INTERDISCIPLINARY LEARNING IN EDUCATION: A FOCUS ON PHYSICS AND PHYSICAL EDUCATION

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Abstract
This article concerns the literature review of interdisciplinarity as an approach used in teaching and learning. It not only includes contributions from different disciplines, but also focuses on theoretical as well as practical work from Physics and Physical Education. It is an attempt to cross the boundaries of the two disciplines involved. Future studies, based on this review, will consider the teaching and learning process between Physics and Physical Education in an attempt to examine how this method can be effective in student learning.

Key words: interdisciplinarity, teaching, primary education, secondary education, higher education.

Introduction
Education is organized traditionally around the idea that students will focus their learning on at least one specific academic field of study, a specialization known commonly as a "major" (Pajewski, 2006). Specializations can range from the traditional academic disciplines such as those in the liberal arts and sciences (i.e., music, art, philosophy, physics and chemistry), to majors that prepare students for “professional” or “applied” fields of study (such as engineering, business administration, and nursing). Organizing an education based on a discipline or field of study accomplishes a number of pedagogical and curricular objectives. Each discipline requires students to focus on specific phenomena. One would be to approach with specific analytical and descriptive methodologies, another, to have specific aims and a third, to employ specific conceptual frameworks and vocabularies (Marion, 2003). It has been supported though that student education has suffered the inferior pedagogy of traditional methodologies that concentrate specifically on only one discipline. In this frame, the interdisciplinary or cross thematic approach has risen in the modern curriculum as an important and challenging technique. Specifically, Bammer (2010, 2013) suggests that this field, which she calls 'integration and implementation', has become increasingly important in recent years and that a community of researchers has emerged with a shared interest in it. This field includes most of the terms and the issues normally grouped under the heading of interdisciplinary education; synthesizing more than one discipline and creating groups of teachers and students that enrich the overall educational experience. It is true that the interdisciplinary approach has been variously defined (Klein, 1990). One general description considers it "a process of answering a question, solving a problem, or addressing a topic that is too broad or complex to be dealt with by a discipline or specialization" (Newell, 1996). Many researchers find many advantages, as well as disadvantages, of interdisciplinary studies. There are educators who advocate the concept of interdisciplinary study, based on the view that the world itself does not exist as separate disciplines or fields of study, and that all knowledge is systematically integrated. Moreover, interdisciplinary study is considered a means of framing and solving problems that cannot be addressed using single methods or approaches (Klein, 1990). Also, the interdisciplinary approach provides many benefits that develop into much needed lifelong learning skills that are essential to a student’s future learning. The foundation of interdisciplinary techniques will lead to a future of discovery and innovation. For example, the chemist Willard Libby who discovered radiocarbon dating, applied his findings in Chemistry to the discipline of Archaeology and won the Nobel Prize for the discovery in 1960 (Youngblood, 2008). In general, it is widely believed and proven that interdisciplinary teaching is the ideal way of approaching a specific area of study as it brings together expertise from different fields in a way that retains and clarifies the fundamental building blocks of a given discipline. Tracing a common thread (a theme or issue) through these different viewpoints leads to valuable synergies among the disciplines and professional skills. At its best, by utilizing the strengths of each area, interdisciplinary cooperation leads to the optimal creation of something far greater than any one area could produce alone. Nevertheless, educators (and specialists) continue to debate the effectiveness of organizing knowledge into disciplinary categories, as well as the definitions of, and boundaries between, these categories (Klein & Newell, 1997). Also, Burton (2001) supports that the interdisciplinary approach should not be considered a panacea for solving the problems of the modern educational system. Cooperation and the value of teamwork can be achieved utilizing conventional teaching methods and not necessarily
interdisciplinary ones. Despite the extensive examination of the interdisciplinary approach (Klein, 1996; Lattuca, 2001; Newell, 1996), literature shows that little attention has been paid to the instructional methods used in such programs, and to the effect of such programs or teaching methods on student learning. As interdisciplinary education claims to have pedagogies and curricula that are distinctly different from the non-interdisciplinary or “traditional” disciplines this should result in different instructional strategies between interdisciplinary and traditional disciplinary programs. The purpose of the present study was to review the literature regarding interdisciplinarity as a method used in both teaching and learning of different subjects, and especially of Physics and Physical Education.

Literature review

Some have viewed interdisciplinary work in science as a natural phase in the development of new disciplines (Klein, 1996; Lemaine et al., 1976; Lenoir, 1993), suggesting that scientists branch out beyond the limitations of their existing field and work with others for a period of time until a new discipline or sub-discipline becomes established. In any case, the interdisciplinary approach employs experience and application as critical elements of the teaching-learning process; learning by "doing" rather than through theory addresses the needs of a significant percentage of students (i.e., in secondary education) who will soon need to apply these skills in the work place. Also, the interdisciplinary model's emphasis on cooperative learning and the use of critical thinking skills speaks to a national educational priority that affects all levels of teaching and learning (Gabbard & McBride, 1990; Sadler, 1993; Schwager & Labate, 1993; Stier, Milchrist, & Kleinman, 1994). In turn, interdisciplinary cooperation facilitates student engagement and active learning encourages student involvement by providing a variety of ways to learn, ways which are appropriate to their discipline and incorporate an experiential component where appropriate. It seems that interdisciplinary teaching and learning engage with the tenets of good teaching and learning as described by Leblanc (1998).

Interdisciplinary learning in Physical Education

Placek (1992) criticizing conventional teaching programs of physical education claimed that their main objective was the development of fundamental skills, the practicing of sports and games and the development of students’ fitness. Cognitive and emotional development, such as the implementation of rules might be of secondary importance to the course. Specifically, the main priority was for students to be trained in such a way, so they could perform well and become competitive in various sports, regardless of the allegations of physical education teachers that unless these goals were taught simultaneously to students, they would not be able to develop their critical thinking and problem solving skills. In line, Placek and O’ Sullivan (1997) taking into consideration the typical physical education programs, believed that the cognitive and emotional objectives of physical education were left to chance, and supported that they could be served only through a multidisciplinary approach. Research studies, although few, attempted to integrate physical education with various curriculum subjects and to examine the effects of such programs. Derri, Aggelousis and Petraki (2004) showed the effectiveness of a health-related fitness and nutrition education program on elementary students’ fitness components and dietary habits. Similar were the results in the study conducted by Zervou, Derri and Patarakis (2004). They found that fourth grade students who were taught topics related to the ancient Olympic Games, through an interdisciplinary movement approach they both acquired and maintained good knowledge compared to their classmates, who were taught the same subject but in a theoretical framework in the classroom. Mylosion and Papaioannou (2005) unified themes from the Greek language and physical education in a six-month collaborative project. Their goal was to investigate the impact of the project on various aspects such as how students approached their objectives, how strong their motivation was, the satisfaction received from the different classes and the feeling that they succeeded in coping with difficult tasks. In addition, self-concept, personal and social responsibility and academic achievement were some more of the project’s aspects that were investigated. The survey findings revealed positive effects on all the studied aspects. Similarly, the positive impact of an interdisciplinary physical education and Greek language program on language learning of preschool students was found in the study by Derri, Kourtessis, Goti-Douras, and Kyrgiridis (2010). Cone and Cone (2001), as well as Sperling and Head (2002), shared the same view. The former showed that the interdisciplinary teaching had a positive impact on improving the language skills of students and the latter, praised the effectiveness of an interdisciplinary physical education program on learning letters and recognizing words by pre-school and primary school students through the formation of letters with their bodies. Also, the increase in interest and internal motivation of ‘indifferent’ pupils was the result of an interdisciplinary physical education program integrated with concepts from the scientific field of natural sciences (Gotzaridis, Papaioannou, Antoniou & Albanidis, 2007). Furthermore, Filippou, Bebetzos, Vernadakis, Zetou and Derri (2014) investigated the effect of an interdisciplinary program of Greek traditional dance with issues from music and sociology, on high school students’ anxiety levels. Results revealed a significant reduction of both the somatic and cognitive anxiety but also an important increase in self-confidence of the experimental group. The results of the latter research come into contrast with the results of Kaprinis, Diggelidis and Papaioannou (2009), in which the students of the experimental group showed increased percentages of somatic and...
cognitive anxiety. Probably, this differentiation is due the content of the interdisciplinary approach which in this investigation was consisted of music and sociology issues, while in the research of Kaprinis et al. (2009) came from mathematics. However, Kaprinis et al. (2009) verified what Usnick, Johnson and White (2003) had also found; the positive impact of the program on the development of mathematical skills, internal motivation and satisfaction of the students. Similar positive learning outcomes were reported by Tsapatori, Pollatou, Gerodimos and Mavromatis (2009) who applied a music-movement program on first grade students. In accord were the findings by Papaoanndiou, Derri, and Filippou (2015) who examined the impact of an interdisciplinary Greek traditional dance, history, and geography program on elementary students’ satisfaction and motivation, as well as of Filippou (2015) in terms of student achievement of goal orientations through interdisciplinary physical education. Based on the above studies, the interdisciplinary integration of grammatical, historical, sociological, mathematical, musical, and nutritional issues with physical activities had better and more positive results than teaching them through conventional curricula. According to Ellis and Fouts (2001), the remarkable point was that students who participated in interdisciplinary teaching were very satisfied with the course and loved the teaching process more than those who were involved in conventional teaching methods, although they recognized that their decisions had to be greater and more difficult than those of conventional programs.

**Integrating Physics and Physical Education**

Moore (1992) and Stevens (1994) suggested the use of Physical Education skills to reinforce concepts in academic disciplines such as physics. This method provides students and teachers with increased opportunities for exploration, problem-solving, and concept application while providing an additional medium for cooperative learning and mutual understanding of each other’s goals and objectives. Also, according to Rasch (1989), the relationship between scientific principles and physical education and sport skills is well established. The laws of Physics, especially those relating to mechanics and motion, have strong parallel relationships with the principles that dictate the foundations of psychomotor movement. For instance, the increased popularity of weight training at the secondary school, and its integral role in programs that advocate wellness and fitness for life make it an appropriate choice from the perspective of physical education. Besides, such approach could be an answer to students’ lack of interest in participating to the course (Gotzaridis, et al., 2007) and as a consequence, to their reduced effort as well as to the absence of satisfaction to gain from that (Diggelidis & Papaioannou, 1999). Therefore, students should be provided with opportunities to apply concepts and principles of Physics acquired through formal classroom teaching to Physical Education environment or/and vice versa, and also to establish collaboration and other social skills that are of crucial importance in life. However, little research has been conducted in regards to interdisciplinary teaching of Physics and Physical Education and even less in secondary education (Gilbert, 1987; House & Coford, 1995). Both the interdisciplinary teaching models that include Physical Education as an integral part of the learning process and the way in which these have been implemented in high schools, emphasize the use of critical thinking, decision making and cooperative learning skills as these are considered prominent strengths of interdisciplinary education (Ivanitskaya, Clark, Montgomery, & Primeau, 2002). Such skills will also help the teaching profession meet the demands of a complex and changing world (Downing & Lander 1997). Tenoschok (1993) designed a "Jog Around the World" interdisciplinary school wide activity in which classes collaborated to jog the equivalent of the earth’s circumference during the school year while learning mathematical applications and elements of geography. Markle (1991) formulated a cross-curricular activity program designed to teach the scientific bases of physical and health fitness. Guthrie and Perea (1995), and Jones (1996) have developed integrated curriculum models that focus on interdisciplinary cooperation and the development of critical thinking processes across grade levels. All these models include Physical Education as an integral to the learning process. Therefore, more programs of this nature are needed in high schools. There are three reasons for this imperative: The success of this technique is apparent in literature. Team teaching approaches that have been implemented in Physical Education (Faucette & Hillidge, 1989; Gabbard, McBride, & Matejowsky, 1989; Ritson, 1989) helped to integrate it into the curriculum; fostered the development of critical thinking skills; and nurtured cooperative implementation of fitness programs.

**The interdisciplinary approach in undergraduate education**

Interdisciplinary study has had an increasing presence in undergraduate education in the past three decades as colleges and universities have added interdisciplinary programs in areas such as Women’s Studies, Information Systems, and International Relations. Colleges and universities continue to be encouraged by educators to offer courses, curricula, and major programs that are interdisciplinary in nature. Edwards (1996) suggested that research of academic programs in the U.S. showed that about half of the colleges and universities had interdisciplinary components to their liberal arts programs. A curriculum requiring students to cross disciplinary boundaries can present complex learning objectives. These may include the use of multiple methodologies for learning problem-solving skills, and the need to integrate or synthesize knowledge claims taken from two or more disciplines. These objectives may be different from the objectives of the curricula of individual traditional disciplines. In their research in understanding the way knowledge is structured and how experts think in specific disciplines, Middendorf
and Pace (2004) wrote: "Thus, we have only begun to understand what kinds of thinking goes on in different disciplines, nor do we know the similarities and differences across the disciplines" (p. 2).

The extensive examination of interdisciplinary education in the past decades has focused on these curricular and pedagogical differences (Klein, 1990; Lattuca, 2001; Newell, 1996).

Guiding students by way of academic advising is crucial to meeting these complex learning objectives of interdisciplinary study. Payne (1998) wrote that faculty members who were attracted to interdisciplinary study tolerated ambiguity, were self-motivated, broadly educated, and dissatisfied with the constraints placed on their intellectual work. These defining characteristics may be found in mature adults who are teachers and researchers, but are undergraduate students prepared for this type of learning model?

Are students made aware of the challenges, the goals, and structures of such programs from their advisors, their college admissions staff, or their high school programs? Interdisciplinary study is often described in terms of hardship and journeying, as these article and book titles suggest: “Barriers to Interdisciplinarity” (Bradbeer, 1999), “Negotiating a Passage Between Disciplinary Borders” (Wissoker, 2000), and "Crossing Boundaries" (Klein, 1996).

Writing about the barriers to interdisciplinary study, Boyer (1998) found that "Students who find that existing majors do not suit their interests often encounter discouraging barriers; advisors will likely first try to fit those interests into one of the existing patterns” (p. 23).

Klein (1996) offered a list of administrative strategies for supporting students, such as loosening structural barriers and clustering programs. Haynes (2002) wrote that interdisciplinary study is "concerned primarily in fostering in students a sense of self-authorship and a notion of knowledge that they can use to respond to complex questions, issues, or problems."

Elsley (2002) recognized that the expressions of such goals are quite lofty, and surmised that not all undergraduate students could rise to this challenge. To what extent are students prepared to achieve such learning outcomes from interdisciplinary study?

In addition to producing scholarship and teaching, programs need to offer personal guidance to students for establishing their educational and professional goals in these interdisciplinary fields of study. The advising of these students plays a key role in achieving such interdisciplinary learning outcomes.

**Discussion and conclusion**

Based on the literature, the interdisciplinary approach is one particular alternative that has been stressed increasingly (Rosenbloom, 1995). Gieryn (1983), Klein (1993), and Fuller (1993) each address academic and disciplinary work as strategies to understand knowledge production practices. Based on the above cross thematic interpretation of lessons can help and improve the conceptual understanding of the students, helping the educators as well to broaden their horizons and use interdisciplinary lessons. Although the views of interdisciplinarity vary within the literature reviewed, all the studies view collaboration between the disciplines as being a source of new solutions and the involvement of multiple disciplines as an approach, which will have a positive effect on the outcome. It seems that the interdisciplinary approach is one of the general trends in the development of educational systems worldwide (Stozhko, Bortnik, Mironova, Tchernysheva, & Podshivalova, 2015). It meets the demands of the competence approach in teaching and learning and contributes to a higher level of understanding and applying in students. An effective form of interdisciplinary integration is interdisciplinary project-based learning, directly implementing the principles of practice (or context)-based learning. The results of the studies revealed that the combination of physical education lessons with any other discipline no matter the different academic level had very good results on the progression of the students. It is evident that interdisciplinary teaching helps to advance critical thinking and cognitive development, engaging students and helping them to develop knowledge, insight, and problem solving skills, self-confidence, self-efficacy and passion for learning. These are the common goals that educators bring to the classroom and interdisciplinary instruction and exploration promotes towards the realization of these objectives. Most of research was conducted in primary and preschool, less in secondary education and even least in higher education. All of them showed how interdisciplinary programs had a positive impact on improving different skills (language, mathematical, movement) of students. Regarding the physics with physical education, especially in secondary education, it is evident that more research needs to be done. Since there is lack of research between interdisciplinary lessons of Physics and Physical Education, we need to think more deeply about a project, the benefits of an interdisciplinary approach, the disciplines to involve, the extent of integration required and how this integration will be achieved.
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INTERDISCIPLINARNO UČENJE U OBRAZOVANJU: FOKUS NA FIZIKU I TJELESNI ODGOJ

Sažetak
Ovaj članak se bavi pregledom literature o interdisciplinarnosti kao pristupu korištenom u poučavanju i učenju. Uključuje ne samo doprinose iz različitih disciplina, nego se također koncentrira na teoretski, kao i praktičan rad iz područja fizike i fizičke edukacije. To je pokušaj prelaženja granica dviju uključenih disciplina. Buduća istraživanja, temeljena na ovom pregledu, razmatrati će poučavanje i proces učenja između fizike i fizičke edukacije u pokušaju proučavanja kako ta metoda može biti učinkovita u učenju studenata.

Ključne riječi: interdisciplinarnost, poučavanje, primarno obrazovanje, sekundarno obrazovanje, više obrazovanje

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