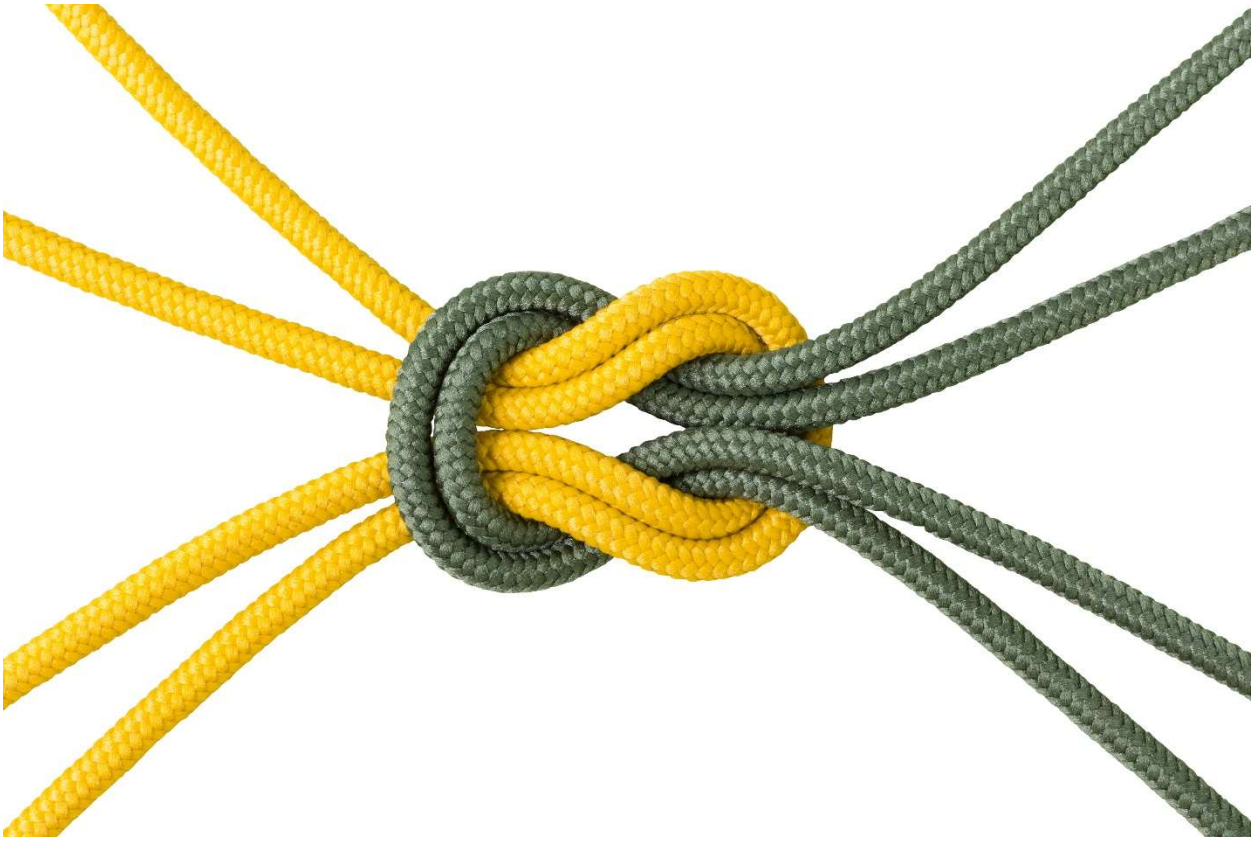
Interdisciplinary Curriculum and Integrated Instruction: A Literature Review



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Crosswalk of NTN and Integrated Curriculum Literature Review

	Recommendations	Intersection with NTN Model
High School	Teachers ● Understanding performance assessment makes teachers more likely to design integration (Newhouse, 2017) ● Ability to communicate & collaborate across teachers enhanced integration (Bull & Dupuis, 2014) ● Combining subject matter areas: one SM class prompts prior knowledge & other SM class builds on that knowledge (Jolley & Ayala, 2015) Students ● Integration leads to positive student attitudes, motivation to learn, and communication skills (Criscan, 2014; Ferguson-Patrick, Reynolds, & Macqueen, 2018; Newhouse, 2017) ● Integration can lead to increased problem solving and reasoning skills and content knowledge (Grouws, Tarr, Chavez, Sears, Soria, & Taylan, 2013) ● Integration leads to improved student engagement and 21st century skills (Dowden, 2007)	● Instructional coaching over a long period of time through NTN (badges) ● Understanding performance assessment ● Ability to communicate & collaborate ● Combining subject matter areas with PrBL and PBL
Middle School	Teachers ● Instructional coaching over a long period of time was more effective in learning how to integrate instruction (Hassaram, Rieth, Raghavan, Kinzer, and Mulloy, 2012) ● Organizational: Teams foster integration rather than departments (Salami, Makela, and de Miranda, 2017) ● Teachers who are more open to working on a team tended to integrate curriculum more frequently and effectively (Havnes, 2009) ● Know all the disciplinary standards for all subjects you are trying to address before planning lessons (Moser, Ivy, and Hopper, 2019) Students ● Integration leads to improved student engagement and 21st century skills (Thomas et al., 2012)	● Instructional coaching over a long period of time through NTN (badges) ● Improved student engagement and 21st century skills ● Teamed Teachers in MS

Elementary School	Teachers ● Teachers are generalists & make connections across content areas (Shriner, Schlee, and Libler, 2010) ● Focus on both products & process (Jamil, Linder, and Stegelin, 2018) ● Assessment is more than literacy skills (Brand & Triplett, 2012) ● Science is a vehicle for integration of other subjects (Aranda, Guzey, & Moore, 2019) Students ● Integration leads to increased content knowledge, student interest, student cooperation (Alghamdi, 2017) ● Repeated exposure builds student self-efficacy (Lamb, Akmal, & Petrie, 2015)	● Teachers make connections across content areas ● Focus on both products & process (e.g. rubrics for performance) ● Assessment is more than literacy skills (e.g. collaboration rubrics) ● Emphasis on building student self-efficacy (voice, choice, and agency) ● Problem-based mathematics enables students to justify their thinking and deepen writing skills ● Student engagement in research projects
Across Levels	Teachers ● Better understanding of type & purpose of integration: more effective planning (Shriner, Schlee, & Libler, 2010;) ● Student-centered pedagogy leads to improved student outcomes (Becker & Park, 2011) ● Learning goals focus on processes that students use to engage in the content over product (Margot & Kettler, 2019)	● Planning resources and support through NTN ● Student-centered pedagogy is prominent ● NTN emphasis on process over product ● NTN promotes authentic learning opportunities

Interdisciplinary Curriculum and Instruction: A Literature Review

The organization of school curriculum has been debated since the introduction of formal schooling systems in the United States (Ornstein & Hunkins, 2004). Interdisciplinarity has been one of the most discussed curriculum and instruction issues since the early 1990s, championed by John Dewey (Applebee, Adler, & Flilhan, 2007). The issue of whether disciplines should be integrated or departmentalized in formal schools has had a history of ebbing and flowing across time. In the 1960s, rapid social change led to a focus on integrated curriculum focused on real-world problems (Vars & Beane, 2000). In the late 1980s, a push for standardized testing and high scores on comparative international tests led to a shift from interdisciplinary topics to departmentalization of content areas (Marsh & Willis, 2007). In the 2000s, interdisciplinary teaching and curriculum development gained more attention as a way to prepare students for awareness of other cultures, 21st Century skills and a global economy (Dowden, 2007).

The purpose of this literature review is to examine the findings of studies related to curriculum integration and co-teaching models to determine student and teacher attitudes, implementation and outcomes. The synthesis of findings across studies will help to inform educators about the most effective techniques for preparing for, planning, and implementing interdisciplinary instruction.

Methods

We began by examining relevant secondary sources such as handbooks for organizing ideas. We then systematically searched for peer-reviewed scholarly articles in four different databases: Education Database, Education Research Complete, PsycInfo, and Social Sciences Citation Index. Since each database pulls from slightly different criteria for identical searches, we felt that four databases would gather all of the relevant articles on the topic. We searched the following terms in each database: cross-disciplinary, interdisciplinary, transdisciplinary, integrated, multi-disciplinary, curriculum, lesson plans, educational programs, assessment,

educational objectives, standards-based-education, teaching, instruction, academic settings, teaching methods, “Teaching interdisciplinary” and “integrated curriculum.”

Our inclusion criteria included articles about K-12 grades, which were sorted by elementary, middle school and high school, formal education, international settings, and empirical studies that were blind peer-reviewed. Our exclusion criteria consisted of pre-service teacher education, college level instruction, informal education, religious education, or single-discipline integration such as geology integrated into physics.

When searching for articles, we narrowed our searches by limiting searches for peer-reviewed articles in the last 10 years. For example, in the Education Database, a search for “interdisciplinary teaching” and “secondary” yielded 1,546 articles. Limiting for peer review narrowed the search to 866 and limiting for publications from the last 10 years narrowed the field to 457 articles, with only 213 relevant to secondary settings. From this group of 213 articles, further inspection for exclusion criteria not mentioned in the abstract yielded 17 articles on teaching and eight articles on curriculum. Tables of search results can be found in Appendix A.

Overview of integration

The goal of integrated learning is the development of the whole student through instruction that has meaning in real-life contexts. Helmane and Briska (2017) found that educators tend to have misunderstandings about the various reasoning strategies, connectedness between subjects and complexities of context across the different approaches to integration. If these educators understood the type of integration in the curriculum, they can better plan for the intended educational goals. The taxonomy of cross-disciplinary models pur forth by Lam et al. (2013) is helpful in understanding the nuances of integrating curriculum.

Lam and colleagues organized a taxonomy of cross-disciplinary approaches using three models from least disruption of the subject boundaries to most disruption: multidisciplinary, interdisciplinary, and transdisciplinary. They define multidisciplinary curriculum as one that has

two or more subjects that share a theme. The organizing theme is subordinate to the subject areas. Interdisciplinary curriculum blends content, and the subjects are tools in which to solve a problem, answer a question, or understand a themed topic. Transdisciplinary models remove boundaries from subject matter, resulting in the greatest degree of restructuring from traditional subject matter areas.

Multidisciplinary models. Within the multidisciplinary model, Lam and colleagues identify three approaches to organizing content around a theme: correlation, sequenced, and threaded. In the correlation approach, teachers from different content areas simultaneously teach one themed topic. In sequenced approaches, teachers develop units of study and teach similar ideas at the same time, although they still teach it as their particular content area. A threaded approach requires teachers to thread skills, such as social skills, technology skills, or study skills across their subjects, teaching them at the same time but in their separate departments.

Interdisciplinary models. The interdisciplinary models in this taxonomy have four approaches: fusion, integrated, shared, and webbed. The fusion approach requires teachers to combine two or more subjects into a new course. In the integrated approach, teachers use overarching concepts and emergent patterns to reorganize subject areas, usually having one subject area take the lead, as if examining different facets of the topic. In a shared approach, teachers share the planning and discover emergent topics that appear when they overlap the content areas. In a webbed approach, a theme is applied to different content areas for the purposes of illuminating concepts and ideas in each content area.

Transdisciplinary models. There is more reorganization in the transdisciplinary models than the other two models, and there are two identified approaches in this model: integrative, and structured and unstructured core. In the integrative approach, teachers plan for optimizing social and personal integration around significant issues without any subject boundaries. Structured and unstructured core approaches feature society-centered problems. Teachers

identify issues and students bring in any disciplinary knowledge or skills necessary to solve the problem. In structured core, teachers design the curriculum, in unstructured core, students and teachers collectively develop a unit of study. Helmane & Briska (2017) found that the transdisciplinary approach was seen as the most productive kind of integration by the teachers in Singapore that they studied. In the studies we found at the elementary level, both interdisciplinary and transdisciplinary models of integration were common. In the studies that we found at the middle school level, most of the integration models were interdisciplinary or with a few being transdisciplinary. At the high school level, most of the integration models we found were at the multidisciplinary level.

Outcomes of integrative approaches K-12

Becker and Park (2011) conducted a meta-analysis to determine the effects of science, technology, engineering and mathematics integration (STEM) on student learning. They found that STEM integration has promise to improve student learning, but it varied by age level and subject matter. They found that the largest effect sizes across studies occurred at the elementary level and the smallest effect sizes occurred at the undergraduate level. This could be related to the level of specificity that is required as students mature. Additionally, when integration consisted of all four content areas, student learning demonstrated the largest effect. When only engineering and mathematics was integrated, students demonstrated smaller learning effects. Similarly, Moss, Benus, and Tucker (2018) found that although core subject matter knowledge gains were low, gains in executive function (self-regulation and operational processes) were high when arts were integrated into core subjects.

Margot and Kettler's (2019) literature review of 25 studies related to teachers' perceptions of STEM integration also provides a broad look at K-12 STEM integration. Their analysis of literature found that teachers consider the integration of STEM to be inherently motivating, but identified six categories of barriers to STEM integration. These challenges include curricular, pedagogical and structural challenges, student concerns, assessment

concerns, and teacher supports. The researchers also captured ways that teachers integrating STEM might need additional support, and identified five main areas that addressed this need: collaboration, curriculum, district support, prior experiences, and professional development. Margot and Kettler's (2019) study examined studies from the US, the UK, Saudi Arabia, South Korea, and Thailand. Their review indicates that teachers' content knowledge was correlated with teachers' comfort level for teaching STEM, and that teachers' comfort level and their perceptions of their students' readiness for STEM content integration influenced their willingness to engage in STEM integration.

Elementary Teachers

Elementary teachers are often well positioned to integrate curriculum with their students, as elementary teachers are usually responsible for addressing all of the core content areas. The focus of most elementary classrooms is on reading, writing, and mathematics, with less time allotted for social studies and science. Curriculum integration can allow for teachers to meet objectives from multiple content areas in a single lesson.

Teacher attitudes. The literature on elementary teachers' attitudes and beliefs about integrated curriculum indicates that teachers value integrated curriculum to provide authentic, engaging learning experiences for students, but do not always connect their integrated instruction to specific curricular standards. Shriner, Schlee, and Libler (2010) surveyed U.S. teachers in Indiana about their plans to integrate curriculum after completion of 15 hours of professional development on the topic. Teachers identified the benefits of curriculum integration in terms of saving time by addressing multiple standards at once, and the opportunity to give students fun, real-life experiences.

Jamil, Linder, and Stegelin (2018) surveyed and interviewed early childhood teachers from the U.S. after they attended a conference related to STEAM curricular integration, and found that teachers were focused on the products of STEAM integration rather than the process that students would engage in or the content that would be learned by students. Teachers'

planning focused on the logistics of classroom instruction and classroom management, and several teachers expressed concern regarding students' ability to complete the STEAM-related tasks.

Fazio and Gallagher (2019) examined Canadian elementary teachers' views and practices of curricular integration. They found that teachers who used an integrated literacy and science curriculum appreciated the ability to address standards across both content areas in a single lesson. Many teachers in the study were successful in developing students' reading comprehension skills while also developing students' science comprehension. The researchers found that the classrooms in which students developed less comprehension of science were ones in which the teachers focused more on the language skills within the science context.

Srikoom, et al. (2017) surveyed teachers in Thailand to explore teachers' perceptions of STEM and STEM integration. Researchers found that Thai teachers had very limited knowledge of STEM teaching, but 79% were aware of the concept of STEM. Teachers had strong concerns about integrating engineering due to their limited knowledge of the topic. This suggests that teachers' content knowledge is important for teachers to be prepared for curricular integration.

Elementary Teacher PD for integrated Curriculum. Professional development plays a critical role in helping elementary teachers plan for the teaching of integrated curriculum. Teachers may be prepared for multidisciplinary and interdisciplinary integration, but are less prepared for transdisciplinary integration. Shriner, Schlee, and Libler (2010) surveyed U.S. teachers after professional development and asked teachers to identify what content areas they would integrate in their classrooms. Teachers identified science as the subject they would be most likely to integrate with language arts (20/36) & math (20/36), and language arts as the subject they would integrate with social studies and fine arts. Although teachers were able to identify the content areas they would seek to integrate, this study did not seek to examine how teachers envisioned integrating the content. Further research in this area is suggested.

Kang's (2019) literature review of integrated STEM and STEAM in South Korea found that teacher professional development increased teachers' confidence in teaching integrated STEAM. They also found that coaching in classroom practices within teachers' professional development was helpful.

The literature on professional development includes PD that is tailored for specific curricular units, as well as PD that generally seeks to prepare teachers for curriculum integration. Many elementary teachers are not able to identify appropriate curriculum integration or plans for curriculum integration. Brewer and Brown's study of 50 U.S. teachers (2009) found that teachers described integration as simply including content knowledge from multiple content areas, and focused on disciplinary vocabulary and skills when considering the integration. There is a need for research that focuses on how to best prepare teachers for curriculum integration.

Implementation. The implementation of integrated curriculum at the elementary level depends on staff readiness, motivation, and support provided (Icel, 2018). Icel's work focused on policies around the integration of STEM in a U.S. elementary science academy, but the findings from this study can be extrapolated beyond this context. Icel (2018) found that team lesson planning supported teacher buy-in for integrated curriculum, and identified professional development and administrative supports as critical elements.

Brand and Triplett (2012) studied first year U.S. teachers to examine how well interdisciplinary strategies taught during pre-service education courses influenced first year teachers' instruction. They found that most teachers reported using written and oral literacies across all disciplines, but reported only meaningful integration between literacy and social studies or science and math. Teachers in the study found resources to be critical and reported that state-mandated testing, district pacing guides, and required curriculum limited the quality and quantity of the interdisciplinary instruction in their classrooms.

A number of studies examine the integration of specific disciplines into non-core subjects. For example, An and Tillman (2014) examined lesson plans to consider how U.S. elementary teachers can integrate music and math, and identified 15 different ways this can be done. They also found differences in how pre-service and in-service teachers planned for curricular integration. Ollila & Macy (2019) examined how U.S. teachers in a rural Pennsylvania school integrated social studies and literacy. Teachers in the study reported addressing social studies concepts in ways they were not able to before they began integrating social studies into other content areas--with a particular focus on integrating social studies into language arts. Teachers in this study were more focused on the products of integration than the process, and considered reading (reading informational text) and writing activities (e.g. writing letters) to be ideal times for social studies integration, as well as in group projects and presentations. Teachers considered the connections to real-life situations and development of civic competence to be advantages for students. Teachers noted barriers to integration, which included inadequate instructional and planning time and a lack of relevant curricular resources.

Other studies examined how specific instructional strategies are enacted within an integrated curriculum. Aranda, Guzey, & Moore (2019) considered how multiple discourses are enacted by the teacher in whole class and small group discussions in an engineering based curricular unit taught in a Midwest U.S. elementary school. Findings included that the teacher merged everyday discourse with disciplinary discourse, while constructing multidisciplinary spaces for whole class discussions that bridged science and engineering.

Zhbanova, Rule, Montgomery, & Nielsen (2010) compared teacher talk and actions in using a social studies integrated curriculum unit with a single-subject mathematics unit taught using traditional direct instruction. This st.

Elementary Student Outcomes

The impact of integrated curriculum on students has been examined by a significant number of studies, with varying reports of the impact on students in both cognitive and non-

cognitive ways. Many teachers embrace integrated curriculum for its power to engage students in learning, but teachers do not always connect integrated curriculum to specific curricular standards. This section of the literature review examines affective and emotional student outcomes, and then goes on to examine cognitive and academic student outcomes.

Affective and Emotional Student Outcomes. Elementary teachers and students identified affective and emotional outcomes for students based on both qualitative and quantitative data. As would be expected from the research presented on teachers' attitudes toward integrated curriculum, student engagement and interest in content are consistently identified as student outcomes. Some studies also found that instruction based on an integrated curriculum increased students' self-efficacy and their collaboration skills.

Lamb, Akmal, and Petrie (2015) compared students at an integrated STEM school in the U.S. with students at a traditional school with similar demographics. In addition to finding evidence of differences over time in both affect and cognition for the students in the two conditions, this study found that early exposure to STEM curriculum increases development of cognitive attributes related to STEM tasks. The additive nature of the repeated exposure to integrated STEM curriculum was critical, as the researchers found that student self-efficacy and interest in STEM content occurred and was magnified with interaction.

Bolat and Karakus (2017) used qualitative case study research to examine the experiences of 14 Turkish fourth grade students in an interdisciplinary unit. Students were able to see connections between the social studies content and math, physical sciences, Turkish, English, arts, and music. Teachers and students reported that integration of curricular content increased students' interest in lessons and contributed to developing a positive attitude and their ability to work collaboratively.

Chen, Cone, and Cone (2011) examined interdisciplinary teaching in a U.S. elementary school. They described students' views of a unit in which movement skills and concepts in physical education were integrated with mathematical skills and concepts. Second grade

students in this study saw connections between math and physical education and were able to apply math in authentic physical education contexts. Researchers reported that students became more interested in both subject areas, and worked cooperatively with peers to complete the integrated learning tasks.

Zhang and Campbell (2012) examined the impact of an integrated curriculum on students' attitudes about science in a Chinese elementary school. When compared with students who participated in a traditional science class over a one year intervention period, students in the integrated curriculum unit had a more improved attitude toward science. Students in the integrated curriculum also enjoyed the learning environment more and reported more support from their teachers.

Cognitive and Academic Student Outcomes. The literature on the impact of integrated curriculum on students' cognitive and academic student outcomes suggests that students learn more when taught with curriculum integration, but the impact on student learning depends on the nature of the integration and the quality of the instruction provided. The importance of teachers using student-centered instructional methods is supported by the literature reviewed below.

A number of studies examined student outcomes from the integration of science and math or science and literacy. Alghamdi (2017) examined science and math integration in a Saudi Arabian elementary school and found statistically significant differences in student knowledge of both mathematics and science favouring the treatment group on the achievement posttest (effect sizes were 0.44 for science and 0.49 for mathematics).

Students' science content and vocabulary understanding were studied by Cervetti, Barber, Dorph, and Goldschmidt (2012) in a quasi-experimental study that compared a U.S. classroom utilizing an integrated science and literacy curriculum to a U.S. classroom with traditional science instruction. Students in the integrated curriculum classes made significantly greater gains on measures of science understanding, science vocabulary, and science writing

when compared with students in the classroom with traditional science instruction. Students in both groups had comparable gains in science reading comprehension.

Bravo and Cervetti (2014) examined science instruction in two conditions: (1) integrated science, literacy, and language curriculum, and (2) hands-on science without integration. Ten U.S. elementary teachers and their students participated in this study, and found that students in the integrated classroom had significantly higher posttest scores on Science Understanding ($F = 5.46$; $p < .05$) and Science Vocabulary ($F = 11.019$; $p < .001$), but reported no differences between the treatment and control groups in Science Reading skill. English learners (ELs) in the integrated classrooms made significant gains as a result of the integrated instruction--as a result of integrated science-literacy instruction, the difference in scores on Science Understanding between EL and non-ELs was negligible, but this difference persisted for control group students.

Bravo and Cervetti's (2014) study differed from many quasi-experimental and experimental studies in that the comparison group was not traditional lecture, but rather a model of good instruction. That is, the control group learned with hands-on science instruction, which is generally student-centered and engaging for learners. Observations of both the treatment (integrated classrooms) and control (hands-on science classrooms) indicated that adaptations were used in both treatment and control classrooms, but treatment classrooms were significantly more often coded as having teacher-student and student-student talk than control classrooms. This suggests that a student-centered philosophy and methods of instruction are vital components of successful integrated curriculum implementation.

Although much of the extant literature related to student outcomes found statistically significant increases in measures of student learning, there is some literature on this topic that simply demonstrates that teaching with integrated curriculum does no harm. One such study examined the impact of the Geo-Literacy for ELLs curriculum, which integrated geography and literacy in U.S. schools (Hinde, Popp, Jimenez-Silva, & Dorn, 2011). This study reported that

the integrated curriculum did not negatively affect reading achievement, and may have enhanced it. Studies of this ilk are important, as they offer a counterpoint to those who are concerned that shifting to an integrated curriculum will have a negative impact on student learning.

Middle School Teachers

Middle school teachers may find several different opportunities to integrate curriculum, particularly middle school teachers who are organized into teams rather than departments. For middle schools that have teams, core content teachers (language arts, mathematics, science and social studies) have the same students in their classes. These teachers also have a common planning time, which affords them the opportunity to integrate curriculum. These teachers may be able to combine classes to have two or more teachers in the room or teach simultaneous topics to the same group of students.

Teacher attitudes. The small amount of literature found on middle school teacher attitudes toward interdisciplinary teaching indicates that beliefs and attitudes may not be influenced by professional development experiences in the same way for all teachers. Al Salami, Makela, and de Miranda (2017) conducted a one-group pre-post test quasi-experimental design of the changes in teacher practice, student learning outcomes and teachers' beliefs and attitudes of middle and high school teachers in selected schools in the western part of the United States. They provided a professional development (PD) experience to 12 high school and 17 middle school teachers that consisted of a five day intensive summer institute and support for teaching from other teachers and research fellows, who were graduate students in chemistry, biology and engineering. The purpose of the PD was to support teachers in integrating biomedical engineering into their classes, ultimately integrating all of the STEM subjects. They measured teacher perceptions toward interdisciplinary teaching, attitude toward teamwork, teaching satisfaction, and resistance to change before the PD and after the time when teachers taught the interdisciplinary unit. They found no significant differences between

pre and post test on attitude to interdisciplinary teaching, attitude toward teamwork, or teaching satisfaction as a group. Of the 29 participating teachers, they found that 12 teachers showed negative change to attitude to teamwork, 11 teachers showed positive change and 6 showed no change to attitude to teamwork. Likewise, 15 teachers showed negative change in satisfaction, 12 with a positive change, and 2 with no change in satisfaction. The bimodal results of the change in attitudes before and after the PD resulted in no significant change across a 1-year time period, which is consistent with other studies on PD not related to integration of subject matter (Guskey, 2002; Tal, Dori, & Keiny, 2001).

Although singular variables showed no overall change for the group, there were several strong correlations found from this study. Change in attitudes to interdisciplinary teaching was strongly and positively correlated with both change in attitudes to teamwork $r(28) = .41$, $p = .03$, and change in teaching satisfaction, $r(28) = .37$, $p = .049$. Change in attitudes to interdisciplinary teaching had a significant and negative correlation with change in resistance to change $r(28) = -.40$, $p = .03$. All of the correlation effect sizes are considered medium to large. These results demonstrate that when teachers feel that they are part of an effective team and are open to change, they have positive attitudes toward interdisciplinary teaching.

Middle school teachers in this study showed differences from high school teachers across the variables. High school teachers showed more positive attitudes to interdisciplinary teaching, attitudes to teamwork and teaching satisfaction than did middle school teachers. Conversely, there were more positive responses by middle school teachers to resistance to change than high school teachers. In follow up interviews, both high school and middle school teachers discussed cross-content collaboration equally, with middle school teachers discussing the formation of student teams and the excitement of guest speakers in the class more than high school teachers.

Teacher PD for interdisciplinary teaching. Teamwork and collaboration were hallmarks of the teacher professional development experiences found in the middle school

setting. Al Salami, Makela, and de Miranda (2017) paired an intensive week of learning from examples of integrated curriculum with the formation of working teams consisting of science and mathematics teachers and STEM doctoral students for their PD. They found that if teachers were open to working on a team, they were more likely to have positive attitudes toward interdisciplinary teaching. Moser, Ivy, and Hopper (2019) put together teams of university methods faculty across a variety of disciplines to support teachers in teaching a thematic unit in the U.S. on the Holocaust. In their study of the PD, Moser et al. found that the themes of collaboration and trust permeated the teacher perceptions to working with faculty. Although it was expected that the teachers would integrate the materials easily, often teachers would teach from only their discipline and would return to an interdisciplinary stance with a great deal of effort from the project leads. These findings suggest that teachers be aware of all of the disciplinary standards and goals at the beginning of the planning stage, and then work together rather than separately with planning the interdisciplinary unit.

Stinson, et al. (2009) surveyed U.S. elementary teachers to understand what teachers considered to be examples of science-mathematics integration, and why. Teachers tended to focus on the content and skills being taught in lessons to determine if the integration was present. In some cases teachers' lack of understanding of science concepts restricted their ability to determine if integration was evident. The researchers suggest that elementary and middle school teachers would benefit from greater understanding of math and science integration.

Implementation. One approach to providing teachers support for integrating subject matter outside of a formal professional development setting is coaching. Coaching allows for collaborative support across a longer period of time than an intensive professional development, which may address the need for time when attempting to create a more positive attitude towards integrated curriculum and co-teaching. Coaching takes into account that teachers are adult learners who have extensive content knowledge and experience. In a three-year integrated

curriculum project with eight middle school language arts teachers, Hassaram, Rieth, Raghavan, Kinzer, and Mulloy (2012) conducted an observational study on coaching in the U.S. for the purposes of integrating the curriculum. The teachers spent 42% of their time observing the target lesson by the professional developer and 30% co-teaching with the professional developer. The remainder of the time was spent modeling integrating behaviors for teachers (8%), technology support (7%), managing materials (5%), coaching (3%), communication (3%), and collaborating with other school personnel (2%). The coaching experience helped teachers move to a more student-centered orientation and offered more opportunities for small group discussion, resulting in a reduction of lecturing by 65%. Teaching with an integrated curriculum over a series of years with consistent coaching support resulted in teachers shifting to a more student-centered classroom.

Middle School Students

Middle school education has often been overlooked in favor of elementary and high school interventions (Andrews, 2011). Students in their middle school years have made a great deal of progress toward their college and career readiness and inattention to their progress during middle school could have consequences on options for a future career, particularly in the STEM fields (ACT, 2008). Integrated curriculum and co-teaching have the potential to influence academic outcomes of middle school students.

Cognitive/Academic student outcomes. Middle school is a crucial time for students to prepare for college or career. Balfanz, Herzog, and Mac Iver (2007) found four early warning signs through a longitudinal study that students in middle school in the U.S. exhibit that can lead to dropping out of high school: (a) failing math, (b) failing English, (c) attending school less than 80% of the time, and (d) receiving a poor behavior grade in one or more classes. Improved engagement in academic subjects in middle school could be one approach to better prepare students for college and careers, and integration of the curriculum is a way to foster

engagement. Thomas et al. (2012) found that integrating the curriculum moved U.S. students to high quality of collaboration and small group discussion, which have been identified as key 21st Century skills for life-long learning.

High School Teachers

It seems that there are more barriers to integration in the organizational structure of a typical high school than at the elementary or middle level. For one, high school teachers are trained as specialists, focusing on one content area, and would need to learn a great deal about other topics before integrating them. Scheduling presents another barrier to integration. Teachers at high school rarely have classes of the same students, since students choose to schedule their classes independently instead of with team. A science teacher who wants to do an integrated lesson with a social studies teacher may not share the same students. Additionally, high school administrators who are dedicated to integrating the curriculum would need to carefully schedule common planning time among teachers from different areas.

Teacher attitudes. High school teacher attitudes toward integration are optimistic when they consider the benefits of student engagement and learning, but high school teachers tend to be reluctant in their attitude of the practicality of implementation. Lam and colleagues (2013) interviewed teachers in Singapore and found commonalities with other studies of high school teacher perception of integration. High school teachers have a range of conceptions related to integration, ranging from multidisciplinary models to transdisciplinary models. Teachers felt that greater student engagement was a benefit of integration of curriculum. Gurkan (2019) found similar attitudes from Turkish teachers about integrated curriculum, that interdisciplinary teaching practices are important to promote effective learning, mental and emotional goals, and provide quality education services. Although both studies found positive teacher attitudes about integrated curriculum, they also found that high school teachers believed there were more barriers than benefits. The barriers articulated included the teacher's lack of subject knowledge and misalignment with the assessment system used in the school district, for example, high

stakes tests (Asghar et al., 2012; Harrell, 2010; Lam et al., 2013). Similarly the teachers in Gurkan's study teachers articulated that they need guidance, adequate knowledge and skills, cooperation, and instructional designs or plans to guide them for practice. In a multiple regression study, teachers had positive attitudes toward integrated curriculum when they had more professional development, personally valued their content area and saw integration as a support for understanding social context. Teachers in Belgium who had more than 20 years of teaching experience and teachers in the areas of mathematics tended to have a negative attitude toward curriculum integration (Thibaut, Knipprath, Dehaene, & Depaepe, 2018).

Teacher implementation of integrated curriculum. Successful models for teachers' implementation of integrated high school curriculum found in the literature provide some guidance on developing teacher collaboration. In one group of studies, the selection of the topics to be integrated was the central focus. One U.S. model, aligned with the correlation multidisciplinary approach, involved an English teacher and a biology teacher who taught the topic of genetics together. According to Bull and Dupuis (2014), the key to this approach was the ways the teachers built connections to student prior knowledge. Once students have activated prior knowledge, teachers can use this leverage to deepen knowledge. The biology teacher connected with student prior knowledge of birds, adaptations, and genetics while the English teacher engaged students with multimodal texts on genetics, diversity, and environmental issues. Because the same group of topics were taught in two different classes, students had various opportunities to reinforce their new learning. The English and biology teacher met daily to discuss their student observations and journal notes to continuously collaborate on their teaching. The constant collaboration of the teachers assisted in deepening the presentation of the genetics content knowledge. Another successful model of an interdisciplinary approach to curriculum involved the topic of volcanoes. Jolley and Ayala (2015) found that combining topics from geoscience and archeology engaged U.K. students at a high level and demonstrated positive student learning gains. The topics chosen for the unit engaged

students in human inhabitation from the past and environmental interaction, which were rich subject from which to draw student-centered learning activities. Likewise, Cozza, McDonough and Laboranti (2011) found that U.S. students were successful when teachers integrated the topics of the novel, *The Scarlet Letter,* and geometry to view the activities in the book from a geometric perspective. Effective curriculum integration at the high school level depends in part on the choice of topics for integration.

Integration of skills across the curriculum was found to be successful at the high school level. These skills include 21 Century skills such as collaboration, communication, and use of technology (Criscan, 2014; Ferguson-Patrick, Reynolds, & Macqueen, 2018; Newhouse, 2017) Teachers studied in these projects improved the integration of technology in teaching and learning and they were successful in mentoring student-centered activities that required group discussion. Critical components to successful integration of skills in the curriculum relied on clear guidelines for the teachers and providing samples of already integrated curriculum from which to model new designs (Ferguson-Patrick, Reynolds, & Macqueen, 2018). Newhouse (2017) found that in Australia, administrators can better support integration of 21st Century skills by opening up forms of assessment that measure application of skills and knowledge, so that assessments do not become a barrier to integration of skills.

Success in integrating curriculum does not only lie on choosing appropriate content and skills, but also depends on the level of teacher collaboration. Fenwick, Minty and Priestley (2013) found in the U.K. that leadership value in integration, strong teacher identity for the content area, strong ability to communicate with teacher collaborators and close proximity to collaborators helped to make integrated learning environments a reality. At the Scottish school they studied, they found a unified culture and a lack of asymmetric power relations among the teachers contributed to their ability to closely integrate subjects at the school. Their success was reinforced by the teachers' ability to talk with colleagues face-to-face due to the close physical arrangement of the school. Havnes (2009) conducted a case study of interdisciplinary teacher

teams in Norway and found four patterns of interaction of successful teams: personal responsibility, coordination of responsibilities, sharing the enterprise, and clarifying pedagogical motives. Neill, Corder, and Stephen-Cox (2017) found corroborating evidence of the need to build a strong team culture that includes shared leadership, mutual trust, commitment, and institutional support. The literature points to appropriate choice of content, skills, and teacher collaboration as key features to successful integrated curriculum design and implementation.

High School Students

Because of the advances of technology, knowledge is no longer about what a single person can understand or do, but is more about how a person can find information and evaluate its authenticity. Integrated curriculum has the potential to help high school students build their skills in locating and synthesizing knowledge as well as demonstrating to students the usefulness of the act of learning, motivating students to become more independent learners.

Student affective/emotional outcomes. There have been several studies that linked positive student attitudes about the content and improved motivation to learn. Students in a high school chemistry class experienced integration of chemistry and sustainability. Initially the students did not see the usefulness of chemistry, but when they learned in the integrated unit, a significant amount of Finnish students saw the usefulness of the content area of chemistry and improved their attitude toward chemistry (Juntunen & Aksela, 2013). Not only did they see value in what they were learning, but more than half of the students improved their communication skills and most of the students asked to spend more time on the integrated project than was initially planned. Integrating the areas of STEM for Taiwanese female students was found to have positive effects on their imagination, attitudes and learning effectiveness (Lou, Tsai, Tseng, & Shih, 2014). Integrating design-focused projects in a U.S. mathematics class improved student connections with each other through collaboration and to the greater community (Remijan, 2016). Literature on affective high school student outcomes related to integrated curriculum demonstrate mostly positive effects on attitudes, value and motivation.

Student cognitive and academic outcomes. The literature demonstrates a strong trend toward positive student cognitive and academic outcomes when engaged in integrated curriculum. In an integrated mathematics study, U.S. high school students who studied through an integrated curriculum were significantly advantaged over students who studied a subject-specific curriculum on classroom content assessments, a problem solving and reasoning test, and a standardized achievement test (Grouws, Tarr, Chavez, Sears, Soria, & Taylan, 2013). In the study on geoarchaeology mentioned earlier (Jolley & Ayala, 2015), students who studied through the integrated curriculum showed positive learning gains. During a unit of study that integrated biology and physical education, students in the treatment group significantly improved their content knowledge as compared to the control group.

Summary

This literature review has examined research studies on K-12 curriculum integration, with a particular focus on teacher attitudes, implementation, and student outcomes. Overall, there is significant evidence that teaching with an integrated curriculum can lead to improved student learning, increased student engagement, and a more positive attitude toward content. However, this review has also identified some potential points of concern of which schools and teachers who are looking to implement an integrated curriculum should be aware.

Overall Impacts on Students

Across all grade levels, teachers and students reported that students find learning with an integrated curriculum to be more engaging than with traditional single-subject instruction. Elementary teachers stated that learning with integrated curriculum is inherently motivating for students (Margot & Kettler, 2019) and more fun than traditional instruction (Shriner, et al., 2010). Teachers and students reported that integration of curricular content increased students' interest in lessons in multiple content areas, and that students saw the usefulness of the content area, thus improving their attitude toward the discipline (Juntunen &

Aksela, 2013). Students enjoyed the student-centered integrated learning environment more than traditional lecture (Zhang & Campbell, 2012).

The studies reviewed also provide evidence that learning with an integrated curriculum contributes to the development of important skills that extend beyond content. These include 21st century skills for life-long learning, such as collaboration and communication (Bolat & Karakus, 2017; Thomas et al., 2012). Teaching with an integrated curriculum all but requires the use of student-centered instruction, and encourages students to think creatively around the content. This helps students learn to work collaboratively while they improve their communication skills.

The literature indicates that meaningful student learning across content areas is possible with curricular integration. At the elementary level, multiple studies found a significant increase in measures of student learning when comparing integrated instruction with traditional single-subject instruction (Alghamdi, 2017; Bravo & Cervetti, 2014; Cervetti, et al., 2012). Similar results were found in studies focused on secondary classrooms, with increases for integrated instruction over traditional subject-specific instruction on content assessments as well as problem solving and reasoning tests (Grouws, et al., 2013). The aforementioned increase in student engagement may explain the increase in student learning for integrated curriculum, but there may be another explanation. Teachers reported addressing concepts in ways they were not able to before they began integrating content areas (Ollila & Macy, 2019), which suggests that an integrated curriculum allows for learning that simply cannot happen with traditional single subject instruction

Potential points of concern

As with any educational innovation, it is dangerous to assume that implementation of an integrated curriculum is without potential pitfalls. Several of the elementary studies reviewed found that the “fun” nature of curricular integration has potential to lead to a more shallow implementation, with teacher planning focused on classroom management, logistics, and final

products, rather than on the process and purpose of integrating content (Jamil, et al., 2018). Additional points of concern include that teachers' content knowledge plays an important role in teacher readiness to implement an integrated curriculum.

Although the literature provides evidence for greater student learning in classrooms with an integrated curriculum, it should not be assumed that this will occur. Some studies found no difference in measures of student learning when compared with a comparison group (Hinde, et al., 2011). It is important to note that integration of content does not naturally lead to more robust learning; content integration must be purposefully planned and carefully implemented.

Teacher resistance to integrating curriculum can be attributed to concerns about time, misalignment with mandated assessments, and discomfort with content that extends beyond the teacher's expertise (Asghar et al., 2012; Harrell, 2010; Lam et al., 2013). Teachers' content knowledge plays a critical role in teacher confidence and readiness for integration. Teachers may be prepared for multidisciplinary and interdisciplinary integration, but are less prepared for transdisciplinary integration.

Recommendations for practice

In order to support teachers and their students in curriculum integration, specific assistance is recommended. These supports include professional development, instructional coaching, a unified school culture, and developing feedback systems to continuously develop curriculum.

Professional Development. Professional development oriented around teachers' specific needs is critical to the success of an integrated curriculum (Icel, 2018). Teachers had positive attitudes toward integrated curriculum when they had more professional development (Thibaut, Knipprath, Dehaene, & Depaepe, 2018). These professional development programs should be long-term and take into consideration the prior experiences of the teachers.

Instructional Coaching. Coaching allows for consistent, collaborative support over a longer period of time than most professional development. Teachers who worked with a coach

were more successful in shifting to a more student-centered classroom. (Hassaram, et al., 2012; Kang, 2019). Coaching sessions were initially structured, with a pre-set goal and timeline, and as teachers became more expert, the sessions were provided on an as-needed basis.

Unified school culture. School leaders play a key role in cultivating a unified culture that values integration. Teachers were more successful in their integration of curriculum when they were already part of an effective team and when they were able to communicate with their collaborators (Fenwick, et al., 2013; Icel, 2018). A school culture that supports open communication and has explicit, agreed-upon and well known goals tends to be more supportive of successful integrated curriculum.

Embedding curriculum integration in practice. At times teachers consider curriculum integration to be a break from their normal routine--something fun for their students to experience. However, it is far more impactful for students to learn with an integrated curriculum on a consistent basis. Lamb, et al. (2015) found that student self-efficacy and interest in content was magnified with additional experiences with integrated curriculum. When curriculum integration is the norm rather than the exception, teachers and students can develop habits of mind around making connections across content areas in a collaborative space.

Focus on effective integration practices. Student-centered instruction is a critical component of successful curriculum integration (Bravo & Cervetti, 2014). Teachers who are accustomed to a teacher-directed classroom must be supported in learning how to change their role in the classroom. Teachers will also benefit from learning about other practices that support curriculum integration, such as activating students' prior knowledge and identifying engaging and relevant topics for integration. Schools must provide teachers adequate planning time and support, and should also provide clear guidelines for teachers and provide samples of already integrated curriculum from which to model new designs (Ferguson-Patrick, Reynolds, & Macqueen, 2018).

Recommendations for future research

A common theme across studies is that teachers are often challenged by aspects of curriculum integration, particularly planning for curriculum integration and identifying appropriate opportunities for it. There is a need for research that focuses on how to best prepare teachers for curriculum integration, and to understand how effective teachers plan for integration.

An advantage of integrated curriculum is that authentic problems can be incorporated, allowing students to make connections between content and real-life. This is now how most of our teachers learned their content, so it will be a challenge for teachers to create meaningful integrated lessons. Research is needed on how teachers envision integrating content, and how leaders and teacher educators can best support them in doing so.

Multiple studies identified teachers' communication skills as being important for successful curriculum integration. As multiple studies indicated that students develop communication and collaboration skills, it is likely that these skills are developed in teachers who engage in collaborative planning and teaching. Research is needed on how planning for and teaching an integrated curriculum impacts teachers professionally--both in terms of teachers' communication and collaboration skills, and their reflection.

The research reviewed suggests that learning with an integrated curriculum is fundamentally different than traditional instruction. Many studies demonstrate that student learning is improved over traditional lecture-based single-subject classrooms, but more research is needed to understand what features are most significant for teachers and students, and why. While further research about curriculum integration is needed, there is substantial evidence that supports its adoption.

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Appendix A

Elementary Database Search					
Database name	Search term	Article hits	Peer-reviewed	Last 10 years	Elementary
Education Database	Cross-disciplinary curriculum	270	66	28	11
	Interdisciplinary curriculum	1527	787	353	148
	Transdisciplinary curriculum	43	27	19	9
	Integrated curriculum	4645	2576	1202	461
	Multi-disciplinary curriculum	36	10	7	2
	Cross-disciplinary teaching	111	67	28	13
	Interdisciplinary teaching	1554	872	463	148
	Transdisciplinary teaching	52	38	31	7
	Integrated teaching	845	550	325	106
	Multi-disciplinary teaching	25	18	13	1
		9108			906
Education Research Complete	Cross-disciplinary curriculum	8	5	4	0
	Interdisciplinary curriculum	4628	3691	2500	175
	Transdisciplinary curriculum	9	9	6	1
	Integrated curriculum	633	509	257	51
	Multi-disciplinary curriculum	4	4	3	0
	Cross-disciplinary teaching	15	14	8	1
	Interdisciplinary teaching	246	201	122	21
	Transdisciplinary teaching	14	14	13	3

	Integrated teaching	158	141	78	12
	Multi-disciplinary teaching	3	3	1	0
		5718			264
PsycINFO	Cross-disciplinary curriculum	3	3	3	0
	Interdisciplinary curriculum	87	55	30	4
	Transdisciplinary curriculum	2	0	0	0
	Integrated curriculum	295	161	96	9
	Multi-disciplinary curriculum	2	2	1	0
	Cross-disciplinary teaching	5	4	2	0
	Interdisciplinary teaching	98	71	40	3
	Transdisciplinary teaching	4	4	4	0
	Integrated teaching	71	59	34	2
	Multi-disciplinary teaching	2	1	1	0
		569			18
Social Sciences Citation Index	Cross-disciplinary curriculum	2	2	2	0
	Interdisciplinary curriculum	66	66	37	4
	Transdisciplinary curriculum	1	1	1	1
	Integrated curriculum	234	234	131	8
	Multi-disciplinary curriculum	5	5	3	0
	Cross-disciplinary teaching	6	6	3	0
	Interdisciplinary teaching	102	102	58	3
	Transdisciplinary teaching	8	8	8	0

	Integrated teaching	85	85	51	2
	Multi-disciplinary teaching	5	5	4	0
		514			18

Secondary Education Database Search

Database name	**Search term**	**Article hits**	**Peer-reviewed**	**Last 10 years**	Secondary
Education Database	"Interdisciplinary teaching" AND secondary	1546	866	457	213
	Integrated curriculum and secondary	2452	1058	459	8
Eliminated articles with Outdoor ed Higher ed (including student teaching) In languages other than English (Mandarin, Spanish, German, Turkish, French) Mono subject articles that mention interdisciplinary teaching Only secondary Practitioner-oriented Editorials Parochial schools Result = 17 relevant articles for teaching and 8 new articles for curriculum					
Education Research Complete	"Interdisciplinary teaching" AND secondary	33	24	16	16
	Integrated curriculum and secondary	255	205	113	5
	"Interdisciplinary teaching and learning" AND secondary	52	42	30	30
Eliminated articles with Religion Integrated science (integrating physics with earth science or integrating labs in lecture instruction) Integrating mathematics disciplines Foreign language integration Teaching Result = 2 new articles, 14 overlapping articles with Education Database Curriculum result = 1 new article Teaching and learning Result = 2 new articles, 28 overlapping articles with Education Database or elementary or higher ed					
Psych INFO	Interdisciplinary teaching and secondary	233	161	85	52
	Integrated curriculum and secondary	16	7	4	1

Result = 5 new articles on teaching and					
Social Sciences Citation Index	Interdisciplinary teaching	58	35	35	14
	Integrated curriculum	129	129	129	10
Result = 1 new article on teaching and 5 new articles on curriculum					