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Multimodal Approaches to Math and Physical Education within Cooperative Learning to Enhance Social Attitudes

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Abstract: This study investigates cooperative learning educational approaches that support preservice teachers' (PSTs) academic and social attitudes. The extent of positive interdependence between PSTs during multimodal cooperative physical and mathematical activities was measured using a validated questionnaire on attitudes (academic and social) toward cooperative learning attitudes. The multimodal activities triggered positive PSTs' interdependence characterized by teaching dimensions such as encouraging learner-to-learner interactions, intersubjective skills, and sociocultural awareness. PSTs believed that the cooperative activities helped to form peer-to-peer relationships among team members, which in turn fostered professional judgments. While social and affective attitudes were rated higher than academic ones, the difference was not significant. Hence, this study emphasizes that the multimodal approaches (based on both mathematical and physical development) triggered deeper social rather than academic attitudes, thus underscoring the importance of promoting key competences and the role they play in sustainable education.

Keywords: cooperative learning; multimodal approaches; pre-service teachers; physical education; mathematics

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1. Introduction

Universities are now focusing on the implementation and development of key competences that contribute to promoting a sustainable education. The most significant change for universities is in the potential new information and communication technologies have as the creating and sharing knowledge are no longer autonomous activities. Interpersonal relations and collaboration, interdisciplinary work, empathy, and a change in perspective are some of the competences that deliver sustainable development [1]. Providing sustainability education to tertiary students implies a reanalysis of today's educational transitions that advance sustainable education through multimodal learning competences. PSTs, as future agents of promoting sustainable education, have different kinds of expectations, increasingly anticipating being formal agents of knowledge and competences production, and with a view towards interdisciplinary projects [1,2]. Students are at the center of transformative educational approaches that consider their individual, group, and social development [3]. As such, this study lays the groundwork for transformative pedagogy, which replaces "authentic" and "synthetic" pedagogies that have been shown to be ineffective in ensuring that students are equipped with the scientific and technological skills they need in both their daily lives and their professions [4–7].

Multimodal enrichment programs can provide specially designed, community-based frameworks to promote responsive and sustaining pedagogies [8]. Exploring active learning in multimodal education is credited with fostering creative thinking [9], developing cognitive structures [10], and improving career decision making [11]. Taking into account multimodal contexts where links between competences and tasks naturally occur, make it easier to devise techniques that appeal to students' visual and bodily senses [4–7]. If a variety of techniques were used in instructional approaches, a wide range of students - and maybe society as a whole- would benefit [12–14].

The principle aim of this project is not only to implement a didactic approach for teaching both math and physical education competences from an integrated viewpoint, but also to investigate a multimodal research technique that will incorporate primary education competences PSTs must acquire and develop through math and physical education. In other words, to create a method for PSTs to experience cross-correlation competences through physical, aesthetic, and mathematical concepts based on cooperative learning. This will be achieved by creating a research corpus of defining strategies that will serve as a guide for tertiary students teaching initial, middle, and higher levels (K6 to K12) of primary school curricula [9,15–17]. This study's core component is merging various learning domains and developing a framework for defining the outcomes of the dialogue between pedagogical mathematics and physical education aesthetics, i.e., the investigation of spatial and temporal patterns (experiments) with an eye to the aesthetic potential (interpretations). The objectives and actions in this study are intended to complement primary school math curricula and are focused on PST activities. While the knowledge component of the European reference framework for key competences for lifelong learning has received considerable empirical support, a new understanding of teachers' responsibilities is necessary to foster the development of students' sustainable competences [12,13]. To support teaching in schools through practice, this study proposes developing specific strategies for PSTs including those highlighted by the New London Group: encouraging collaborative, committed, and creative engagement in which students take risks, embrace teamwork, and persevere in problem solving [18].

Most people can learn about forms and structures by interacting with them physically [19–22] and in doing so, aiding intellectual and emotional learning [23,24]. According to Lakoff and Johnson [25], space is an essential reference for how we live and learn. Recognizing that three-dimensional geometrical forms offered a way to organize and represent space [26–28], Laban [26] developed a symbolic movement-oriented model to be used for multiple physical and emotional purposes. Choreographers Trisha Brown (USA) and William Forsythe (Switzerland) used this explicitly to map three-dimensional body movements into perceived discrete space directions [29]. Thus, by using basic geometry movements, PSTs could not only explore the limits of their own bodies and develop an understanding of the knowledge the diverse levels of primary school students have regarding body language, but also experience conceptual terms as continuity, symmetry, directions, axes, and surfaces, among others. Likewise, PSTs could interpret math concepts through language of movement and motion experiments [30].

The intuitively obvious observation that learners who are given a variety of representational possibilities display increased brain activity as they attempt to make sense of this information is also supported by neuroscientists. Inferring connections between the kinesthetic, visual, and symbolic senses and mathematical concepts is possible thanks to Papert's insight into the relationship between motion and logical experience [31]. The idea that the body speaks in a universal language indicates that there is a constant cycle of cognition and action. Sometimes action must sometimes be guided by thought, but in other cases, action is realization and understanding. Mathematics and physical movements interact with encoded concepts and patterns (i.e., symmetry and spatial awareness problems). There are also aesthetic similarities such as the need for internal consistency and achieving a balance between analysis and intuition. The idea of symmetry, for instance, underpins a dance. Symmetry is also reflected in mathematics education through geometry. In addition, body exploration through movement is expressive, and thus allows students of mathematics to experience how art and science interact [17,32].

It is important to remember that guided or free, physical movement promotes values such as respect, freedom, and tolerance [33,34]. When developing body activities, biological, cognitive, and psychomotor benefits may be activated including, for instance, the pleasure sense of movement and release of energy experienced in the search for expressivity [35,36]. Multimodal cooperative methodology development takes into account both individual and collective physical language and body language to promote various artistic representations and analysis of reality [13,17,35]. Despite this, physical education curriculum competences in primary education still need to be further developed using visual and multimodal cooperative approaches to promote body communication with others, feelings, and personal ideas such as those found in math curriculum which explore concepts and ideas, not only via multiple approaches and contexts, but also collectively using multimodal languages in various formats. Consequently, integrating disciplines such as mathematics and physical education can help trigger learning for tertiary students through academic and social attitudes.

The underlying rationale of this project then is to develop a cooperative multimodal approach to cross-correlate knowledge content and competences in mathematics and to experience them through artistic movement (the body) encased within cooperative learning. The project will develop body-kinesthetic (BK) and visual-spatial (VS) approaches for physical education, and math (M) education approaches for PSTs to best develop and obtain curricula competences required in mathematics. The following hypotheses are to be tested: 1) cooperative BK and VS physical activities in the domain of physical education that incorporate mathematical representations increase PSTs' cooperative positive interdependence; and 2) the level of social and affective attitudes is higher than academic attitudes when PSTs are embedded in developing multimodal BK, VS, and mathematical activities all at once. The analysis of students' competences and attitudes addressed in this study will provide interdisciplinary ways for PSTs to both express themselves and communicate as perceiving, representing, understanding, and enrichment through different realities and individual/cooperative productions. As Ausubel noted [34], if a student is to produce meaningful learning, then not only do they need to relate the new knowledge with previously acquired knowledge [36,37], but also be interested in learning what is being shown. In this respect, exploring new methodologies is fundamental [38–40].

2. Theoretical Background

2.1. The Multimodal Approaches to Learning within Historical Development

Education for sustainable development defends integral perspectivism as it attempts to aggregate all perspectives without favoring any of them, to learn what is comprehensive: an ability that internalizes all [4,33]. The development of a competence involves mustering divergent and convergent thoughts, to develop ideas to solve a variety of situations, thus bringing into play feelings and expression [16,17].

Nearly no effort is being made to create and implement future-oriented modes of synergistic teaching and learning for new generations, despite the numerous educational projects being undertaken [41]. For instance, technologically oriented abilities have been gaining ground in schools at the expense of the creative arts, which were thought to be less valuable and less lucrative in highly competitive environments [12]. That said, more space is currently being given to creativity in the curriculum, and this new trend is seeing educational establishments starting to adjust their multimodal approaches to learning; sometimes rather drastically [16]. Nevertheless, is now understood that fostering creativity plays a significant role in developing well-rounded people who can think critically, question received wisdom, and empathize with others [36]. Additionally, creativity is a multidisciplinary resource that encourages inventiveness and ingenuity in all spheres of life rather than being a hermetic capacity [23].

Common educational practices throughout Europe are easily recognized [12], for instance, educating through the dialogue between sciences and the humanities may promote educational approaches that foster key competences for sustainable development. This is a concept that has begun to be investigated through STEAM models of teaching [17]. For example, STEAM research shows a positive relationship between arts and science concepts, that may sustain a balanced and holistic curriculum towards students' development in all educational systems [13,38]. UNESCO emphasized three main goals in its Seoul agenda to ensure that: (i) arts education is implemented throughout sustainable development, (ii) activities and programs are of high-quality in conception and delivery, and (iii) principles and practices of arts education addressing current social and cultural challenges [42].

2.2. Multimodal Approaches for Sustainable Education

There are considerable hidden costs associated with the current disparities in education and training for people, society, and economies. To produce high degrees of excellence and raise the overall level of abilities, education should be effective and egalitarian [12]. Education ministers from EU member states, for example, have identified teacher development, key competencies, language learning, ICT, math, science, technology, active citizenship, and social cohesion as priority objectives to be developed in all educational levels in order to improve their respective countries' educational systems [43,44]. These priorities are based on an analysis of education which revealed that 25% of children under the age of 15 attain only the lowest level of reading competence; 15% of students aged between 18 and 24 drop out of school before they should; only 78% of 22-year-olds complete upper secondary school, and interest in several disciplines, including science and mathematics, is low [45].

Change begins with the notion of being oneself, engaging one's capacity for self-reflection, and developing empathy for others [33–35]. Implementing reflective and self-cognitive learning also entails developing a unique way of thinking, behaving, and building a different, more sustainable way of being [16]. It is a methodological instrument for practice-based actions used to create systemic processes that respond to issues and challenges. Place-based sustainability has developed into a major revolutionary endeavor, in large part because of artists and cultural activists who have kept a critical eye on how we use the concept of wealth [33]. New sources of information are continually produced through the creative arts and the cultivation of knowledge, but new dimensions must be applied to cultivate humanistic and scientific culture [16,17]. Schools frequently focus on developing students' cognitive potential at the price of achieving their entire human potential, in contrast to artistic settings that work to enrich students' emotional and social development.

The current educational model largely depends on science, logic, rational thought, and standardized testing. It is recognized that formal systems of education have partially abandoned the goal of producing inspired, inventive, creative students [15] and instead have become production facilities of technologists, consultants, designers, and other creative employees, with art being relegated to the realm of art-event promotion. Anywhere the synergies between the arts and culture are promoted, must be done so on both individual and social scales [46]. The foundational myths of Western culture must be critically examined from an artistic perspective, and education for creativity and creativity for sustainability must be seen as the sources of regenerative knowledge [47].

Additionally, it has recently been recognized that the skills required for the workplace include creativity, problem solving, independence, innovation, and collaboration. Thus, any learning activity should take these skills into account as being essential to a creative education [1]. Likewise, high levels of motivation, creative potential, talent and skill, individuality, positive independence, enthusiasm, curiosity, imagination, and placed-based approaches are among just some of the essential characteristics required to study creative arts [14,33,36].

2.3. Multimodal Learning in Math and Physical Education

Recent cognitive research has led to the development of Gardner's theory and *"documents the extent to which students possess different kinds of minds and therefore learn, remember,* *perform, and understand in different ways"* [48]. A set of learning styles is considered as a conjectural categorization *"we are all able to know the world through language, logical-mathematical analysis, spatial representation, musical thinking, the use of the body to solve problems or to make things, an understanding of other individuals, and an understanding of ourselves."* [48,49]. Cognitive research sets down that individuals may differ in how they apply the ways in which they combine previous and newly acquired cognition to carry out tasks, solve problems, and progress in various domains. For example, both visual-spatial and bodily-kinesthetic skills may be used synergistically to communicate concepts and to develop competences through body language [15].

The eights key competences for lifelong learning are underpinned by enhancing grounded and sustainable competences with a myriad more towards managing one's feelings. Transversal or cross-curricular competences are now defined in terms of promoting sustainable development and equity and require new educational approaches for them to be developed [50]. The need to develop new, holistic approaches to teaching and learning is also emphasized in the 2008 communication from the Commission of the European Communities' Improving competences for the 21st Century-an Agenda for European Cooperation on Schools. Despite many countries using the European framework of key competences as a starting point for educational reform, the commission's communication from November 2009 comes to the conclusion that much more work needs to be done to support teachers' competence development, modernize assessment techniques, produce learning materials, and introduce new organizational strategies for learning [50].

The multi-modal approach in math learning uses different modes to represent content (verbal and non-verbal): numbers, words, symbols, diagrams, stories, and real things, among others, to deepen understanding and flexibility in thinking [51]. A multimodal approach enhances links between different modes of representation. For example, a multimodal language model for math education that uses mathematical symbols and pictorial and natural languages has been employed to help students' understand and further their knowledge of the concept of division [52]. Indeed, while the integrity and uniqueness of the mathematics and physical education areas are important, the relationship between them is critical to provide a deeper knowledge understanding [53]. For example, classroom-based physical education has been found to improve children's math achievement [54]. Also, students that were immersed in both light or moderate-to-vigorous physical activity and mathematics developed higher key educational outcomes that those immersed in sedentary processes [55,56]. In our study, the merging of physical and mathematics education through developing body-kinesthetic and visual-spatial representation skills is directed towards visualizing, applying, presenting, and communicating mathematics. The use of body language and cooperative group activities to represent mathematical concepts and competences may boost learning in mathematics and develop mathematical understanding [56].

2.4. Cooperative Learning in Mathematical and Physical Education

The theories of cognitive learning and social interdependence lend support to the pedagogical practice of cooperative learning. For the past three decades, cooperative learning has been explored, and there is evidence that it is effective in fostering social interdependence, for best promotion of the ideals of justice, social responsibility, and mutual trust among learners. The fundamental tenets of cooperative learning are the capacity to work on grounded and complex situations in interdisciplinary contexts, and to comprehend inter- or multi-disciplinary complex systems across multiple scales as well as the capacity to promote the cooperation between team members to either tackle problems and projects. In cooperative learning, it has been noted that when teachers promote using cognitive, affective, and motivational resources, students feel positively interdependent when they deal with cooperative activities [57–59]. Positive interdependence is understood as the capacity to build individual competences for the benefits of the members of a group (intertwined roles, shared resources, joint rewards, etc.), who work together to achieve a shared learning goal [58–60]. In the domains of physical and science education, cooperative learning is recognized to promote PST socialization [57], enhance their professional identity [58,60], and increase task interdependence [61,62].

Models of cooperative learning in physical education have been developed in the last twenty years with later emphasis on the development of the students' social and relational skills within the classroom [63]. The social domain is considered to be a key parameter for students' development provided that students have the perception of competence [63]. However, as noted by Serdà and Alsina [37] and Colomer et al. [9] the use of cooperative learning in multimodal approaches needs to be critically approached, particularly in terms of students' developing their social, affective (socials skills in receiving information and self-assertion), and academic attitudes (cognitive skills for teamwork) that may configure different levels of student' interdependence. Furthermore, relatively little research into multimodal education (including math and science) has investigated what activities should be offered in schools to effectively promote students' positive interdependence and enhance learning. While factors such as attitudes towards teamwork, team potency, and the social skills and self-assertion required in a team setting to be able to effectively receive and process information have been identified in physical education [57,58,63], determining students' interdependence for enhancing learning in multimodal education has yet to be investigated.

3. Methodology

3.1. Participants

One hundred and twenty-four PSTs were involved in the study. Of the participants, 64% were female and 36% male. All were in their fourth year of one of the three bachelor's degrees in either early childhood teacher education, primary school teacher education, or the double degree in primary and early childhood teacher education, at the department of subject-specific education at the authors' university (University of Girona, Spain).

After an initial information session, all participating students agreed to take part in this research project and provided their written consent that included consent for collecting and analyzing information. All the research output was anonymized to ensure equal analysis of data.

The students participated in the following two-hour long seminars on cooperative learning: (1) dimensions of cooperative learning, (2) cooperative learning and sustainable development, (3) professional identity, (4) multimodal approaches and cooperative learning, (5) multimodal approaches and cooperative learning, (6) cooperative learning to reduce inequalities, (7) multimodal learning and mathematics, and (8) physical education and cooperative learning. Following the seminars, students created and applied cooperative physical activities to determine best practices in primary schools.

3.2. Context

Spain specifies PST curricula in mathematics on a regional basis. The final definition for the core skills are described as follows: (1) translate and understand issues and everyday situations by developing a personal mathematical representation of them using ideas, tools, and techniques to assess the most essential elements; (2) solve issues by using various techniques, strategies, and forms of reasoning to explore and exchange multiple approaches, acquire answers and confirm their validity from a formal standpoint and in connection to the context addressed, and generate new questions and challenges; (3) communicate and describe mathematical concepts, techniques, and findings (both individually and collectively) utilizing oral, written, visual, and multimodal language in various formats and the proper mathematical terminology, to provide meaning and permanence to mathematical ideas and (4) develop social skills by actively participating in work teams and appreciating the diversity and importance of others' contributions in order to collaboratively share and foster mathematical knowledge. The math concepts that were explored in the cooperative activities were the following: two and three spatial movements, geometrical figures, distance, the concepts of time, the relation between time and space, interpretation of graphics, and the classification of figures and magnitudes.

The two fundamental competencies that are stressed by physical education teachers are the following: (1) utilizing one's own body to communicate experiences, feelings, and ideas, and (2) participating in group activities that promote expression and body communication to build relationships with others. The movements that were explored in the cooperative activities were the following: recognition of body parts, awareness of tension, relaxation, and breathing, experimenting with different body positions, self-perception and interaction with space and time, experimenting with various forms and possibilities of movement, investigating and discovering the expressive potential of the body and movement, movement synchronization using pulsations and basic rhythmic frameworks, uninhibited expression of emotions and sentiments through the body, gesture, and movement, experimenting with various expressive forms and materials, reproducing dance and basic choreographies, and finally recognizing distinctions in one's own style of expression.

3.3. Instructional Approach

An integral part of this study is developing mathematical expressions through a multimodal learning methodology, through movement, and visual and spatial experiments. In this way, bodily-kinesthetic (BK), visual-spatial (VS), and mathematical (M) learning categories can be developed.

The tasks in which the PSTs are involved in are based on five dimensions embedded in cooperative learning:

(1) The controlled experiment dimension (CED): PSTs conduct controlled experiments in groups of three around a mathematical concept by showing different results (cooperative physical activities) to two other groups of students until they have iterated to an optimal solution [32]. Although the controlled experiment dimension is the best method yet devised to reveal the grasping of knowledge if applied effectively, results might be often inconclusive in the first instance, with the need for different cycles to obtain an effective result [16].

(2) The learner-to-learner dimension (DD): Horizontal, learner–learner dialogues, with the teacher in a position to control the dimensions of cooperation within the progress of an experiment. In the learner–learner interaction within the cooperative groups, the feedback provided by the teacher is aimed at promoting positive interdependence among individuals [33,34]. Positive interdependence is directed at fostering students' personal commitment and motivation, since the capacity for a student to build an individual competence is directly dependent on the success the group has in developing a controlled experiment. Within cooperative groups, individual and group responsibility entails individuals treating others fairly and empathetically and being supportive and culturally attentive. It is recognized that in cooperative instructional approaches disruptive conflicts, social laziness, and lack of individual responsibility may arise [9,17].

(3) Intersubjective dimension (ID): Learner-surrounded interactivity where multiple teacher–learner relationships develop. The teacher aims to promote not only cooperative skills, but also the formulation of mathematical concepts through BK and VS expressions.

(4) Socio-cultural dimension (SCD): The cooperative activities must be governed under the principles of inclusive learning and pluralism [17].

(5) Pedagogical dimension (PD): The teacher maximizes teaching dialogues by providing continuous effective feedback. The learner uses a variety of knowledge processes, and epistemological 'takes'.

The proposed dimensions 1 to 5 embody a grounded place-based pedagogy, in which the teacher fosters sustainable education in contextualized environments [64], with students, as citizens, participating in globalized realistic sustainable settings, taking action and balancing personalities during cooperative tasks [1,13]. Moreover, the set of dimensions was based on mathematics and BK/VS experiments interchange to promote mathematical literacy.

This comprehensive study is designed using a set of cooperative tasks divided into three groups (A, B, and C). The groups are not separate from choices of theoretical perspective and epistemology, therefore the choice of methodology is determined by the kinds of research objectives that this study is intended to develop, and the tasks needed to be dynamically linked and continually enlivened though engagement with a wide comprehension of mathematical concepts and experiments based on movement. Hence, the tasks responded to the promising methodologies emerging for math and science audiences, albeit possibly being well established in education research. The three types of cooperative tasks that the PSTs developed are:

Group Task A: PSTs were encouraged to interact with the immediate environment taking into account BK and artistic expressions. They were asked to cooperatively solve problems involving objects, their body, and their position. PSTs integrated the concepts of time, space, dimensions, change, and continuity. Likewise, math concepts such as light, sound, noise, and silence in relation to time and space. PSTs drafted artistic proposals resulting from sensory perception, imagination, experiences, ideas, and emotions. They were also made aware of the possibilities of the human body, body languages, and the team languages around a mathematical concept.

Group Task B (GB): PSTs cooperatively explored movement representations through VS exploration. They investigated two- and three-dimensional geometrical forms [65]. They also experienced iconic and symbolic modes of representation in math, they experienced physicality—physical imagery and physical memory—and they experienced shape, hands-on learning, acting out, and role playing. Finally, they explored kinesthetic and musical sensitivities, i.e., rhythm and patterns [66].

Group Task C (GC): In cooperative groups PSTs explored abstract representations of structure in math via BK and VS. The PSTs developed formal descriptions and interpretation in mathematical communication and representation, including spatial relationships, geometric figures, and geometric transformations. They were made aware of the interrelations with peers as a result of producing cooperative group aesthetic interpretations around the math concepts.

Each student took part in six cooperative activities, i.e., two GA, GB, and GC cooperative tasks, lasting three hours each. To reduce student-to-student preferences and maximize task interdependence, the cooperative groups' members were chosen at random for each cooperative task. In their lab classes, the PSTs were asked to design and implement, the six cooperative activities incorporating at least two mathematical and one physical education concept each. Each cooperative group was also asked to present a cooperative activity in class that would later be discussed within the whole class.

3.4. Cooperative Learning: Positive Interdependence Analysis

For the analysis of the students' assumed cooperative dimensions' positive interdependence was analyzed and quantified. Positive interdependence operates under reciprocal interdependence, which is established in students' shared objectives, intertwined roles, shared resources, and joint outputs [61]. The goal of interdependence amongst individuals may be seen as a motivational perspective where everyone has the capacity to make their own decisions and achieves assumes both individual and group responsibility via interaction with other peers [57–59]. The validated questionnaire on attitudes towards learning teams [62] was used to measure academic and social and affective attitudes to quantify the level of students' positive interdependence, within the cooperative learning. The questionnaire has twelve questions. All students scored each question on a 5-point Likert scale to specify their level of agreement to a statement: (1) Strongly disagree, (2) Disagree, (3) Neither agree nor disagree, (4) Agree, and (5) Strongly agree. The questions are presented in Table 1.

Table 1. Questionnaire on Attitudes Towards Learning in Teams [62].

Academic Attitudes	
(1)	Working in a team increases my interest in and motivation for the topics covered
(2)	The quality of the work improves when performed in a group
(3)	My grades improve when I work in a team
(4)	Teamwork is important for my professional training
(5)	Teamwork seems like a waste of time to me *
(6)	I learn more when working alone than in a team *
Social and Affective Attitude	
(1)	I feel useful and appreciated by my teammates
(2)	I feel comfortable working with my classmates on team activities
(3)	Teamwork favors friendly relations
(4)	I am confident that my teammates will fulfil their share of the work
(5)	Teamwork helps me to know my teammates better
(6)	Consensus among the team members helps to make better decisions

* Items were inversely worded and recoded for analysis.

As the original version of the questionnaire was in English, it was translated into Catalan. A speaker whose first language (L1) is English translated the twelve questions back into English after they had first been translated into Catalan by a speaker whose first language (L1) is Catalan. The translation procedure turned up no significant problems.

Each student scored the group activities GA (BK activities), GB (VS activities), and GC (BK/VS activities) at the end of each task using the questionnaire on attitudes towards learning teams. To ensure data confidentiality throughout the whole procedure, which was solely utilized for research purposes, the questionnaire was filled out anonymously. Each individual's data was entered onto a spreadsheet for final analysis. Descriptive statistics (mean and standard deviation indexes) were used to describe the data. The reliability of the questionnaire was checked with Cronbach's alpha (α), the composite reliability coefficient (CR), and the average variance extracted (AVE) coefficients. The Kruskal–Wallis test was used for comparisons between attitudes ('Academic' and 'Social and Affective') and between the activities GA, GB, and GC. All analyses were performed using the statistical package SPSS version 27.0.

4. Results

The Cronbach's α for the 'Academic Attitudes' and the 'Social and Affective Attitudes' factors were found to be 0.89 and 0.86, respectively, for all the PST scores (integrated GA, GB, and GC tasks) therefore presenting good global reliability. The composite reliability and the average variance extracted for the academic attitudes' factor were found to be CR = 0.84 and AVE = 0.51, respectively, while for the social and affective attitudes' factor they were CR = 0.88 and AVE = 0.55, respectively.

The PST scores for the social and affective attitudes factor were somewhat higher than for the academic attitudes with a 5.8% increase for the GC activities (Table 2). Task GC had a mean score across all questionnaire questions that were 25.5% and 19.5% higher than Task GA and GB, respectively. The two questions with the highest scores were 11 and 12 (Table 2). Students thought that the cooperative activities helped them to form relationships within the team which, in turn, encouraged them to make better judgments. Students' academic attitudes suggested that cooperative learning-based activities will aid their professional growth (Question 4).

The reliability of the questionnaire when considering a two-related-factor model provided the averaged variance extracted (AVE) scores of 0.562 and 0.598 for the two factors academic attitude' and social and affective attitudes, respectively. In addition, the composite reliability (CR) scores were found to be 0.871 for the first factor and 0.885 for the second one. Since the AVE and CR ratings, respectively, exceeded 0.50 and 0.80, it was established that the twelve questions were reliable.

Table 2. Mean and standard deviation values for the three cooperative tasks (GA, GB, GC).

Question	Task GA (BK)		Task GB (VS)		Task GC (BK/VS)	
	M	SD	M	SD	M	SD
Academic Attitudes						
1	3.12	0.67	3.34	0.81	4.19	0.53
2	3.35	0.86	3.61	0.82	4.27	0.91
3	3.09	0.74	3.12	0.69	3.77	0.66
4	3.01	0.52	3.63	0.75	4.33	0.92
5	3.41	0.87	3.44	0.81	4.01	0.87
6	3.86	0.74	3.88	0.87	4.11	0.83
Social and Affective Attitudes						
7	3.83	0.66	3.65	0.79	4.22	1.01
8	3.11	0.64	3.45	0.63	4.39	0.65
9	3.54	0.63	3.76	0.81	4.21	0.84
10	3.62	0.59	3.54	0.76	4.26	0.63
11	3.09	0.75	3.55	0.80	4.54	0.72
12	3.37	0.61	3.52	0.71	4.49	0.64

The Kruskal–Wallis test for the comparative factors revealed that there were no significant differences between the scores for attitudes (Table 3). The pairwise comparison between cooperative (Table 4) tasks demonstrated that for both factors, the differences were significant between GA and GC, and GB and GC, but not between the GA and GB tasks.

Table 3. Results corresponding to the Kruskal–Wallis test for the comparative attitudes factors: cooperative Tasks GA (GA), cooperative tasks GB (GB), and cooperative tasks GC (GC), with the degrees of freedom (df), H-value and *p*-value.

	GA	GB	GC
df	2	2	2
H-Kruskal–Wallis	1.653	2.351	2.043
p-value	0.438	0.309	0.227

Table 4. Results of the *p*-value for the pairwise comparison between cooperative tasks for both factors.

Pairwise Comparison between Cooperative Tasks (*p*-Value)		
	Academic Attitudes	Social and Affective Atitudes
GA vs. GB	0.639	0.361
GA vs. GC	0.034 **	0.043 **
GB vs. GC	0.039 **	0.048 **

Note: ** denotes 95% confidence (in bold).

5. Discussion

This study dealt on the quantitative analysis of PSTs attitudes towards learning within multimodal physical activity and math cooperative tasks. Academic and social and affective attitudes quantified the level of students' positive interdependence, when PSTs were immersed in integrative bodily-kinesthetic, visual-spatial, and math activities. The integration of both physical education and math activities proved to highly enhance the students' social and affective attitudes, especially with teammates producing cooperative group aesthetic interpretations around the math concepts. Indeed, some authors report improved math achievement (for example subtraction learning) among elementary school children with the implementation of physical activities in school settings [54–56]. When developed to integrate knowledge from different curricula, movement-based learning has not only found to improve brain function but also student recall [53].

5.1. Task Interdependence within Cooperative Learning

Interdependence in cooperative group activities is thought to promote peer relationships and teamwork effectiveness, which in turn directly affects the students' demonstration of a greater professional identity and high levels of self-assurance, communication, and adaptability [58]. Positive interdependence together with individual accountability, promotive interaction, proper use of social skills, and group processing are the five characteristics that mediate the inner mechanisms of cooperative learning [61]. The intricate interaction between the cooperative dimensions is what cooperative learning mostly depends on. By specifying the open responsibilities for the team members (though these can also be negotiated) and by providing the tools needed to implement a cooperative activity, teachers can facilitate student involvement [60].

However, most researchers believe that positive interdependence is at the heart of cooperative learning because it detects when team members' interactions are productive [57,60–62]. During this cooperative learning development, each student is dependent on the performance of the entire group. To accomplish a cooperative assignment, several interactions were required, with each team member contributing to the solution, regardless of the amount of individual accountability exhibited by each team member [35]. The results of this study clearly showed that interdependence by team members was higher when PSTs implemented cooperative body-kinesthetic and visual-spatial tasks at once, thus proving the validity of the first hypothesis of this study. In addition, task interdependence was greater in our study for social and emotional attitudes than for academic attitudes, thus proving the second hypothesis of this study. Students performed better when they felt a social connection with their peers, felt valued and respected by their teammates, and consequently making better judgments overall. PSTs scored higher on the academic factor once when the quality of the effort required to produce a task improved when the level was a professional one.

Indeed, implementing a cooperative methodology within multimodal activities is a way to work on complex problems in interdisciplinary contexts, a way to comprehend inter- or multi-disciplinary complex systems across multiple literacy levels and to collaborate to either solve (mathematical) problems or conduct physical challenges. Multimodal activities have been found to produce significantly higher science learning when equity among team members is encouraged by fostering positive interdependence [58,67]. Critical factors such as cognitive load, affective domain, and psychomotor domain, when transformed into essential social and affective attitudes, clearly impacted on the students' continuous learning as well as their learning attitudes and intentions [11]. The planning and implementation of cooperative multimodal activities, however, requires appropriate school flow models of art integration with interdisciplinary integration to account for both perceived cognitive and social attitudes by students [62].

5.2. Multimodal Approaches: Math Literacy through Physical Activities

In cooperative physical activity tasks, BK, or VS in symbolic forms of representations or the production of synergies between BK and VS representations were the key drivers of math literacy. To pose some examples, the notion of light, sound, noise, and silence in connection to time and space, or two- and three-dimensional geometrical forms through movement, images, and thought were examined through artistic representations. In our study, the cooperative tasks for mathematical and physical movement development paid particular attention to both body language and movement and how the body itself was considered a way to communicate arts and communicate with others; specifically, how to use the body to create and promote various artistic representations and analysis of reality. When no restrictions were applied, such as in BK or VS representations, the PSTs included in the study showed stronger interconnectedness, demonstrating that multimodal techniques foster higher levels of creativity. Multimodal learning approaches can produce a significant sense of competence readiness and perception of modes of cooperation such as individual responsibility and promotive interaction [9,64]. Implementing multimodal cooperative approaches in schools may foster critical thinking [67–71] which may allow students to be successful in a continually changing world.

As reported by Bores-García et al. [63], short-term intervention in physical education (sport, motor skills, or physical abilities) leave body expression underrepresented. The experience activities indicated that while designing multimodal activities, the cyclic modal process of continuous experimentation around mathematics, as well as the interpotential of the body and interrelationships, should be taken into account. Cooperative activities may help individuals improve their interpersonal skills as well as change their perspectives, attitudes, and competences to produce a transformative view of the social context. This study has shown that preservice teachers may create higher levels of social interdependence among individuals when they collaborate through the arts and mathematics. Without a doubt, PSTs led the development of the optimal applications of motor skills and achieved a higher comprehension of the body's potential (as a language) to perform both individual and collective movements and aesthetic interpretations. Using multimodal learning may increase communication and cohesion for higher level principles, distributed cognition, and discursive learning cohesion at the individual level [72]. At a synoptic level, multimodal models may help connect education agents, schools, communities, workplaces, and organizations [13,73,74]. Within cooperative teaching models students can solve practical problems and create products, which may later posit the basics for the development of the students' competencies, and learner profiles for sustainable development [42,74,75].

6. Conclusions

The integration of math and physical education activities in PSTs curricula proved that PSTs increased their task interdependence for social and emotional attitudes rather than for academic attitudes. In addition, the perception of PSTs when developing a multimodal learning model integration of bodily-kinesthetic, visual-spatial, and mathematical learning contents and competences resulted to be higher than for bodily-kinesthetic activities only (a 25.5%) or visual-spatial activities only (a 19.5%). Results showed that the cooperative integrative math and physical education activities helped to form peer-to-peer relationships among team members (which is at the base of cooperative learning), which in turn fostered professional development. Overall, this study highlights how multimodal approaches (based on both physical and mathematical education) elicited deeper social rather than academic attitudes, highlighting the significance of the need to strengthen specific competences, and competences for sustainable education as well.

7. Limitations of the Study

It was intended for students to design and produce two BK activities, two VS activities, and then two BK/VS representations to create educational cooperative tasks based on BK and VS representations in a sequential manner. When students are confident in their ability to develop task activities, the relationships between their classmates are solid, and there are clear expectations regarding the fundamentals of cooperative learning for professional development. This may be why the results may be biased towards PSTs scoring higher on the BK/VS tasks.

Using BK or VS separately may prevent PSTs from properly developing certain aspects of the learning dimensions and mathematical abilities. Exactly which representation is best suited for each mathematical skill or content needs to be determined which would require a more extensive investigation than what was proposed here.

When analyzing PST outcomes, it would be advantageous to fully recognize cooperative learning dimensions, such as face-to-face interactions. The group works together face-to-face at some point during the process to improve its members' social competency and adaptability along with individual responsibility, under the principle that no member of the group can succeed without the success of the other team members. Likewise, interpersonal skills, also state that students must develop these abilities in addition to others in order to achieve group objectives. PST group processing might also add valuable qualitative results to the research's quantitative component.

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