between class members have, until now, been used as an effective teaching method to achieve educational goals. However, there is now an urgent need for PE teaching methods to change, so that they meet the demands of the times and increase self-directed learning skills. Aiming to find a potential solution, studies need to be carried out to ascertain whether available STEAM theme-based problem-solving lessons can be used in PE classes.

STEAM schools and programs are being initiated across the United States (7). STEAM refers to the convergence of different disciplines in education, and the acronym stands for science, technology, engineering, arts, and mathematics. Its purpose is to assimilate the principles of science and mathematics, which develop logical thinking, and to achieve creative results by adding esthetic elements (arts) based on creative design (engineering) and technology. In particular, STEAM starts from one main theme, rather than subject-specific classes. It allows students to explore an issue from a variety of perspectives and develop creative problem-solving skills. In other words, the STEAM curriculum focuses on interdisciplinary and inquiry-based learning.

STEAM education can enhance students' learning (8), academic performance (9), critical thinking, and problem-solving skills (10). As a result, many countries, including Australia and the United States, have implemented STEAM programs to improve students' achievements and remain competitive in the global economy (11). However, there are only a few evidence-based studies that confirm these practical experiences. Thus, relevant and reliable research is urgently required to expand on the emerging STEAM movement with accompanying activities (12). Moreover, PE has little in common with STEAM, and as a result, there are few examples of how it can be applied (13).

Therefore, we aimed to improve the understanding of the connection between STEAM and PE, by examining the effect of STEAM-based PE classes on middle school students' attitudes toward PE and self-directed learning abilities, and to examine various teaching and learning methods.

## Methods

### *Participants*

Six classes were selected for this study in Jeollabuk-do province, Republic of Korea in 2019. The experimental and control groups consisted of students from three classes, with 87 and 88 students, respectively. In the selection of these students, convenience sampling out of non-probability sampling was practiced. Students completed a questionnaire to gauge their attitudes toward PE classes and their self-directed learning abilities. A total of 178 participants were finally selected, with four students excluded from the experimental and control groups, due to their unreliable or insincere responses in the questionnaire. The general characteristics of this study's participants are listed in Table 1.

**Table 1:** General participant characteristics

| *Variable* | *First year middle school students* | | |
|---|---|---|---|
| | Male | Female | Total |
| Class 1* | 15 | 14 | 29 |
| Class 2* | 14 | 14 | 28 |
| Class 3* | 16 | 14 | 30 |
| Class 4** | 16 | 14 | 30 |
| Class 5** | 16 | 15 | 31 |
| Class 6** | 15 | 15 | 30 |
| Total | 92 | 86 | 178 |

*Experimental group; **Control group

All study participants provided informed consent, and the study design was approved by the JeonJu PyeongHwa Middle School, Jeollabuk-do, Korea.

To verify the homogeneity between the experimental and control groups participating in this research, the independent sample t-test was used, based on preliminary scale values obtained from the questionnaires regarding attitudes toward PE classes and self-directed learning abilities. As shown in Tables 2 and 3, no statistically significant differences were observed between the two groups in terms of the sub-factors of attitudes toward PE classes and self-directed learning abilities. Therefore, the two groups were considered homogeneous and the experiment was carried out ($P$<0.05).

**Table 2:** Homogeneity test results as per pre-scores of attitudes toward PE classes

| *Factors* | *Sub-factors* | *Group* | | *t* | *p* |
|---|---|---|---|---|---|
| | | Experimental group (n=87) M±SD | Control group (n=91) M±SD | | |
| Attitudes toward PE classes | Health and physical strength | 14.35±2.05 | 14.54±2.07 | -0.629 | 0.530 |
| | Interpersonal relations | 10.39±1.66 | 10.72±1.66 | -1.358 | 0.176 |
| | Active participation and positive performance | 8.31±2.01 | 8.39±2.22 | -0.250 | 0.803 |
| | Positive emotions | 10.81±1.53 | 10.78±1.79 | 0.104 | 0.917 |
| | Negative emotions | 7.21±1.54 | 6.98±1.56 | 1.550 | 0.123 |
| | Physical activities and movement | 7.33±0.97 | 7.06±1.19 | 1.657 | 0.099 |

**Table 3:** Homogeneity test results as per pre-score results of self-directed learning abilities

| *Factors* | *Sub-factors* | *Group* | | *t* | *p* |
|---|---|---|---|---|---|
| | | Experimental group (n=87) M±SD | Control group (n=91) M±SD | | |
| Self-directed learning abilities | Desire for learning | 12.34±2.60 | 11.79±2.12 | 1.585 | 0.115 |
| | Learning objective establishment | 11.56±3.18 | 11.21±2.95 | 0.782 | 0.435 |
| | Basic self-management abilities | 10.67±2.04 | 10.31±1.87 | 1.290 | 0.199 |
| | Selection of learning strategies | 12.24±2.39 | 11.57±2.42 | 1.877 | 0.062 |
| | Self-reflection | 14.87±3.71 | 14.67±2.90 | 0.422 | 0.673 |

### *Attitudes toward PE classes*

To accommodate the purpose of this study, Park's (14) questionnaire on attitudes toward PE classes was revised and used, which supplemented the questionnaire based on Kim's (15) multidimensional theory on attitudes. The questionnaire on attitudes toward PE consisted of six factors and 18 questions. Each question was measured on a five-point Likert scale. The higher the points, the better the student's attitudes toward PE classes in five factors, except for negative emotions.

### *Self-directed learning abilities*

The questionnaire of Lee et al (16) on self-directed learning abilities was revised, supplemented, and used according to this study's purpose. The questionnaire consisted of five factors and 20 questions. Each question was measured on a five-point Likert scale. The higher the points, the greater the student's self-directed learning abilities.

### *Selection and organization of learning content*

The specific class content of each sport discipline and lesson, and the associated STEAM elements, are shown in Table 4.

**Table 4:** Class content of each game, lesson, and STEAM element

| *Section & Theme* | *Subject* | *Content* | *Lesson* | *STEAM elements* |
|---|---|---|---|---|
| Section 1 (Fine dust and 1,000m running) | Science | • Definition of fine dust, impact on human body<br>• Measuring fine dust in the classroom<br>• Experimenting with fine dust mask performance<br>• Measuring fine dust in a mask after 1,000m running | 1-3 lessons | S, M |
| | Arts | • Designing a fine dust mask | 1-2 lessons | A |
| | Technology Home Economics | • Making a fine dust mask based on scientific principles | 1-2 lessons | T, E |
| | PE | • Understanding physical strength<br>• Cardiopulmonary strengthening class<br>• Understanding the relationship between motion and fine dust | 1-7 lessons | A, S |

| | | | | |
|---|---|---|---|---|
| | | • 1,000m running after wearing a mask (measuring three times interval according to fine dust level)<br>• Group presentations of fine dust and 1,000m running experience | | |
| Section 2 (Creative expression activities) | Science | • Understanding the principles of force and motion according to movements | 1-2 lessons | S, M |
| | Technology Home Economics | • Making costumes and props using a variety of materials | 1-3 lessons | T, E, A |
| | Korean | • Identifying the meaning of physical expression activities through the features of mask dance<br>• Creating creative dance themes and stories<br>• Group presentations of experiences in creative expression activities | 1-4 lessons | A, |
| | PE | • Understanding physical expression activities<br>• Selecting group themes and creating movements<br>• Group activities by understanding the elements of movement (space, time, force, and flow)<br>• Performing creative expression activities | 1-6 lessons | A, S |
| | Music | • Selecting and editing background music suitable for creative expression activities | 1-2 lessons | A, T |
| Section 3 (Table Tennis) | Science | • Understanding kinematic principles<br>• Applying the kinematic principles of table tennis swing and table tennis ball spin<br>• Understanding the materials of rackets and table tennis balls | 1-3 lessons | S, M |
| | Arts | • Designing a variety of table tennis rackets | 1-2 lessons | A |
| | Technology Home Economics | • Creating table tennis rackets in a variety of materials | 1-2 lessons | T, E |
| | PE | • Understanding net games<br>• Learning table tennis adaptation games and their functions<br>• Playing a simple game<br>• Dealing with new rackets<br>• Group presentations of table tennis experiences | 1-6 lessons | A, S |
| | Society | • Understanding the history of Korean net games<br>• Understanding table tennis development and social background | 1-2 lessons | A |
| Section 4 (Tee-ball) | Science | • Understanding the nature of substances<br>• Learning the characteristics of different balls<br>• Learning kinematic principles | 1-3 lessons | S, M |
| | Arts | • Designing baseballs based on mechanical principles | 1-2 lessons | A |
| | Technology Home Economics | • Creating baseballs in a variety of materials | 1-2 lessons | T, E, |
| | PE | • Understanding the characteristics of tee-ball<br>• Learning the basic functions of tee-ball<br>• Hitting new balls<br>• Giving a presentation about tee-ball experiences | 1-6 lessons | A, S |
| | Society | • Understanding the history of Korean baseball<br>• Understanding the social background associated with baseball and tee-ball development | 1-2 lessons | A |

### Research process

Four sport disciplines were selected (i.e., long-distance endurance running, creative expression activities, table tennis, and tee-ball) to verify the effect of PE classes based on STEAM, by conducting the classes for 14 weeks, from March 11 to June 14, 2019. It took three weeks to complete the tasks related to each discipline because the curriculum related to each one coincided with other activities. Prior to the classes' commencement, questionnaires were administered for two days, on March 4 and 5, 2019, after explaining the nature of the PE classes and the research objectives to the students. A post-test was performed for two days, on June 17 and 18, 2019, after completion of the application of flipped learning classes.

### Validity and reliability of attitudes toward PE classes

The explained variation of the whole dispersion regarding the six sub-factors of attitudes toward PE classes was 69.81%, and the Kaiser-Meyer-Olkin Measure of Sampling Adequacy (KMO) was 0.736 ($\chi^2$=1216.689, $P$<0.001). As for factor loading by sub-factor, it turned out that each sub-factor was valid, by showing health and physical strength values between 0.834-0.645, interpersonal relations between 0.863-0.760, active participation and positive performance between 0.844-0.712, positive emotions between 0.808-0.646, negative emotions between 0.840-0.668, and physical activities and movement between 0.916-0.867.

For the reliability test of internal consistency, "health & physical strength," "interpersonal relations," "active participation and positive performance," "positive emotions," "negative emotions," and "physical activities & movement" reported Cronbach's α values of 0.785, 0.791, 0.749, 0.764, 0.690, and 0.823, respectively.

### Self-directed learning abilities

The explained variation of the whole dispersion regarding the five sub-factors of self-directed learning abilities was 57.43%, and KMO was 0.820 ($\chi^2$=1100.498, $P$<0.001). As for factor loading by sub-factor, it turned out that each sub-factor was valid, by showing self-reflection values between 0.803-0.623, learning objective establishment between 0.784-0.573, selection of learning strategies between 0.745-0.610, desire for learning between 0.748-0.597, and basic self-management abilities between 0.846-0.673.

For the reliability test of internal consistency, "self-reflection," "learning objective establishment," "selection of learning strategies," "desire for learning," and "basic self-management abilities" reported Cronbach's α values of 0.825, 0.763, 0.689, 0.647, and 0.610, respectively.

### Statistical analysis

SPSS 21.0 statistics program (IBM Corp., Armonk, NY, USA) for Windows was used to process the results. First, the validity and reliability analysis of the questionnaire used exploratory factor analysis and Cronbach's α according to a Varimax rotation. Second, the independent sample t-test was used to test the homogeneity of pre-scores regarding the attitudes toward PE classes and self-directed learning abilities between the experimental and control groups. Third, to verify the effect of PE classes based on STEAM on self-directed learning abilities and attitudes toward PE classes, this study carried out a multivariate analysis of variance (MANOVA). Statistical significance was set at $P$<0.05.

## Results

### Attitudes toward PE classes based on STEAM

The experimental group showed higher average scores in all sub-factors of attitudes toward PE classes, except negative emotions, compared to the control group, as shown in Table 5. To confirm the changes in attitudes toward PE classes observed among students after participating in PE classes based on STEAM, MANOVA was carried out to determine the differences between the two groups. As shown in Table 6, the experimental group, which participated in PE classes based on STEAM, reflected a higher score and, therefore, better attitudes toward PE classes than the control group (Hotelling's=0.476, F=14.285, $P$<0.001, $\eta^2$=0.323).

**Table 5:** The Mean and standard deviation of attitudes toward PE classes for both groups

| *Factor* | *Sub-factor* | *Group* | *M±SD* |
|---|---|---|---|
| Attitudes toward PE classes | Health and Physical Strength | Experimental group | 17.25±2.78 |
| | | Control group | 14.97±2.08 |
| | Interpersonal Relations | Experimental group | 13.11±2.12 |
| | | Control group | 11.34±1.68 |
| | Active Participation and Positive Performance | Experimental group | 11.01±2.38 |
| | | Control group | 9.57±1.95 |
| | Positive Emotions | Experimental group | 12.34±2.11 |
| | | Control group | 11.09±1.71 |
| | Negative Emotions | Experimental group | 4.69±1.33 |
| | | Control group | 6.45±1.39 |
| | Physical Activities and Movements | Experimental group | 8.56±1.62 |
| | | Control group | 7.49±1.10 |

Observing sub-factors of attitudes toward PE classes, there were statistically significant differences in health and physical strength (F=30.831, $P<0.001$, $\eta^2=0.143$), interpersonal relations (F=36.441, $P<0.001$, $\eta^2=0.165$), active participation and positive performance (F=10.948, $P=0.001$, $\eta^2=0.056$), positive emotions (F=25.764, $P<0.001$, $\eta^2=0.122$), negative emotions (F=75.740, $P<0.001$, $\eta^2=0.290$), and physical activities and movement (F=27.302, $P<0.001$, $\eta^2=0.129$). According to the results, the experimental group that participated in PE classes based on STEAM showed an improvement in all sub-factors of attitudes toward PE classes, compared to the control group.

**Table 6:** The results of MANOVA and ANOVA on the sub-factors of attitudes toward PE classes

| *Variable* | *MANOVA* | | | | *ANOVA* | | |
|---|---|---|---|---|---|---|---|
| Sub-factor | Hoteling's ² | F | p | $\eta^2$ | F | p | $\eta^2$ |
| Health and Physical Strength | 0.476 | 14.285 | 0.000 | 0.323 | 30.831 | 0.000 | 0.143 |
| Interpersonal Relations | | | | | 36.441 | 0.000 | 0.165 |
| Active Participation and Positive Performance | | | | | 10.948 | 0.001 | 0.056 |
| Positive Emotions | | | | | 25.764 | 0.000 | 0.122 |
| Negative Emotions | | | | | 75.740 | 0.000 | 0.290 |
| Physical Activities and Movement | | | | | 27.302 | 0.000 | 0.129 |

### *PE classes and self-directed learning abilities based on STEAM*

The experimental group showed higher average scores in all sub-factors of self-directed learning abilities than the control group (Table 7). To compare the changes in self-directed learning abilities that were observed after participation in PE classes based on STEAM, MANOVA was carried out.

**Table 7:** Mean and standard deviation of self-directed learning abilities for both groups

| *Factor* | *Sub-factor* | *Group* | *M±SD* |
|---|---|---|---|
| Self-Directed Learning Abilities | Desire for Learning | Experimental Group | 13.49±2.53 |
| | | Control Group | 12.32±2.28 |
| | Learning Objective Establishment | Experimental Group | 13.17±3.21 |
| | | Control Group | 10.94±2.86 |
| | Selection of Learning Strategies | Experimental Group | 12.85±2.48 |
| | | Control Group | 11.01±2.71 |
| | Self-Reflection | Experimental Group | 16.98±3.45 |
| | | Control Group | 13.99±3.34 |
| | Basic Self-Management Abilities | Experimental Group | 11.18±2.03 |
| | | Control Group | 9.88±1.79 |

As shown in Table 8, there were statistically significant differences in all sub-factors (Hotelling's=0.201, F=7.281, *P*<0.001, $\eta^2$=0.167). As for self-directed learning abilities by sub-factor, there were significant differences in terms of desire for learning (F=15.962, *P*<0.001, $\eta^2$=0.079), learning objective establishment (F=22.510, *P*<0.001, $\eta^2$=0.108), selection of learning strategies (F=24.670, p<0.001, $\eta^2$=0.118), self-reflection (F=19.239, *P*<0.001, $\eta^2$=0.094), and basic self-management abilities (F=15.605, *P*<0.001, $\eta^2$=0.078). According to the results, the experimental group that participated in PE classes based on STEAM showed an improvement in all sub-factors of self-directed learning abilities, compared to the control group.

**Table 8:** Results of MANOVA and ANOVA on the sub-factors of self-directed learning abilities

| *Variable* | *MANOVA* | | | | *ANOVA* | | |
|---|---|---|---|---|---|---|---|
| Sub-factor | Hotelling's ² | F | p | $\eta^2$ | F | p | $\eta^2$ |
| Desire for Learning | 0.201 | 7.281 | 0.000 | 0.167 | 15.962 | 0.000 | 0.079 |
| Learning Objective Establishment | | | | | 22.510 | 0.000 | 0.108 |
| Selection of Learning Strategies | | | | | 24.670 | 0.000 | 0.118 |
| Self-Reflection | | | | | 19.239 | 0.000 | 0.094 |
| Basic Self-Management Abilities | | | | | 15.605 | 0.000 | 0.078 |

## Discussion

### *Attitudes toward PE classes based on STEAM*

PE classes based on STEAM influenced the improvement of students' attitudes toward PE classes for several reasons. First, it increased students' academic motivation and participation. STEAM provides a practical environment that enhances learning motivation, by teaching students how to apply this knowledge and how it is related (17). In particular, the practical environment allows students to enjoy classes more than they would have if they were learning through listening alone, and to find ways to effectively solve difficult tasks (12). Moreover, PE alienation occurs when motor functions are central (3). Therefore, it seems that students' interest and learning motivation improve when they know how the basic motor functions learned during physical activities are related to scientific theories, and when they make and use new tools based on mechanical principles. The self-determination theory of Deci and Ryan (18) suggests that an individual's motivation and performance will be maximized if an educational context that satisfies the needs for competence, autonomy, and relatedness is provided. These three needs are naturally satisfied as the students solve a task through student-centered cooperative learning in PE classes based on STEAM, increasing their motivation and participation.

Second, PE classes based on STEAM strengthened attitudes toward PE classes, by facilitating interaction among students, as well as between students and teachers. The PE classes based on STEAM encouraged team members to solve abstract theory tasks, while sharing a variety of thinking strategies among themselves. STEAM learning increases students' motivation, interaction with teachers, and effective learning (19). Students can achieve more when they study with friends rather than alone, and this process promotes their social development and voluntary participation in PE classes (20). As a result, PE classes based on STEAM positively changed students' attitudes toward PE classes, by increasing their learning motivation, participation, and facilitating interaction among class members.

### *PE classes based on STEAM and self-directed learning abilities*

There are several reasons why PE classes based on STEAM have a positive effect on students' self-directed learning abilities. First, PE classes based on STEAM are based on problem-based learning. This allows students to participate in complex problems that cannot be solved with a single clue, applying new knowledge between different disciplines, and reflecting on their own learning (21). For example, students showed leadership and divergent thinking during a presentation about their tee-ball class experiences, in which they discussed a recent problem concerning the official ball used in baseball, and presented their studies on the ball's reaction force by using rubber, paper, iron, wood, etc. The improvement of self-directed abilities after STEAM-based classes is supported, not only by Zimmerman's study (22) that explains how these abilities are improved by an open environment in which students can choose and apply knowledge, but also by the study of Plucker et al (23) that explains how students can improve their self-directed learning abilities when they explore, observe, reflect, and ask specific questions in a STEAM environment.

Second, PE classes based on STEAM enhance self-efficacy. Students with high academic self-efficacy have high self-directed learning abilities because they use self-directed learning, motivational, and cognitive strategies (24). The factors contributing to self-efficacy improvement in PE classes based on STEAM can be found in the case of small-scale cooperative learning. This enhances self-efficacy by sharing and solving problems assigned to individuals, improving their abilities to cope with task stresses, while achieving higher performance (25). PE classes based on STEAM reduces the need for explanations and demonstrations that are important in traditional teacher-centered classes, and instead, increases the time available to practice functions and participate in problem-solving tasks through cooperative learning. This change ensures that students feel that their peers can help them solve their learning problems due to increased feedback between them, especially in small-scale cooperative learning, thereby improving the achievement of tasks as students concentrate on learning comfortably. As a result, PE classes based on STEAM operate based on problem-solving learning, and are considered as having affected self-efficacy, thereby improving self-directed learning abilities.

## Conclusion

Efforts are required to apply STEAM to PE. Many educational leaders have interpreted subjects and taught subject knowledge from a narrow viewpoint, hence balanced teaching and learning methods have been requested in the arts, sciences, and humanities. In particular, PE is struggling to resolve students' alienation and avoidance problems, despite numerous efforts. Thus, discussions have been conducted on how the STEAM philosophy can be implemented in the field of PE. Studies should be conducted to explore important changes, other than attitudes, toward PE and self-directed learning abilities.

## Ethical considerations

Ethical issues (Including plagiarism, informed consent, misconduct, data fabrication and/or falsification, double publication and/or submission, redundancy, etc.) have been completely observed by the authors.

## Acknowledgements

This research received no external funding.

## Conflict of interest

The authors have no conflicts of interest to declare.

## References

1. Carlson TB (1995). We hate gym: Student alienation from physical education. *J Teach Phys Educ*, 14(4):467-77.
2. Kim JP, Park DW, Park JL (2016). Study on Teacher's Practical Knowledge for Improve the Physical Education Class Alienation Phenomenon. *Journal of Learner-Centered Curriculum and Instruction*, 16(4):173-202.
3. Johns DP, Dimmock C (1999). The marginalization of physical education: impoverished curriculum policy and practice in Hong Kong. *J Educ Policy*, 14(4):363-84.
4. Organisation for Economic Cooperation and Development (2001). *Lifelong Learning for All Policy Directions*. OECD Publishing.
5. Jo YH (2009). *Study of high school student's academic life and culture*. Korean Educational development Institute: Seoul.
6. Seo DH (2007). An educational meaning of "Leisure": A phenomenological study on time experiences of homeschooling. *J Curric Stud*, 25(2):63-90.
7. Costantino T (2018). STEAM by another name: Transdisciplinary practice in art and design education. *Arts Educ Policy Rev*, 119(2):100–6.
8. Kang N, Lee N, Rho M, et al (2018). Meta-analysis of STEAM (science, technology, engineering, arts, mathematics) program effect on student learning. *Journal of the Korean Association for Science Education*, 38(6):875-883.
9. Kim HB, Chae DH (2016). The development and application of a STEAM program based on traditional Korean culture. *Eurasia J Math Sci Technol Educ,* 12(7):1925–36.
10. Mehalik MM, Doppelt Y, Schuun CD (2008). Middle-school science through design-based learning versus scripted inquiry: Better overall science concept learning and equity gap reduction. *J Eng Educ*, 97(1):71–85.
11. Kuenzi JJ (2008). *Science, technology, engineering, and mathematics (STEM) education: Background, federal policy, and legislative action (Research Rep. No. RL33434)*. Retrieved from Congressional Research Service website: http://digitalcommons.unl.edu/cgi/viewcontent.cgi?article=1034&context=crsdocs.
12. Thuneberg H, Salmi H (2018). To know or not to know: uncertainty is the answer. *J Sci Commun*, 17(2):1–28.
13. Li C, Kam WKK, Zang M (2019). Physical Education Teachers' Behaviors and Intentions of Integrating STEM Education in Teaching. *Physical Educator*, 76(4):1086–101.
14. Park JP (2015). *A Study on the Design and Implementation of Smart Device-based SCAN Program for Physical Education Class*. Unpublished Doctoral dissertation. Korea National University of Education.
15. Kim JH (2004). An Analysis on the Effectiveness of Physical Education Attitude and Self-Efficacy of Cooperative Learning. *Korean Journal of Sport Pedagogy*, 11(2):91-103.

16. Lee SJ, Jang YK, Lee HN, et al (2003). *Development of life-ability measurement tool.* Korean Educational development Institute: Seoul.
17. Eccles SJ, Wigfield A (2002). Motivational Beliefs, Values, and Goals. *Annu Rev Psychol*, 53:109-32.
18. Deci EL, Ryan RM (2000). The "What" and "Why" of Goal Pursuits: Human Needs and the Self-Determination of Behavior. *Psychol Inq*, 11:319-38.
19. Henrkisen DM, DeSchryver P, Mishra et al (2015). Rethinking Technology & Creativity in the 21st Century Transform and Transcend: Synthesis as a Trans-disciplinary Approach to Thinking and Learning. *J Sci Educ Technol*, 59(4):5-9.
20. Kim JH (2004). *Development and Validation of a Korean Version Attitude Scale for Physical Education*. Unpublished Doctoral dissertation, Kongju National University, Korea.
21. Hmelo-Silver CE (2004). Problem-based learning: What and how do students learn? *Educ Psychol Rev*, 16(3):235-66.
22. Zimmerman BJ (1989). A social cognitive view of self-regulated learning. *J Educ Psychol*, 81(3):329-39.
23. Plucker JA, Guo J, Dilley A (2018). *Research-guided programs and strategies for nurturing creativity*. In S. I. Pfeiffer, E. Shaunessy-Dedrick, & M. Foley-Nicpon (Eds.), APA handbooks in psychology®. APA handbook of giftedness and talent (p. 387–397). American Psychological Association.
24. Zimmerman BJ, Bandura A, Martinez-Pons M (1992). Self-motivation for academic attainment: The role of self-efficacy beliefs and personal goal setting. *Am Educ Res J*, 29:663-76.
25. Bandura A (1997). *Self-Efficacy: The Exercise of Control.* New York: Freeman.