Literature Review: Learning Across the Disciplines

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How do we learn best? Is it better to take a holistic approach or to specialize in a specific area due to the overwhelming amount of material to be learned? This question has probably been asked for as long as mankind has existed. It is interesting to see that humanity started the quest for knowledge analysing the world as a whole, then went to take it apart to have a closer look and now has started to put the puzzle pieces back together. Once more, we are trying to get a complete view of the universe that surrounds us. In some disciplines, this trend of going back to a holistic approach manifests itself in the form of the research questions that are asked. In physics, for example, the main goal in recent years was literally to find the "theory of everything", that one body of knowledge that can explain all the natural phenomena surrounding us. But the trend has also allowed us to look, once again, beyond the disciplines, resulting in this new approach called interdisciplinarity. But what exactly is interdisciplinarity? To determine if interdisciplinarity helps us to learn better, it is important to know the key concepts, how it is best implemented and the problems associated with it.

Let's go back to the beginning. During the classical times of Greece and Rome, philosophy, science and the arts used to be studied as a whole (Klein,

1990b). In the Renaissance, scholars like Galileo or DaVinci were usually still mastering many disciplines. It was not until the 18th and 19th century, when, driven by social demand and increasing complexity, that the fragmentation of disciplines occurred and the individuals started specializing in one field (Klein, 1990b). Interestingly, as Beane (Beane, 1997) and Vars (as cited in Hatch & Smith, 2004) point out, already during that time of fragmentation, first ideas of curriculum integration emerged. However, it was not until the educational reforms in the 1960th, that the idea of interdisciplinarity and universal education gained, once more, real momentum (Klein, 1990b). Interdisciplinarity started to be seen as a solution to the disciplinary problems (Lattuca, 2001) and fragmentation (Beane, 1997). The growing complexity of the questions to be answered that originally lead to the development of the disciplines was now also fuelling this new interdisciplinarity (Klein, 1990c). However, pedagogical research on interdisciplinarity and curriculum integration is quite a recent phenomena (Beane, 1997), with most publications dating from the 1990's or later.

When this research started, the concept of the discipline was already clearly defined as a body of knowledge with consistent taxonomy and research methods (Donald, 2002). What to understand as interdisciplinary was less coherent. The problem was that very different ideas were grouped under the same term. To clarify, it was necessary to create more labels. While some authors (Association for Integrative Studies, 1996; Klein, 1990a, 1990c; Repko, 2007) base their categorization on the relation between the involved disciplines,

others (Boix Mansilla, 2006; Lattuca, 2001) are grouping the different forms according to the level of integration between the disciplines and the underlying research question. For Klein, Repko as well as the Association for Integrative Studies, multi-disciplinarity describes a setup where the disciplines are simply juxtaposed and used side by side without real interaction. There is an agreement that this form does not bring many advantages. Repko even cautions his readers to avoid this type of interdisciplinarity altogether. Cross-disciplinarity or cross-fertilization are used by Klein as well as the Association for Integrative studies when one dominant discipline borrows from another. Multi- and cross-disciplinarity combined correspond roughly to "informed disciplinarity", Lattuca's lowest level of integration. Interestingly, Klein reserves the term interdisciplinary for the situations where a gap between two disciplines is filled and there is a dependence on both disciplines. In Lattuca's framework, this would probably qualify as the second lowest level, which is synthetic disciplinarity. Klein then uses trans-disciplinary to describe the holistic approach that includes the disciplines as a whole and makes their borders disappear. This definition is similar to the one given by Lattuca, seeing trans-disciplinary as trying to form a super-discipline that provides an overarching synthesis. Lattuca provides a final fourth level, conceptual interdisciplinarity, for questions without a disciplinary basis. Out of these various definitions emerges an agreement that interdisciplinarity should be more than just juxtaposing disciplines (Boix Mansilla, 2006; Davis, 1995a). It is a combination of disciplines, used to address a problem that could not have been adequately solved by the individual disciplines

(Klein, 1990b; Newell, 1994; Repko, 2007), resulting in more than the sum of the disciplinary parts (Davis, 1995a).

The example of James Clerk Maxwell can be used to illustrate how a combination of fields results in much more than just the sum of the parts. Towards the end of the 19th century, Maxwell drew on the works of Gauss, Ampère and Lorentz to provide a theory that could explain every known phenomenon of electricity and magnetism in one set of equations. But the resulting theory was much more than the sum of the parts. It predicted the existence of electromagnetic waves and therefore was able to explain the observations of optics, an up to then, independent field of study. This discovery ultimately resulted in the creation of radio-communication and the revolutionary special theory of relativity. It was the first step towards the development of the "theory of everything" mentioned in the introduction.

It is probably not a coincidence that the interest in interdisciplinary approaches increased at the same time as the advancement of the understanding of how we learn resulted in various educational reforms. The old model of the teacher talking and the student listening is in conflict with every principle of optimal student learning (Haynes, 2002). Knowledge has to be actively constructed based on context (Beane, 1997; Donald, 2002) and learning should be connected (Davis, 1995a). This will lead to unforgettable, transferable knowledge (Beane, 1997). Therefore, holistic and interdisciplinary education is

now a priority in educational settings (Klein, 1990b). Interdisciplinary approaches are used to foster critical thinking, reading and writing (Field & Stowe, 2002). Including various perspectives caters to different types of meaning makers (Haynes, 2002) and learning styles (Hargreaves & Moore, 2000, as cited in Hatch & Smith, 2004). It probably does not hurt either, that as an added benefit, interdisciplinary work organization promises to lower cost, as some resources can be shared, thus making it appealing to the administration (Klein, 1990c).

We learn through patterns and connections (Beane, 1997), therefore, interdisciplinarity works best in an integrated curriculum. According to Beane, curriculum integration should center the curriculum on life itself. Fragmentation in various subjects is hindering the learning process. Hatch and Smith (Hatch & Smith, 2004) agree and argue that curriculum integration helps the students gain the knowledge and skills necessary to solve the complex problems that they will encounter in life. These real life problems usually can not be resolved by a single discipline (Beane, 1997). Davis (Davis, 1995a) goes in the same direction when stating that some competencies can not be learned in individual courses.

Hatch and Smith (Hatch & Smith, 2004) report that for some teachers, this integration is not even optional anymore, as evaluations (for example in Texas) require the teacher to provide evidence of student learning taking place connected to other subjects. When integrating physics, math and physical science around the topic of projectile motion, Hatch and Smith experienced

increased student motivation and performance. The physical education background related the otherwise rather abstract physics and math to something real. It also gave it purpose, as the results were used to improve the throwing techniques.

Good integration requires a high level of communication between the teachers and usually results in team-teaching (Davis, 1995a, 1995b). However, Newell (Newell, 1994) points out that, while the preparation has to be done in teams, the actual teaching could be done by an individual. This way, the teacher would serve himself as the model of integration. Davis reminds us to clearly identify the tasks that have to be done in teams and those that are better done individually. But how is this integrated curriculum achieved best?

Newell, Davis and Beane (Beane, 1997; Davis, 1995a; Newell, 1994) agree that planning has to start with a theme. Only then should the subjects be linked to it and the target competencies selected. If one starts with the disciplines and competencies and then tries to look for an overarching theme, the result will be a multidisciplinary project that offers no integration. These themes, such as "the Renaissance" or "The industrial revolution" sometimes are already included in the curriculum (Beane, 1997). Other sources listed by Beane are social issues and process oriented concepts. Working around themes aligns with the mission-oriented projects in research cited by Klein (Klein, 1990b) as a key example of interdisciplinarity.

Another aspect of designing an integrated curriculum is assessment planning. Assessments should help the students make the connections (Newell, 1994) and evaluate synthesis (Vars, 2002). Field and Stowe (Field & Stowe, 2002) suggest using continuous evaluation with portfolios and holistic rubrics. They think that the traditional pre- and post- evaluations are not well suited in this case. Vars points out that a low student-teacher ratio and involvement of the students in the creation of the evaluation criteria can be helpful.

However, this integration also creates problems. Apart from the many administrative, organisational and political issues, there are also conceptual difficulties. In order to have optimal student learning, the balance between the quantity and quality has to be kept (Davis, 1995a). For Klein (as cited in Haynes, 2002), triangulation of depth, breadth and synthesis is required. Also for Newel (Newell, 1994), it is important that the topics are abstract enough, but not too broad or too narrow. If students feel overwhelmed or realize that the evaluations focus on memorization only, they will take a surface or strategic approach (Donald, 2002). As team teaching, or at least, collaboration in the preparation, is required for those courses, there will be the typical power struggles related to the various stages (Storming, Norming and Performing) associated with group work (Davis, 1995b, 1995a). In addition to this, there is the potential conflict between the involved disciplines. In the ideal course, no discipline should dominate the other (Newell, 1994). The selection and preparation of the teachers, who are usually disciplinary specialists might also be problematic (Davis, 1995a; Haynes,

2002). If the integration is to work, the participating teachers are required to function effectively in the interdisciplinary context and be able to collaborate (Newell, 1994).

While two decades ago, the definition of interdisciplinary was unclear, there is now a consensus that interdisciplinary stands for well-integrated disciplines, organized around central themes. The result is more than just the addition of the disciplines. Some of the initiatives that advertise themselves as "interdisciplinary", at best, could be called multi-disciplinary and might cause confusion surrounding interdisciplinarity. There are other problems, mostly of organizational nature, that have to be overcome. But when integrated properly, interdisciplinary courses offer a tremendous potential for active, context-based and connected learning. They probably will not replace the disciplines, as they are based upon them. Specialization is still needed to look at the details of the puzzle pieces. However, one should not forget to look at the picture as a whole. Therefore, interdisciplinarity does and should have its place in every curriculum.

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