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Interdisciplinarity in Physical Education: Effect on Students' Situational Interest

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Abstract: The purpose of this paper is to estimate the effect of interdisciplinary teaching in physical education (PE) on the interest of upper secondary students by considering the extent to which different disciplines are integrated. Three interdisciplinary projects are studied and compared to their discipline-based counterparts. Depending on the extent to which the disciplines are integrated, some sequences are considered interdisciplinary (project 1), while others are considered multidisciplinary (projects 2 and 3). The experimental design includes a total of 90 students and six teachers. Student interest is measured using a situational interest (SI) scale and an individual interest (II) scale. Paired *t*-tests show significant differences for Maintained-SI Feelings in PE (p = 0.008) in favor of the interdisciplinary sequence for project 1 (PE and art), as well as for Maintained-SI Feelings (p = 0.004) and Maintained-SI Value (p = 0.002) in art (project 1). However, when integration is limited (projects 2 and 3), higher Maintained-SI Feelings ($p < 0.001$) are measured in the disciplinary sequence during the PE lessons. These results show that interdisciplinary sequences have positive effects on students' interest when the disciplines are sufficiently integrated, indicating that training must be initially developed and maintained accordingly.

Keywords: interdisciplinarity; physical education; situational interest; secondary school

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1. Introduction

In recent years, research on interdisciplinarity in schools has been valorized, and some studies have underlined many benefits to such an approach but also many obstacles. Implementing interdisciplinarity seems quite difficult, and few studies have previously focused on the motivational effects of interdisciplinary programs. Interdisciplinary instruction seems to have a beneficial effect on students' levels of motivation [1–5]. However, ecological studies are particularly difficult to implement through an interdisciplinary approach, and many obstacles may interfere that could deteriorate the quality of the disciplines' integration. Integration is defined by McPhail [3] as the act of putting together several disciplines and can be associated with the term "interdisciplinarity". In this study, we test the effect interdisciplinary teaching has on motivation in physical education (PE) through the theory of interest.

1.1. Situational Interest and Individual Interest

Interest is considered an important construct of motivation [6]. According to the theory of interest, the expression of an intrinsically motivated behavior can be affected through personal preferences (individual interest) or through a stimulating task (situational interest).

Situational interest (SI) is a momentary psychological state characterized by heightened attention, concentration, and affect during activity [7]. According to Linnenbrink-Garcia, Durik [8], SI can be conceptualized through three factors. Triggered SI represents an increased affective state mainly initiated by the context. Although this variation in state

only remains for a short period of time, it can lead to a Maintained-SI, as defined by Hidi and Renninger [9]. Maintained SI includes two factors: Maintained-SI Feelings and Maintained-SI Value. The first factor measures the positive feelings experienced by students towards an activity in response to instructional support. The second measures the meaning and usefulness of the task to the students [10].

In addition to SI, individual interest (II) is a stable trait of personality and a consistent predisposition to re-engage with a particular content [7]. It is characterized by three factors [9]. The "Positive affect and willingness to reengage" is linked to the task. This first factor refers to the positive state of enjoyment or excitement experienced by students while engaged in an activity and their willingness to reengage with it [7,11,12]. Second, the "Stored utility value" represents students' awareness of the value of an activity. Third, the "Stored attainment value and knowledge-seeking intentions" refers to the way an activity becomes personally important for students and relates to their goals and intention to deepen their knowledge [13].

1.2. Interdisciplinarity at School

The term interdisciplinarity is often used generically to represent the interaction between two or more disciplines. It is essential to clearly define the terms used in this study. First, it is important to specify that in this paper, we only discuss interdisciplinarity in schools according to the definition by Lenoir and Hasni [14]. Disciplinarity represents the division of knowledge and skills into compartmentalized and autonomous disciplines [15]. Each discipline defines its limits and its field of application. The scope of a given discipline may vary according to the country, state, or even institution. Multidisciplinarity is a cumulative juxtaposition of several disciplines [16,17] that creates a patchwork of knowledge around a common theme and does not lead to integration. Finally, interdisciplinarity aims for a deeper integration and interaction between disciplines. Whether at the level of objectives, methods, concepts, knowledge, etc., interdisciplinarity aims to go beyond disciplinary boundaries to answer a complex, common problem [15,17]. According to several authors, it is essential that a strong link exists between the disciplines and, in particular, between concepts within the disciplines [18–21]. Such a strong link ensures a successful and high-quality integration.

However, disciplinary and interdisciplinary approaches should not be seen as opposites. Interdisciplinarity is often used to address complex issues that a disciplinary approach cannot address holistically. However, these complex issues are often accessible when certain disciplinary skills have been acquired. Ebbing and flowing between disciplinary and interdisciplinary approaches can maximize the quality of the teaching sequences [3,22,23]. According to the literature, the implementation of interdisciplinary sequences in schools has positive effects on students' motivation and academic success, e.g., [5,19,24,25]. However, ecological studies are still relatively rare due to the difficulties teachers have in setting them up, such as time constraints, hurdles encountered in their collaboration with other teachers, difficulties dialoguing with their institution, or problems related to their professional identity, e.g., [4,23,26,27].

1.3. Motivational Effect of Interdisciplinary Approaches in Disciplines outside PE

Previous studies have shown the effects of interdisciplinary sequences on students' motivation. Interdisciplinary teaching more closely matches students' needs and interests than discipline-based teaching, e.g., [2,4,28]. Students also enjoy interdisciplinary lessons more, e.g., [26,29] because these lessons are more meaningful to them, e.g., [4,27,30]. Among previous studies, only two have used motivational theory. Through SI theory, Michelsen and Sriraman [4] (n = 255) argued that upper secondary students' interest in scientific disciplines can be increased when taught in an interdisciplinary way. Although the sample size used in that study was small (n = 30) [2], the results show that, through goal-oriented activities, interdisciplinary teaching could be a motivating learning strategy for a wider

variety of students. None of these studies used a control group or compared results with those obtained in discipline-based teaching.

1.4. Motivational Effect of Interdisciplinary Approaches in PE

Three studies have examined the motivational aspects of interdisciplinary teaching in relation to PE. Only one study has been based on a validated theory of motivation. Based on the self-determination theory (SDT) framework, Papaioannou, Milosis [5] (n = 487) measured an increase in autonomous motivation and satisfaction and a decrease in motivation during interdisciplinary sequences. Additionally, Tammaro, D'Alessio [31] (n = 176) built a multidisciplinary sequence based on orienteering (aligning geography with PE), and McPhail [3] (n = 12) presented a practical interdisciplinary model in which health, PE, and biology were integrated. These two studies have found positive effects on student motivation. In PE classes, interdisciplinary teaching appears to provide more meaningful learning, and students feel more involved in the construction of the sequence. Interdisciplinary sequences also better match students' interests and needs. However, none of these studies used a control group or compared their results to those of discipline-based teaching.

1.5. Study Relevance and Purpose

The purpose of this paper is to estimate the effect of PE interdisciplinary teaching on interest in upper secondary students' SI by considering the extent to which different disciplines have been integrated. The present study is relevant for four main reasons. First, to date, there have been very few ecological studies using interdisciplinary approaches. Second, among ecological studies, few have focused on the effect of interdisciplinary approaches on students' motivation. Third, these previous studies have not often been based on a reputable theory and have presented some limitations. Indeed, because organizing such studies is complex, there have also been a few interdisciplinary ecological studies focusing on motivation and involving more than 90 participants [4,5,27,31]. Moreover, as explained above, only three studies have used motivational theory to analyze their results. PE has also been an underrepresented field in the interdisciplinary literature on secondary education (there have been only three studies) [3,5,31]. Fourth, SI theory is relevant since SI is situated in and related to the content proposed by teachers, which allows us to compare the effect of two approaches to teaching (i.e., interdisciplinary or discipline-based approaches) in the same sample. So far, this theory has only been used to study fields other than PE. Finally, none of those other studies have used a control group or compared results to those obtained when analyzing discipline-based teaching.

To fulfill its purpose, this study reviews 3 ecological interdisciplinary projects that were conducted in PE classes (project 1: PE and the arts; projects 2 and 3: PE and the sciences) and for which the results were analyzed in relation to the extent to which disciplines were integrated. Second, the effects of these projects on students' motivation were estimated in comparison to disciplinary sequences. More precisely, project 1 focused on the implementation of an eight-week interdisciplinary sequence that involved the arts and PE. Two classes were merged, and video projects were launched around optical illusions and gymnastic movements. A total of 2 teachers taught 45 students as a pair. The results were compared to those obtained in two monodisciplinary sequences (the arts and PE) lasting the same time, whose data were gathered among the same students during the subsequent semester. Projects two and three focused on the implementation of two five-week interdisciplinary sequences combining the sciences and PE. Instruction alternated between science and PE, and teachers shared information about the progress of the projects. The first project focused on energy expenditure (physics) in relation to running (PE), while the second project brought together the notion of the cardiovascular system and the concept of training and fitness.

One hypothesis was proposed. Based on previous studies on the motivational effects of interdisciplinary approaches, we hypothesized that students' motivation is higher

in interdisciplinary sequences than in discipline-based sequences when disciplines are well integrated.

2. Materials and Methods

2.1. Participants

The sample used in this study consisted of 90 students (M = 16.68, SD = 1.20, 57.78% girls, aged 15–18) from 2 upper secondary schools. Located in the states of Vaud and Fribourg, 4 classes (21–24 students per class) took part in the study. Of the 90 students, 67 were enrolled in the 10th grade, and 23 were enrolled in the 11th grade. Interdisciplinary sequences and discipline-based sequences were conducted with the same students (see Table 1). Six teachers volunteered to participate in this study: three were full-time PE teachers; one was a full-time art teacher; one was a full-time anatomy and biology teacher; and the last one was a full-time physics and math teacher. All were seasoned male teachers with no experience in interdisciplinary teaching (see Table 1). Authorization to conduct the study was obtained from the institutional ethics committee. Participants were told that their participation was voluntary and that they could leave the study at any time.

Table 1. Projects, participants, disciplines, and conditions.

Project	Schools	Teachers	Classes	Students (*N*)	Disciplines	Conditions
1	1	1; 2	1; 2	45	PE and Art	Test
1	1	1	1	21	PE	Control
1	1	2	2	24	Art	Control
2	2	3; 4	3	22	PE and Physics	Test
2	2	3	3	22	PE	Control
2	2	4	3	22	Physics	Control
3	2	5; 6	4	23	PE and Anatomy	Test
3	2	5	4	23	PE	Control
3	2	6	4	23	Anatomy	Control

Note. PE—physical education; 1, 3, and 5 = PE teacher; 2 = art teacher; 4 = physics teacher; 6 = anatomy teacher.

2.2. Measurement

SI was measured using the 12-item scale created by Roure [10]. This scale includes the three factors of SI: Triggered-SI, Maintained-SI Feelings, and Maintained-SI Value [32]. Triggered-SI represents an increased affective state mainly initiated by the context (e.g., what we learned was of a level of complexity appropriate to my abilities). Maintained IS includes two factors: Maintained-IS Feelings and Maintained-IS Value. The first factor measures the positive feelings experienced by students towards the activity in response to instructional support (e.g., what we learned was attractive to me). The second factor measures how meaningful and useful the task is to students (e.g., what we learned is useful for my physical activities outside of school) [10]. Each factor consists of four items that are randomly ordered. In the present study, SI was measured in relation to each school subject included in the teaching sequences (i.e., PE, art, physics, anatomy). We verified that the questionnaire used by Roure [10] and initially used in PE is adapted for other school subjects. Notably, the development of Roure [10] questionnaire was based on work by Linnenbrink-Garcia, Durik [8] in mathematics. Finally, only the headings of the questionnaire were adapted to specific school subjects (e.g., art), and none of the 12 items were modified.

II were collected through a 14-item scale validated by Roure, Lentillon-Kaestner [7]. This scale also included three factors: (1) positive affect and willingness to reengage (e.g., when I have free time, I like to do activities that I have seen in PE); (2) stored utility value (e.g., if I could choose my courses at school, I would like to enroll in more PE hours); and (3) stored attainment value and knowledge-seeking intentions (e.g., it is important for me to succeed in PE). The questionnaires usually used in PE classes have been adapted to art classes so that the data gathered in both types of classes could be as similar as possible without the items' meanings being changed (e.g., "I practice the physical activities seen in

PE whenever I have a free moment" has been changed to "I practice artistic activities seen in art whenever I have a free moment").

Internal consistency was controlled for the IS and II questionnaires and was satisfactory for the dataset when taking into account the number of participants. Cronbach's alphas were between 0.66 and 0.93.

2.3. Procedure

Three interdisciplinary projects were conducted and analyzed. To estimate the motivational potential of interdisciplinary sequences in comparison to standard teaching, we had students participate in an interdisciplinary teaching sequence (the test) and in discipline-based teaching sequences (the control) (see Table 1). Both types of sequences lasted as long, from 5 to 8 weeks depending on the project. The same teachers taught the test and control sequences. More precisely, project one focused on the implementation of an eight-week interdisciplinary sequence involving art and PE. Two teachers (PE and art) and two classes were included in the first project. These two classes were merged, and video projects were launched around optical illusion and gymnastic movement. The two teachers taught the 45 students together (see Table 1). Projects two and three focused on the implementation of two five-week interdisciplinary sequences that included science and PE. Two teachers (PE and physics) and one class were part of the second project, and two teachers (PE and anatomy) and one class were part of the third project (see Table 1). Instructions alternated between science and PE, and teachers shared information about the progress of the projects. The second project focused on energy expenditure (physics) in relation to running (PE), while the third project brought together the notion of the cardiovascular system and the concepts of training and fitness.

For each project, the two teachers created the didactical and pedagogical aspects of the sequences (test and control). They chose the theme and the most favorable period of the year for the implementation of the sequences. The researcher did not intervene in the development of the discipline-based sequence (control); however, he helped teachers in the development of the interdisciplinary sequences. The main researcher guided the teacher thanks to a half-day training and regular meetings (three to four meetings) before the implementation of the sequence as well as a weekly follow-up during the sequence. He also ensured that the scientific process was respected. During the training, the main researcher notably explained that the test sequences had to involve not only cross-curricular moments but also a complementary mix of disciplinary and interdisciplinary moments [14]. After the sequences were held, two researchers verified and classified the interdisciplinary nature of the sequence based on the foundational principles for the school's interdisciplinarity set by Lenoir and Hasni [14]. The two researchers compared and discussed their analyses, and a third external reviewer was consulted to resolve any disagreements. Thus, all projects respected the first principle, which mentions that there can be no interdisciplinarity without disciplinarity. In fact, all our projects encompassed two disciplines and were based on the methodological and curricular aspects of each discipline. For example, in project 2, both programs (physics and PE) had to address the concept of energy, but with a more mathematical approach in physics and a more practical approach in PE. The second principle showed that interdisciplinarity is not a simple aggregate of perspectives. Differences emerged on this question across the projects that were conducted to examine the extent to which disciplines had been integrated. In project 1, the 2 disciplines created a common language and approach to produce a video project. Disciplines were truly integrated. In projects 2 and 3, teachers took turns, which yielded a much stronger focus on the teachers' respective disciplines. This approach proved to be more multidisciplinary. The third principle states that interdisciplinarity is a means to an end and not an end in itself. Therefore, it must be applied to a real situation. In project 1, the socio-constructivist approach promoted by the teachers as well as the desire to adhere to a concrete project (the creation of a video including optical illusions and gymnastic movements) allowed this principle to be fully satisfied. In projects 2 and 3, although the approach was slightly

more hierarchical, the focus on a real situation predominated (e.g., the focus of project 3 was about experiencing and feeling the effects of activity on the cardiovascular system). All three of these projects adhered to the fourth principle, which states that no discipline dominates the others, and all disciplinary perspectives should be treated equally. This point has been particularly well addressed in the creation of the sequences. The fifth principle states that interdisciplinary approaches should combine three logical elements, i.e., meaning, functionality, and effectivity. All our projects were built around these three principles (mind, hands, and heart), but only project 1 assessed all these skills at the end of the sequence. Finally, the sixth principle was well respected in all the projects since teachers from different disciplines joined forces to create a common project. After a detailed analysis, we were able to determine that project 1 was indeed an interdisciplinary project in which different disciplines were appropriately integrated, while projects 2 and 3 were closer to being multidisciplinary projects, particularly based on the second principle. We then asked for teachers' opinions on the degree of integration of their own interdisciplinary sequence. Their comments were consistent with the analysis proposed by the researchers.

Data about II were collected at the very beginning of the test and the control sequences. II were estimated for both disciplines (PE and art/physics/anatomy). SI was collected at the end of the fourth lesson. As the whole sequence was strongly interdisciplinary, we chose the fourth lesson to test SI because that lesson did not include lengthy disciplinary teachings and appeared to stand in the middle of the sequence (see Supplementary Materials).

In the case of disciplinary sequences, the data were collected at the same time to ensure that the test and control groups were designed in similar ways. We ensured that the questionnaires were not completed during a specific lesson (e.g., evaluation).

2.4. Data Analysis

The 12 items on the SI questionnaires were aggregated according to the 3 SI factors (i.e., Triggered-SI, Maintained-SI Feelings, and Maintained-SI Value). All data were analyzed using the IBM SPSS Statistics software (version 28.0.0.0). Preliminary analyses were performed to examine (1) the internal consistency of the responses and (2) the normality of the dataset. Simple linear regressions were performed to estimate the part of SI predicted by the three factors of II. Paired *t*-tests were then performed to determine if there were significant differences between the interdisciplinary and control sequences. As tests were conducted for the three SI factors and for both school subjects (PE and arts/physics/anatomy), we used the Bonferroni correction to avoid type I errors.

3. Results

As explained above, one of the roles of the researcher was to verify a posteriori of the nature of the interdisciplinarity practiced by following the fundamental principles of Lenoir and Hasni [14]. After having analyzed the sequences experienced by the students, we decided to separate the results of project 1 from the results of projects 2 and 3. Indeed, we were able to determine that projects 2 and 3 (45 students) were close to reaching multidisciplinary integration [15], while project 1 (45 students) respected all the criteria of an interdisciplinary school project.

3.1. Project 1

3.1.1. Preliminary Analyses

The internal consistency of the responses was controlled using Cronbach's alpha. These responses were satisfactory for all factors of SI and II, with results between 0.66 and 0.93. The normality tests revealed through the analysis of skewness (−0.95 to 0.65) and kurtosis (−1.41 to 1.26) that the data were normally distributed.

As explained above, SI was determined by the context of the activity but also by each student's II. To ensure that the effect found was due to the context of the proposed activity rather than to personal preferences and interests, we performed a simple linear regression between II (the predictor) and SI (the response variable) for each dimension of II

and SI. The regression was verified for both disciplines and for test and control sequences (see Tables 2 and 3). Tables 2 and 3 showed nonsignificant results except for one: the II dimension "Stored attainment and knowledge-seeking intention" significantly predicted ($\beta = 0.613$, $p = 0.006$) the SI dimension "Maintained-SI feelings in physical education" for the test sequence. These results mean that the SI factors are mainly influenced by the context of the activity rather than by the participants' II. Nevertheless, special attention must be given to the "Maintained-SI feelings" dimension during the analysis of SI in PE (test sequence).

Table 2. Project 1: Linear regression between individual interest factors and situational interest factors in physical education for test and control sequences.

Response Variable	Predictor Variable II	B	SD	β	t	p	R^2
Triggered-SI PE Test	PAWR_PE	0.188	0.154	0.275	1.217	0.231	0.045
	SUV_PE	0.019	0.216	0.018	0.089	0.929	
	SAVKSI_PE	−0.110	0.214	−0.124	−0.514	0.610	
Maintained-SI Feelings PE Test	PAWR_PE	−0.134	0.134	−0.200	−0.999	0.324	0.250
	SUV_PE	0.017	0.187	0.017	0.093	0.926	
	SAVKSI_PE	0.533	0.185	0.613	2.877	0.006	
Maintained-SI Values PE Test	PAWR_PE	−0.188	0.126	−0.326	−1.499	0.142	0.117
	SUV_PE	0.321	0.176	0.359	1.826	0.075	
	SAVKSI_PE	0.096	0.174	0.128	0.553	0.583	
Triggered-SI PE Control	PAWR_PE	0.121	0.168	0.243	0.718	0.486	0.392
	SUV_PE	0.091	0.368	0.084	0.247	0.809	
	SAVKSI_PE	0.240	0.291	0.360	0.822	0.427	
Maintained-SI Feelings PE Control	PAWR_PE	−0.008	0.228	−0.011	−0.033	0.974	0.366
	SUV_PE	0.171	0.498	0.119	0.344	0.737	
	SAVKSI_PE	0.458	0.394	0.519	1.162	0.268	
Maintained-SI Values PE Control	PAWR_PE	−0.050	0.228	−0.084	−0.218	0.831	0.204
	SUV_PE	0.051	0.498	0.040	0.102	0.921	
	SAVKSI_PE	0.378	0.395	0.480	0.958	0.357	

Note. PAWR—positive affect and willingness to reengage; SUV—stored utility value; SAVKSI—stored attainment value and knowledge-seeking intentions; PE—physical education; II—individual interest; SI—situational interest.

Table 3. Project 1: Linear regression between individual interest factors and situational interest factors in arts education for test and control sequences.

Response Variable	Predictor Variable	B	SD	β	t	p	R^2
Triggered-SI Arts Test	PAWR_Arts	−0.095	0.198	−0.109	−0.481	0.633	0.015
	SUV_Arts	0.162	0.250	0.167	0.649	0.520	
	SAVKSI_Arts	0.012	0.248	0.011	0.048	0.962	
Maintained-SI Feelings Arts Test	PAWR_Arts	−0.189	0.186	−0.221	−1.017	0.315	0.091
	SUV_Arts	−0.125	0.235	−0.131	−0.530	0.599	
	SAVKSI_Arts	0.440	0.233	0.414	1.887	0.066	
Maintained-SI Values Arts Test	PAWR_Arts	−0.042	0.166	−0.057	−0.252	0.803	0.034
	SUV_Arts	−0.179	0.210	−0.218	−0.854	0.398	
	SAVKSI_Arts	0.209	0.208	0.228	1.008	0.320	
Triggered-SI Arts Control	PAWR_Arts	−0.184	0.240	−0.193	−0.767	0.453	0.101
	SUV_Arts	0.356	0.316	0.334	1.128	0.273	
	SAVKSI_Arts	0.056	0.347	0.046	0.161	0.874	
Maintained-SI Feelings Arts Control	PAWR_Arts	−0.340	0.309	−0.271	−1.100	0.285	0.144
	SUV_Arts	0.119	0.408	0.084	0.291	0.774	
	SAVKSI_Arts	0.577	0.448	0.363	1.288	0.213	
Maintained-SI Values Arts Control	PAWR_Arts	−0.266	0.280	−0.221	−0.951	0.354	0.234
	SUV	0.106	0.369	0.079	0.288	0.777	
	SAVKSI	0.747	0.406	0.491	1.840	0.082	

Note. PAWR—positive affect and willingness to reengage; SUV—stored utility value; SAVKSI—stored attainment value and knowledge-seeking intentions; SI—situational interest.

3.1.2. Main Analyses

T-tests were performed for each of the three SI factors (Triggered-SI, Maintained-SI-Feelings, and Maintained-SI-Value) and for both disciplines (PE and art). Table 4 reports the means (M), standard deviations (SD), t-statistic, *p*-value, and adjusted *p*-value (Bonferroni correction). Paired *t*-tests revealed interesting results between the data collected during the interdisciplinary sequence (test) and the disciplinary sequence (control). A significant difference was measured for Maintained-SI Feelings in PE in favor of the interdisciplinary sequence. Moreover, significant differences were measured for Maintained-SI Feelings and Maintained-SI Value in art in favor of the interdisciplinary sequence.

Table 4. Project 1: Paired *t*-tests: Differences in SI Factors for PE and art between sequences using interdisciplinarity and disciplinarity sequences.

Pairs	Item	M	SD	*t*	*p*	Adj. *p*-Value
1	Triggered-SI PE Test Triggered-SI PE Control	3.50 3.78	0.87 0.68	−1.486 (16)	0.157	0.942
2	Maintained-SI Feelings PE Test	3.25	0.93	0.652 (16)	0.524	1.000
	Maintained-SI Feelings PE Control	3.09	0.90			
3	Maintained-SI Value PE Test Maintained-SI Value PE Control	3.47 2.84	0.64 0.80	3.009 (16)	0.008	0.048
4	Triggered-SI Arts Test Triggered-SI Arts Control	3.68 3.79	0.77 0.77	−0.690 (22)	0.498	1.000
5	Maintained-SI Feelings Arts Test	3.55	0.66	3.268 (22)	0.004	0.024
	Maintained-SI Feelings Arts Control	2.89	1.02			
6	Maintained-SI Value Arts Test Maintained-SI Value Arts Control	3.71 3.08	0.62 0.98	3.454 (22)	0.002	0.012

Note. SI—situational interest; PE—physical education.

3.2. Projects Two and Three

3.2.1. Preliminary Analyses

The internal consistency of the responses was controlled using Cronbach's alpha. They were satisfactory for all factors of SI and II, with results between 0.66 and 0.93. Normality tests revealed through the analysis of skewness (−0.95 to 0.65) and kurtosis (−1.41 to 1.26) that the data were relatively normally distributed.

As explained above, SI is not only defined by the context of the activity but also by the II of each student. To ensure that the effect found is due to the context of the proposed activity rather than personal preferences and interests, we performed a simple linear regression between II (the predictor) and SI (the response variable) for each dimension of II and SI. The regression was verified for both disciplines and for test and control sequences (see Tables 5 and 6). Compared to project 1, more relationships were found between II and IS factors in the second and third projects. Nevertheless, considering the *t*-tests' results (see Table 7), only one relationship should be carefully considered: the feeling of maintaining SI in PE was predicted by the utility value of II for 50.5% of the variance.

Table 5. Projects two and three: Linear regression between individual interest factors and situational interest factors in physical education for multidisciplinary and disciplinary sequences.

Response Variable	Predictor Variable	B	SD	β	t	p	R^2
Triggered-SI PE Test	PAWR_PE	0.119	0.150	0.196	0.792	0.436	0.147
	SUV_PE	−0.008	0.194	−0.009	−0.039	0.969	
	SAVKSI_PE	0.183	0.193	0.238	0.949	0.352	
Maintained-SI Feelings PE Test	PAWR_PE	0.012	0.111	0.020	0.108	0.915	0.505
	SUV_PE	0.535	0.144	0.695	3.731	<0.001	
	SAVKSI_PE	0.005	0.143	0.006	0.033	0.974	
Maintained-SI Values PE Test	PAWR_PE	−0.010	0.121	−0.016	−0.081	0.936	0.477
	SUV_PE	0.577	0.157	0.704	3.674	0.001	
	SAVKSI_PE	−0.006	0.156	−0.007	−0.038	0.970	
Triggered-SI PE Control	PAWR_PE	0.091	0.144	0.162	0.628	0.535	0.113
	SUV_PE	−0.068	0.171	−0.096	−0.396	0.695	
	SAVKSI_PE	0.196	0.193	0.264	1.019	0.317	
Maintained-SI Feelings PE Control	PAWR_PE	0.196	0.126	0.315	1.553	0.132	0.447
	SUV_PE	0.109	0.150	0.139	0.727	0.474	
	SAVKSI_PE	0.253	0.168	0.308	1.502	0.145	
Maintained-SI Values PE Control	PAWR_PE	0.079	0.143	0.119	0.554	0.584	0.379
	SUV_PE	0.253	0.170	0.301	1.491	0.147	
	SAVKSI_PE	0.251	0.191	0.285	1.312	0.200	

Note. PAWR—positive affect and willingness to reengage; SUV—stored utility value; SAVKSI—stored attainment value and knowledge-seeking intentions; PE—physical education; SI—situational interest.

Table 6. Projects two and three: Linear regression between individual interest factors and situational interest factors in sciences for multidisciplinary and disciplinary sequences.

Response Variable	Predictor Variable	B	SD	β	t	p	R^2
Triggered-SI Sciences Test	PAWR_Sciences	0.025	0.080	0.048	0.305	0.762	0.226
	SUV_Sciences	0.032	0.098	0.055	0.327	0.745	
	SAVKSI_Sciences	0.449	0.172	0.432	2.607	0.013	
Maintained-SI Feelings Sciences Test	PAWR_Sciences	0.268	0.100	0.370	2.684	0.011	0.402
	SUV_Sciences	0.253	0.122	0.308	2.078	0.045	
	SAVKSI_Sciences	0.226	0.214	0.154	1.056	0.298	
Maintained-SI Values Sciences Test	PAWR_Sciences	0.117	0.086	0.203	1.364	0.181	0.301
	SUV_Sciences	0.126	0.105	0.193	1.207	0.235	
	SAVKSI_Sciences	0.378	0.184	0.324	2.056	0.047	
Triggered-SI Sciences Control	PAWR_Sciences	−0.034	0.092	−0.062	−0.369	0.714	0.099
	SUV_Sciences	−0.156	0.113	−0.246	−1.387	0.174	
	SAVKSI_Sciences	0.371	0.202	0.328	1.839	0.074	
Maintained-SI Feelings Sciences Control	PAWR_Sciences	0.170	0.104	0.257	1.630	0.112	0.196
	SUV_Sciences	0.132	0.127	0.175	1.041	0.305	
	SAVKSI_Sciences	0.222	0.228	0.164	0.974	0.337	
Maintained-SI Values Sciences Control	PAWR_Sciences	0.161	0.082	0.306	1.953	0.059	0.207
	SUV_Sciences	0.103	0.101	0.171	1.026	0.312	
	SAVKSI_Sciences	0.136	0.180	0.127	0.756	0.454	

Note. PAWR—positive affect and willingness to reengage; SUV—stored utility value; SAVKSI—stored attainment value and knowledge-seeking intentions; SI—situational interest.

Table 7. Projects two and three: Paired *t*-tests: Differences in SI factors between multidisciplinary and disciplinary sequences.

Pairs	Item	M	SD	*t*	*p*	*Adj. p*
1	Triggered-SI PE Test Triggered-SI PE Control	3.48 3.64	0.89 0.73	−0.860 (31)	0.397	1.000
2	Maintained-SI Feelings PE Test Maintained-SI Feelings PE Control	2.76 3.41	0.85 0.80	−4.169 (31)	<0.001	<0.001
3	Maintained-SI Value PE Test Maintained-SI Value PE Control	3.02 3.32	0.91 0.87	−1.880 (31)	0.070	0.420
4	Triggered-SI Sciences Test Triggered-SI Sciences Control	3.76 3.91	0.57 0.65	−1.300 (37)	0.202	1.000
5	Maintained-SI Feelings Sciences Test Maintained-SI Feelings Sciences Control	3.58 3.48	0.78 0.74	0.665 (37)	0.510	1.000
6	Maintained-SI Value Sciences Test Maintained-SI Value Sciences Control	3.51 3.08	0.63 0.98	−0.658 (37)	0.515	1.000

Note. SI—situational interest; PE—physical education.

3.2.2. Main Analysis

In comparison to the results obtained in project 1, *t*-tests in projects 2 and 3 showed less significant differences between multidisciplinary (test) and disciplinary (control) sequences. Table 7 reports the means (M), standard deviations (SD), t-statistic, *p*-value, and adjusted *p*-value (Bonferroni correction). Once again, *t*-tests were performed for each SI dimension and both disciplines (PE and sciences) (anatomy and physics). For both disciplines, only one significant difference was measured. Students had higher Maintained-SI Feelings in the disciplinary sequence (control) during the PE lessons. This result should be analyzed while taking into account the preliminary results of the linear regression, which are discussed in the next section.

4. Discussion

The purpose of this paper was to estimate the effect of interdisciplinary teaching on upper secondary students' SI by considering the extent to which disciplines were integrated. The first project mixed PE and art and revealed positive effects on the SI of interdisciplinary sequences. Indeed, on the one hand, both factors included in the Maintained-SI showed significantly positive results in favor of the interdisciplinary sequence. On the other hand, in projects two and three, in which multidisciplinary sequences were compared to disciplinary sequences (sciences and PE), only one significant difference was observed in favor of disciplinary sequences. These results can be explained for different reasons.

First, the interdisciplinary project (project 1) differed in its integration level from projects 2 and 3. Indeed, if we refer to the definitions by Darbellay [15] and to the analysis of the supplemental material provided, we can say that in project one, the two disciplines were better integrated than in projects two and three. Project 1 integrated disciplines to provide an interdisciplinary sequence, while projects 2 and 3 represented more of a multidisciplinary approach (according to the second principle). In addition, the 2 teachers teaching in tandem in project 1 may have facilitated the integration of the disciplines. With better integration, those projects could have been vastly different, even more so because the results revealed positive effects on SI factors for both school subjects covered in the interdisciplinary sequence in project 1, i.e., those pertaining to Maintained-SI Feelings and Maintained-SI Value in the art class and for Maintained-SI Value in the PE class. A positive effect on Maintained-SI Value means that the students better grasped the meaning of the activity in each school subject [10]. These results are in perfect agreement with previous works on interdisciplinarity [3,4,26–28,30,31,33,34] that have shown that interdisciplinary teaching increases the meaningfulness of knowledge acquisition. In projects two and three, the multidisciplinary sequences, lacking a true integration of the disciplines, are not sufficient to increase the Maintained-SI Value and students' motivation.

When examining the factor Maintained-SI Feelings, it is interesting to note that a significant effect was found in project 1 only for the arts and in favor of the interdisciplinary sequence. This result could mean that students tend to enjoy artistic disciplines more when they are paired with PE. This result is consistent with previous works on interdisciplinarity [1,2,5,25,26,29,35] that have concluded that interdisciplinarity tends to make the classroom more enjoyable. The fact that no effect was found for PE could be explained through the work of Lentillon-Kaestner, Deriaz [36]. More precisely, the results showed that in the canton of Vaud (where grades are not given in PE classes), teachers strongly value health and enjoyment, whereas in the canton of Jura (where grades are given but the evaluation is not certifying, as it would be in the canton of Fribourg), opinions are more heterogeneous. However, the predominant values are enjoyment, health, and motor learning. The present study was conducted in the cantons of Vaud and Fribourg in the French-speaking part of Switzerland. It is therefore logical that the average value of the factor Maintained-SI Feelings is especially high for this discipline under the control and test conditions. On the other hand, in projects two and three, we noted a significant effect of the factor Maintained-SI Feelings in favor of the PE control sequence. The regression's results (see Table 5) show that 50.5% of the variance is explained by the II factor stored utility value. As the mean score for this factor is relatively weak (M = 2.42), the impression of the uselessness of PE felt by the students during the multidisciplinary sequences is confirmed. These results support the idea that the integration between disciplines must be effective to positively affect students' motivation, especially when considering that teachers strongly value enjoyment in the Fribourg and Vaud contexts.

Thus, our hypothesis is verified. Indeed, if the integration of disciplines is sufficient and the link between concepts is strong enough, interdisciplinary sequences seem to have a beneficial effect on students' motivation. Indeed, the analysis of the SI results shows an increase in positive feelings as well as in the meaningfulness and usefulness of the task. Nevertheless, the integration must be sufficient because, in the framework of a multidisciplinary sequence, negative effects on positive feelings have been perceived in PE classes. It is therefore essential to work upstream on the integration of concepts from each discipline. According to several authors, it is essential that a strong link exists between the disciplines and, in particular, between the disciplines' concepts, e.g., [18–21]. A strong link ensures the success of quality integration. It is therefore important to consider that in the three projects, the link between PE and the other disciplines (i.e., art and science) could explain the differences obtained between the test and control sequences. Indeed, on the one hand, the lack of effects reported in projects two and three may be due to the complicated relationship between PE and scientific concepts. On the other hand, the arts and PE were well integrated into the interdisciplinary sequence developed (see Supplementary Materials). Interdisciplinarity in project 1 thus seems to have had positive effects on students' motivation as a result of successful integration. To avoid pseudo-interdisciplinarity, as Lenoir and Hasni [14] defined it, it is necessary to focus on the strength of the links between the disciplines' concepts before the sequence.

Limits and Perspectives

The findings of this study must be interpreted with caution because of some limitations.

First, our study did not allow us to consider the effects of sequence duration. In the present study, the compared control and test sequences (disciplinary vs. interdisciplinary sequences) had the same duration. However, project 1 was longer than projects 2 and 3. Further studies need to estimate the potential moderating effect of interdisciplinary sequence duration on students' motivation or other educational outcomes (e.g., achievements).

Second, this study focused on three interdisciplinary projects including PE, the arts, and science. The research protocol implemented in this study allowed us to estimate the effects of interdisciplinary projects compared to discipline-based projects but did not allow us to estimate whether there are some disciplines that could be more relevant to

interdisciplinary projects in PE. Further studies need to compare the effects of various interdisciplinary projects in PE using different disciplines.

Third, this study took place in the French-speaking part of Switzerland and included only 90 students and six teachers from two upper secondary schools. As the organization of interdisciplinary sequences is dependent on the context, it could be interesting to develop other ecological studies on interdisciplinary sequences in other schools, grade levels (primary or secondary schools), states, and countries. In addition, all six teachers were volunteers in this study and had no experience in interdisciplinary teaching. Further studies are needed to test the influence of teachers' characteristics (e.g., perceived expertise, experience level) on the beneficial effect of interdisciplinary teaching at school.

Fourth, the SI data collection focused on one measure at a specific point in time. It could be interesting to observe students' SI in a repeated measures design to analyze the development of SI during the sequence. It would be interesting to develop longitudinal studies over a longer time period, such as one school year, rather than during one sequence.

5. Conclusions

To date, this study is the first to estimate the effect of interdisciplinary instruction on students' SI in PE by considering the extent to which the disciplines are integrated. The results show that interdisciplinary instruction has a positive effect on students' SI if the sequence properly integrates the disciplines involved. Indeed, promising results show a significant difference in the Maintained-SI Feelings and Maintained-SI Value for the arts factor and in the Maintained-SI Value for the PE factor, showing a preference for interdisciplinary sequences over disciplinary sequences in project 1. This result means that interdisciplinary teaching may be more enjoyable and meaningful for students. Since the quality of integration plays a major role in achieving positive motivational outcomes, it is therefore important to provide quality training in both initial and continuing education. In future studies, it will be important to guide teachers in the process of creating different interdisciplinary sequences and to check the degree of integration at the end of these sequences. Moreover, further studies need to be developed to better understand the role of other factors (e.g., sequence duration or type of discipline) when interdisciplinary sequences are implemented in PE. Finally, given the increased motivation of students obtained when disciplines are sufficiently integrated, an interdisciplinary sequence may contribute to better achievement of each disciplinary objective. In this regard, further research is needed.

Supplementary Materials: The following supporting information can be downloaded at: https://www.mdpi.com/article/10.3390/educsci13040373/s1, Project descriptions.

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References

1. Baillat, G.; Niclot, D. In search of interdisciplinarity in schools in France: From curriculum to practice. *Issues Integr. Stud.* **2010**, *28*, 170–207.
2. Holmbukt, T.; Larsen, A.B. Interdisciplinary teaching as motivation: An initiative for change in post-16 vocational education. *Nord. J. Mod. Lang. Methodol.* **2016**, *4*, 67–82. [CrossRef]
3. McPhail, G. Curriculum integration in the senior secondary school: A case study in a national assessment context. *J. Curric. Stud.* **2017**, *50*, 56–76. [CrossRef]
4. Michelsen, C.; Sriraman, B. Does interdisciplinary instruction raise students' interest in mathematics and the subjects of the natural sciences? *ZDM* **2009**, *41*, 231–244. [CrossRef]
5. Papaioannou, A.; Milosis, D.; Gotzaridis, C. Interdisciplinary Teaching of Physics in Physical Education: Effects on Students' Autonomous Motivation and Satisfaction. *J. Teach. Phys. Educ.* **2020**, *39*, 156–164. [CrossRef]
6. Harackiewicz, J.M.; Knogler, M. Interest: Theory and Application. In *Handbook of Competence and Motivation: Theory and Application*; Elliot, A.J., Dweck, C.S., Yeager, D.S., Eds.; The Guilford Press: New York, NY, USA, 2017; pp. 334–352.
7. Roure, C.; Lentillon-Kaestner, V.; Pasco, D. Students' individual interest in physical education: Development and validation of a questionnaire. *Scand. J. Psychol.* **2021**, *62*, 64–73. [CrossRef]
8. Linnenbrink-Garcia, L.; Durik, A.M.; Conley, A.M.; Barron, K.E.; Tauer, J.M.; Karabenick, S.A.; Harackiewicz, J.M. Measuring Situational Interest in Academic Domains. *Educ. Psychol. Meas.* **2010**, *70*, 647–671. [CrossRef]
9. Hidi, S.; Renninger, K.A. The Four-Phase Model of Interest Development. *Educ. Psychol.* **2006**, *41*, 111–127. [CrossRef]
10. Roure, C. Clarification du Construit de L'intérêt en Situation en Éducation Physique. *Staps* **2020**, *130*, 61–77. [CrossRef]
11. O'Keefe, P.A.; Linnenbrink-Garcia, L. The role of interest in optimizing performance and self-regulation. *J. Exp. Soc. Psychol.* **2014**, *53*, 70–78. [CrossRef]
12. Schiefele, U. Situational and Individual Interest. In *Handbook of Motivation at School*; Wenzel, K.R., Wigfield, A., Eds.; Routledge; Taylor & Francis Group: Abingdon, UK, 2009; pp. 197–222.
13. Krapp, A. Basic needs and the development of interest and intrinsic motivational orientations. *Learn. Instr.* **2005**, *15*, 381–395. [CrossRef]
14. Lenoir, Y.; Hasni, A. Interdisciplinarity in Primary and Secondary School: Issues and Perspectives. *Creative Educ.* **2016**, *7*, 2433–2458. [CrossRef]
15. Darbellay, F. *L'interdisciplinarité à L'école: Succès, Résistance, Diversité*; Alphil: Neuchâtel, Switzerland, 2019.
16. Choi, B.C.K.; Pak, A.W.P. Multidisciplinarity, interdisciplinarity and transdisciplinarity in health research, services, education and policy: 1. Definitions, objectives, and evidence of effectiveness. *Clin. Investig. Med.* **2006**, *29*, 351–364.
17. Klein, J.T. *Interdisciplinarity: History, Theory, and Practice*; Wayne State University Press: Detroit, MI, USA, 1990.
18. Ghisla, G.; Bausch, L.; Bonoli, L. Interdisciplinarity in Swiss Schools: A Difficult Step into the Future. *Issues Integr. Stud.* **2010**, *28*, 295–331.
19. Hasni, A.; Lenoir, Y.; Alessandra, F. Mandated Interdisciplinarity in Secondary School: The Case of Science, Technology, and Mathematics Teachers in Quebec. *Issues Interdiscip. Stud.* **2015**, *33*, 144–180.
20. Michelsen, C. Mathematical modeling is also physics—Interdisciplinary teaching between mathematics and physics in Danish upper secondary education. *Phys. Educ.* **2015**, *50*, 489–494. [CrossRef]
21. Moser, K.M.; Ivy, J.; Hopper, P.F. Rethinking content teaching at the middle level: An interdisciplinary approach. *Middle Sch. J.* **2019**, *50*, 17–27. [CrossRef]
22. Locke, J. Curriculum integration in secondary schools. *Curric. Matters* **2008**, *4*, 69–84. [CrossRef]
23. McPhail, G.J. From aspirations to practice: Curriculum challenges for a new 'twenty-first-century' secondary school. *Curric. J.* **2016**, *27*, 518–537. [CrossRef]
24. Hardré, P.L.; Ling, C.; Shehab, R.L.; Nanny, M.A.; Nollert, M.U.; Refai, H.; Ramseyer, C.; Herron, J.; Wollega, E.D. Teachers in an Interdisciplinary Learning Community:Engaging, Integrating, and Strengthening K-12 Education. *J. Teach. Educ.* **2013**, *64*, 409–425. [CrossRef]
25. Moss, J.; Godinho, S.; Chao, E. Enacting the Australian Curriculum: Primary and Secondary Teachers' Approaches to Integrating the Curriculum. *Aust. J. Teach. Educ.* **2019**, *44*, 24–41.
26. Ríordáin, M.N.; Johnston, J.; Walshe, G. Making mathematics and science integration happen: Key aspects of practice. *Int. J. Math. Educ. Sci. Technol.* **2016**, *47*, 233–255. [CrossRef]
27. Rodríguez, J.G.; Blasco, C.M.; Lenoir, Y.; Klein, J.T. Interdisciplinarity and research on local issues in schools: Policies and experiences from Colombia. *Issues Interdiscip. Stud.* **2010**, *28*, 109–137.
28. Pountney, R.; McPhail, G. Crossing boundaries: Exploring the theory, practice and possibility of a 'Future 3' curriculum. *Br. Educ. Res. J.* **2019**, *45*, 483–501.
29. Kneen, J.; Breeze, T.; Davies-Barnes, S.; John, V.; Thayer, E. Curriculum integration: The challenges for primary and secondary schools in developing a new curriculum in the ex-pressive arts. *Curric. J.* **2020**, *31*, 258–275.
30. Samson, G. From Writing to Doing: The Challenges of Implementing Integration (and Interdisciplinarity) in the Teaching of Mathematics, Sciences, and Technology. *Can. J. Sci. Math. Technol. Educ.* **2014**, *14*, 346–358.
31. Tammaro, R.; D'Alessio, A.; Petolicchio, A. Orienteering: Motivation, multidisciplinary and skills. A project in a secondary school in the province of Salerno. *Int. J. Humanit. Soc. Sci.* **2017**, *9*, 34–40.

32. Linnenbrink-Garcia, L.; Patall, E.A.; Messersmith, E.E. Antecedents and consequences of situational interest. *Br. J. Educ. Psychol.* **2012**, *83*, 591–614. [CrossRef]
33. Queiruga-Dios, M.; López-Iñesta, E.; Diez-Ojeda, M.; Sáiz-Manzanares, M.-C.; Vázquez-Dorrío, J.-B. Implementation of a STEAM project in compulsory secondary education that creates connections with the environment (Implementación de un proyecto STEAM en Educación Secundaria generando conexiones con el entorno). *J. Study Educ. Dev.* **2021**, *44*, 871–908. [CrossRef]
34. Vieira, A.A.S.; Dias, L.A.N.P.; Chediak, S. Challenges and contributions regarding integration of disciplines in the Vocational Education integrated to Upper Secondary Education at IFMS, Nova Andradina Campus. *Rev. Ibero-Am. Estud. Educ.* **2018**, *13*, 359–378. [CrossRef]
35. Vega, E.S.; Schnackenberg, H.L. Integrating Technology, Art, and Writing: Creating Comic Books as an Interdisciplinary Learning Experience. In Proceedings of the Association for Educational Communications and Technology 27th, Chicago, IL, USA, 19–23 October 2004.
36. Lentillon-Kaestner, V.; Deriaz, D.; Voisard, N.; Allain, M. *Noter en Éducation Physique? Incidences sur L'enseignement et les Élèves*; EME: Louvain-la-Neuve, Belgium, 2018.