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Content Coverage and the Role of Instructional Leadership

Introduction

In October 2005, *Rising Above the Gathering Storm: Energizing and Employing America for a Brighter Economic Future* (National Academy of Science), a seminal non-partisan report, was released. This report highlighted the urgency of investing in science and mathematics education in the U.S. This investment was considered critical for the country to "compete, prosper, and be secure in the global community of the 21st century." In his best-selling book *The World is Flat,* Thomas Friedman (2005) underscored the same concerns: "The truth is, we are in a crisis now…And this quiet crisis involves the steady erosion of America's scientific and engineering base, which has always been the source of American innovation and our rising standard of living."

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The *Gathering Storm* identified improvement of K-12 mathematics and science education as the most pressing issue confronting policymakers. At the convocation marking two years since the dissemination of the report (April 2008), there was general consensus that "the report continues both to inspire and to guide the actions of policymakers, business leaders, and educators" (p. 18).

There is growing concern about the performance of U.S. students on international assessments such as Third International Mathematics and Science Study (TIMSS) and Program for International Student Assessment (PISA). Student performance on cross-national comparisons seems to decline as they progress from elementary to middle to high school. The relative position of U.S. elementary students in the area of science has slipped when comparing the results of TIMSS 1995 to the more current international assessments. Trend results in science from the National Assessment of Educational Progress (NAEP) show essentially no change in student performance over the past 30 years (Gross et al., 2005). Such poor student outcomes reinforce the view that America is losing its competitive edge.

In outlining the education reform agenda for the new administration in March of 2009, President Obama articulated similar concerns. He stated, "The relative decline of American education is untenable for our economy, it's unsustainable for our democracy, it's unacceptable for our children – and we can't afford to let it continue."

The Role of Standards

The National Research Council (NRC) and the American Association for the Advancement of Science (AAAS) had a leadership role in the development of standards for science education. The standards-based framework included recommendations for student outcomes in science as well as guidelines for science teachers (AAAS, 1993, 2001; NRC, 1996, 2000).

Researchers point out that the connection between these and state standards may be nebulous at best (Marx & Harris, 2006). Some teachers have argued that the standards articulated by AAAS and NRC are incompatible with state-mandated curricula and accountability systems such as NCLB (Southerland, Smith, Sowell & Kittleson, 2007).

According to DeBoer (2002), the states' "focus on testing has…led individual states to create curriculum standards that are more detailed and highly specific" (p.413). Such standards, with the extensive listing of topics to be covered in the year, have served to "prohibit a robust, clear, intensive treatment of foundational ideas." (Southerland et al., 2007). Wandersee and Fisher (2000) reinforced the notion that a focus on a myriad of facts and details prevents students from obtaining a "big picture" of the science being studied. In their recent report on *State of the State Science Standards*, the authors (Gross et al., 2005) indicated that 19 states, serving about 55 percent of U.S. children, have science standards that are considered exemplary. However, 45 percent of the U.S. students are served by state science standards that have received grades of C, D, or F.

Standards and Instructional Time

The development of state standards in science has largely been in preparation for the NCLB science mandate that went into effect in 2007-2008. The initial NCLB accountability policies focused on mathematics and language arts. This initial NCLB focus on the two subjects has led to a reduced emphasis and time devoted to science instruction, especially in elementary grades (Saka, 2007). In many schools instructional time allocated to science was completely at the discretion of teachers. At other schools, teachers, at their principals' behest, only focused on NCLB accountability subjects, especially in the last few months preceding testing (Lee & Luykx, 2005).

The Need for Instructional Leadership

The widespread push for educational improvement has included calls for coherent, rigorous and focused content coverage in science. These concerns have been driven by international data that shows U.S. science standards lack coherence, include too many topics at each grade level, repeat many topics grade after grade and are not very demanding. Those same studies show that what happens in the classrooms mirrors the characterization of the standards (Schmidt, McKnight, Cogan, Jakwerth & Houang, 1999; Schmidt, Wang & McKnight, 2005). This has led to a reexamination of the role and responsibilities of state and district superintendents as well as principals with respect to issues of curriculum. According to Elmore (2000), improvements in instructional quality and student outcomes, "[are] possible with dramatic changes in the way public schools define and practice leadership" (p.2). Elmore (2000) and other researchers (Rowan, 1990; Meyer & Rowan, 1992) maintain the institutional structure of public schooling in the United States can best be understood through the lens of the institutional theory of "loose-coupling." Such a lens is useful for understanding why "the most durable innovations occur in the structures that surround teaching and learning, and only weakly and idiosyncratically in the actual processes of teaching and learning" (Elmore, 2000, p.6).

Educational leaders such as district superintendents and principals typically do not consider instructional leadership and in particular content coverage central to their role as administrators. Empirical evidence suggests that school administrators are least involved with issues related to direct instruction and only a very small proportion of educational administrators consistently demonstrate instructional leadership (Cuban, 1988; Murphy, 1990). Much of the effort related to improvement of student outcomes has been prompted by the effective schools research (Heck, 1992). The basic premise undergirding this research is that "improved student outcomes can be attained through strategic school organization and strong principal leadership" (p. 21).

International reports based on TIMSS data (Schmidt et al., 1999) provide evidence for the notion that leadership which focuses on the central mission of an educational institution and promotes policies and practices that support teachers and student learning is crucial for positive student learning outcomes. In TIMSS countries such as Czech Republic, Germany, Hong Kong, Norway, Spain, and Switzerland, principals (headmasters) spent more than half of their professional time on teaching and administrative tasks directly related to the school's central mission. These studies also indicated that in the U.S., principals in schools of seventh and eighth graders did not view their mission as directly related to educational functions. Much of the principals' time was spent on internal/external relations and little time was allocated to teaching or internal administration. Additionally, U.S. educational systems have the characteristic of being independent and organizing curriculum at the local district level. This has led to variability in access to school curricula, which in turn is related to student achievement (Schmidt et al., 1999). Given the "loosely-coupled" structure of the U.S. educational system, especially with regard to curriculum and the general lack of instructional leadership, the purpose of this paper is to examine the consequences for improved student performance and for equality of opportunity – in effect providing evidence of the need for leadership around instructional content in science.

BACKGROUND

Findings from TIMSS and PROM/SE (Promoting Rigorous Outcomes in Mathematics and Science Education) underscore the importance of content in student learning of both mathematics and science. When content coverage is coherent, focused, and coupled with rigorous expectations, student learning is increased.

For example, classroom level analyses of U.S. TIMSS data revealed that in the U.S., where instructional decisions are typically left to local districts or individual classroom teachers, the amount of time teachers spent on topics was related to achievement. Even after adjusting for prior learning and SES, more time spent on topics was related to higher achievement scores. Further, such a relationship was stronger when the increase in time was allocated to tasks that were a departure from dull and routine procedure (Schmidt et al., 2001). TIMSS studies further suggest that when policies and school organization emphasize the importance of curriculum and communicate clear expectations about quality of the implemented curriculum, more students learn at higher levels of attainment (Schmidt et al., 1997; Stigler & Heibert, 1999).

The connection between teacher time spent on content and student learning has been established in the 1970s and 1980s (Bloom, 1971; Carroll, 1989; Fisher, Berliner, 1985; Wiley & Harnishfeger, 1974). Increasing time on learning has also been linked to enhanced skill development and deeper conceptual understanding (Clark & Linn, 2003; Smith, 2002). These and other studies show a positive correlation between time spent on content and student learning (Huyvaert, 1998; Rangel & Berliner, 2007).

The Curriculum Structure of TIMSS' Top Achieving Countries

As part of the comprehensive TIMSS (1995) study, researchers reviewed textbooks and national standards of nearly 50 countries and coded the documents. The framework developed was based on a cross-national consensus regarding science topic coverage in grades one through eight in the participating TIMSS countries.

Content standards of the four top achieving nations[1] were used to develop a model of coherent content coverage in science. For the mathematics curriculum, subsequent analysis of the model by research mathematicians indicated that the model was consistent with the logic intrinsic to the discipline (Schmidt & Houang, 2007).

According to Schmidt and Houang (2007) a coherent curriculum introduces topics and develops the ideas in a logical sequence. Individual topics are connected via a systematic conceptual framework both within and across grade levels. In such a curriculum a teacher introduces a simple concept and develops the concept fully before moving to more complex concepts. Once the development of a topic is complete it is excluded from the curriculum, thus freeing instructional time for the introduction of more complex topics. In a focused curriculum, a relatively small number of topics are selected for inclusion, especially in the early grades.

Figure 1 depicts the common topics that three-quarters or more of the top achieving countries intended to cover in grades one through eight. The data suggest a logical progression in the coverage of topics from the simpler/basic to more advanced topics. When examined by scientists with whom we have worked it is recognized as being coherent and is what we view as one model of curricular coherence.

[1] The nations included were Singapore, Japan, Korea and the Czech Republic.

Figure 1. Science Topics Intended at Each Grade by Majority of TIMSS 1995 Top-Achieving Countries

	Grade							
Topics	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Organs, Tissues			●	●	●	●	●	●
Physical Properties of Matter			●	●	●	●	●	●
Plants, Fungi			●	●	●	●	●	●
Animals			●	●	●	●	●	●
Classification of Matter			●	●	●	●	●	●
Rocks, Soil			●	●	●	●	●	●
Light			●				●	●
Electricity				●		●	●	●
Life Cycles				●	●	●	●	●
Physical Changes of Matter				●	●	●	●	●
Heat & Temperature				●	●	●	●	●
Bodies of Water				●	●	●	●	●
Interdependence of Life					●	●	●	●
Habitats & Niches					●	●	●	●
Biomes & Ecosystems					●	●	●	●
Reproduction					●			●
Time, Space, Motion					●	●	●	●
Types of Forces					●	●	●	●
Weather & Climate					●	●	●	●
Planets in the Solar System					●	●	●	●
Magnetism						●	●	●
Earth's Composition						●	●	●
Organism Energy Handling						●	●	●
Land, Water, Sea Resource Conservation						●	●	●
Earth in the Solar System						●	●	●
Atoms, Ions, Molecules							●	●
Chemical Properties of Matter							●	●
Chemical Changes of Matter							●	●
Physical Cycles							●	●
Land Forms							●	●
Material & Energy Resource Conservation							●	●
Explanations of Physical Changes							●	●
Pollution							●	●
Atmosphere							●	●
Sound & Vibration							●	●
Cells							●	●
Human Nutrition							●	●
Building & Breaking								●
Energy Types, Sources, Conversions								●
Dynamics of Motion								●
Organism Sensing & Responding								●

While the data presented in Figure 1 depicts the ***intended*** science curriculum of high achieving TIMSS countries, it also provides an analytical framework for assessing the coherence of state and district-level curricular intentions. The framework is also useful for assessing the pattern of topic coverage by teachers in the current study. In this study the number of instructional days teachers spend on topics that appear in the high achieving science curriculum was determined.

The Role of Instructional Leadership

Recognizing the centrality of content to student learning makes what teachers do in the classroom with reference to content coverage perhaps the most important resource a school or district has. The implication is clear since school time is a limited resource (180 days in a year, 6 hours per day), and how this time is used should be of central concern to principals and superintendents as instructional leaders. Given the salience of content coverage to student learning we argue that instructional leadership in this domain should be one of the most important responsibilities defining good leadership at all three levels of the American educational system – state, district and school. We further argue that this must be the role of superintendents and principals. Elmore's (2000) discussion of distributed leadership emphasizes the role of instructional leaders at various levels acting as buffers against the encroachment of non-instructional issues. Thus superintendents are called upon to provide a buffer against non-instructional issues so that principals and teachers can focus on the instructional core. Similarly, at the school level, principals as instructional leaders buffer non-instructional issues from teachers so that teachers can concentrate on issues of instruction and content coverage.

State Level Instructional Leadership. Instructional leadership related to content coverage at the state level may be manifested through the development of and adoption of rigorous and focused content standards—the intended curriculum. Schmidt, McKnight and Raizen (1997) in their analysis of 50 state science standards found a lack of uniformity in both content and quality; some state standards were weak and incoherent while others displayed rigor and coherence. Variability in focus and coherence led to curriculum frameworks and textbooks that were often unfocused and ineffective in supporting student learning. A more recent study of state science content standards corroborates the earlier findings (Gross et al., 2005).

An analysis of the intended curriculum of high achieving TIMSS countries revealed that the articulated standards identified topic sequences that were logical across grade levels and when appropriate elucidated the hierarchical organization of the disciplinary content (Schmidt, Houang & McKnight, 2005). Such standards were considered coherent. Schmidt & Houang (2007) found that measures of curriculum coherence in mathematics were related to student achievement across some 30 countries.

District Level Instructional Leadership. Instructional leadership at the district level may be manifested through textbook adoptions, prescription of instructional objectives and assessment tests to accompany objectives (Floden et al., 1988). If instructional leaders at the district level encounter state standards that lack rigor and coherence, they would have to make judgments about what might be better, e.g., international standards. However, if schools are viewed as "loosely coupled" organizations, policies adopted at one level of the organization may not be reflected in decisions at other levels. For example, researchers have found considerable variability in the implementation of district policies at the classroom level (Meyer & Rowan, 1977; Resnick & Resnick, 1985). This would imply the need for instructional leadership at the district level that insures consistency across schools, especially with respect to content coverage.

School Level Instructional Leadership. Ultimately all educational reform efforts involve teaching and learning and as a result, the role of the teacher is pivotal. Educational researchers (Floden et al., 1988) recognize that teachers, because of their direct involvement in the instructional process, play a central role in the implementation of instructional reform. Even teachers who are committed to and have embraced change and reform may not implement the reforms that are intended (Gess-Newsome, Southerland, Johnson & Woodbury, 2003). Craig (2006) believes that teachers do not simply implement the curriculum but help shape the curriculum.

Principals, by exercising their role as instructional leaders, can frame and articulate school goals, provide instructional supervision and protect teachers' instructional time (Blase & Blase, 1999). Instructional leadership behaviors are known to be related to teacher commitment and professional involvement (Blase & Blase, 1999) and exert an influence on teachers' instructional practices (Spillane, Hallett & Diamond, 2003). Purkey and Smith (1983) pointed out that effective schools –

schools in which teachers are able to devote time to the core curriculum in ways that enhance student learning—are characterized by school principals in instructional leader roles and an agreement regarding the school's educational goals.

In the absence of such instructional leadership at any or all of these levels, teachers make the decisions regarding which topics to teach, which to add or delete, or whether to reorder topic coverage defined by the prescribed textbook. Most importantly, teachers' decision-making focuses on two crucial aspects of instruction:

- How to use the 45–60 minute class period for content coverage; and
- How to allocate the total available instructional time in one academic year to specific topics.

Content coverage, the choices teachers make in allocating instructional time to various science topics, must become a major concern for instructional leaders, especially principals. The management of this resource is the most important task a principal can engage in toward improving student learning. This is especially germane in the U.S. because of the absence of national standards that are uniformly adopted and powerfully enforced. The result is that the curriculum that is implemented by the teachers displays considerable variability across classrooms, within the school, across schools within the district and across districts within the state. Such variability contributes to poor performance internationally as well as inequality in opportunities to learn.

If the focus of instructional leadership is on the central mission of schools, then evidence regarding the extent to which school districts, schools and classrooms differ in their allocation of time in covering content would be invaluable toward understanding achievement gaps as well as how serious the current situation is and, as a result, how important pushing for instructional leadership would be. In school districts, schools and classrooms, when there is a high degree of coordination or alignment between the intended (standards) and implemented (teacher coverage) curriculum one would expect to see, at a given grade level, little or no variability in content coverage among districts within the same states, schools within the same district or classrooms within the same schools. Presence of large variations in topic coverage would be indicative of unequal opportunities to learn science between districts, schools and classrooms. Such variability in content coverage is likely to produce differences in student learning outcomes, creating achievement gaps which arbitrarily result from regional or SES differences.

It is this variability that is presented in this paper to demonstrate that the management of content coverage including associated time allocations is among the most important tasks for educational leadership, first across 53 districts—21 in Michigan and 32 in Ohio—then within districts themselves and finally within schools at the same grade level.

METHOD

The analyses presented in this paper are based on data collected as a part of the PROM/SE project. The goal of the PROM/SE project, a comprehensive Mathematics and Science Partnership (MSP), was to stimulate systemic curriculum reform using an evidence-based model to promote change. The curriculum-sensitive data collected for the project was used to provide individualized curriculum portraits of a school district's mathematics and science content coverage both at the district and at the classroom level. These curriculum portraits were designed to enable district and school level leaders, teachers and curriculum experts to develop informed plans for the improvement of student learning in the areas of mathematics and science. The data were also useful for informing the design and delivery of PROM/SE-supported professional development activities for the participating districts.

Instrumentation

Several of the instruments used in PROM/SE were initially designed and used for the TIMSS. The TIMSS Curriculum Frameworks were employed to measure the curriculum at different levels. As a result, comparisons could be made across each level in which curriculum was measured, i.e., state and district (Intended), and classroom (Implemented). All results could also be compared to international benchmarks developed as a part of TIMSS.

In the study reported here, the *Teacher Content Goals Survey* was used. In its present version this survey was a web-administered[2] self-report measure[3] of the implemented curriculum. In addition to background information, teachers were asked to indicate the number of class periods they taught specific science topics (Appendix A). The exhaustive list of school topics used in the study was obtained from the TIMSS Curriculum Frameworks (Survey of Mathematics and Science Opportunities, 1992a, 1992b).

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[2] A paper-and-pencil version was also made available for those who had difficulty accessing the web.
[3] Self-reports have limitations but validation studies have found an acceptable level of agreement among self-reports of the implemented curriculum and direct observation (Porter, 1993).

Participants

Data from 1,699 elementary and 373 middle school teachers were obtained between Spring 2004 and Spring 2005. These teachers represented 277 elementary schools and 144 middle schools from 53 school districts in two Midwestern states. Response rates ranged from 55 percent for some school districts to around 90 percent for other districts.

For each of the identified topics the teacher was asked to address the following close-ended question:

> *To what extent did you teach each of the following topics in the science course indicated in #1 above during the 2003-2004 school year?*

Teachers indicated the extent of topic coverage on the following scale representing class periods: 0; 1 or < 1; 2-5; 6-10; 11-15; > 15

Index of Content Coverage

Data on the number of periods over the year for each topic was first converted into percent teaching time and then into number of instructional days.[4] The 24 topics at the elementary level and 35 topics at the middle grade level were aggregated for some analyses to broader categories such as Biology, Life Science, Earth Science, Physics and Chemistry. They were also aggregated by grade level to characterize content coverage associated with the model of coherence.

Teacher content coverage data were grouped by state. Within each state the time allocations were averaged across all teachers in the district to produce an average for each district by grade level. For district level analyses an average of instructional days on specific aggregations of topic areas were calculated at each grade level, for each school. Next, within each district we identified the schools (at each grade level) with the highest and lowest average number of instructional days. The difference between the two averages provided the range of average days of instruction within districts. Districts with only one school were eliminated from these analyses. A low value for the range was indicative of small differences between schools within a district, on average, in the reported instructional time for specific areas of science.

For school level analyses, the variability in topic coverage between classrooms within a single school at each grade level was calculated by determining the classroom with the largest number of instructional days and the classroom with the smallest number of instruction days. Once the range (difference) for each grade level

[4] For purposes of this study 180 instructional days was used.

within a school was determined, we summarized the entire distribution of ranges across all schools. The two extreme range values at each grade level were excluded in the summary. Schools with only one classroom per grade were also excluded from the analysis.

RESULTS

In this section data are first presented regarding variation in reported science content coverage *among districts* within each of the two states. Variation in reported content coverage is also described among schools within participating districts and among classrooms within a school. Variation among districts within a state is relevant to issues of instructional leadership at both the state and district level, while variation among schools within a district is particularly germane for the instructional leadership provided by district superintendents and principals. Variation in content coverage between classrooms within the same school is the concern of principals who potentially provide leadership for school level instruction.

The results for each of the three levels focus on the group of topics covered at each grade level by the model of curricular coherence, as well as those that fall into the broad topic areas of Life, Earth and Physical Science. Such variation in content coverage is reported by grade level: grades 1-5 for the elementary school and grades 6-8 for the middle school. To maintain the flow of the narrative the use of figures is mostly limited to depiction of content coverage related to topics defined by the coherence model.

Districts Within States

Topics Covered in the Coherence Model. Teachers' reported content coverage of topics consistent with the model of coherence is summarized in Figure 2 for each of the participating school districts in Michigan and Ohio. At the elementary level, the model of curriculum coherence does not intend for introduction of science topics until grade three. At grade three, only seven topics are the focus of study. School districts in Michigan and Ohio at the third grade have a difference of about 50 days between the lowest and highest average total number of instructional days for those seven topics. In the Michigan and Ohio districts, respectively, a maximum of about 70 and 55 days are devoted to these topics. Thus, even in these districts, many instructional days are used for other additional science topics. Coverage of too many topics leads to an implemented curriculum that is diffuse and lacking in focus. Across the elementary grades, the school districts in Michigan showed a wider range of average

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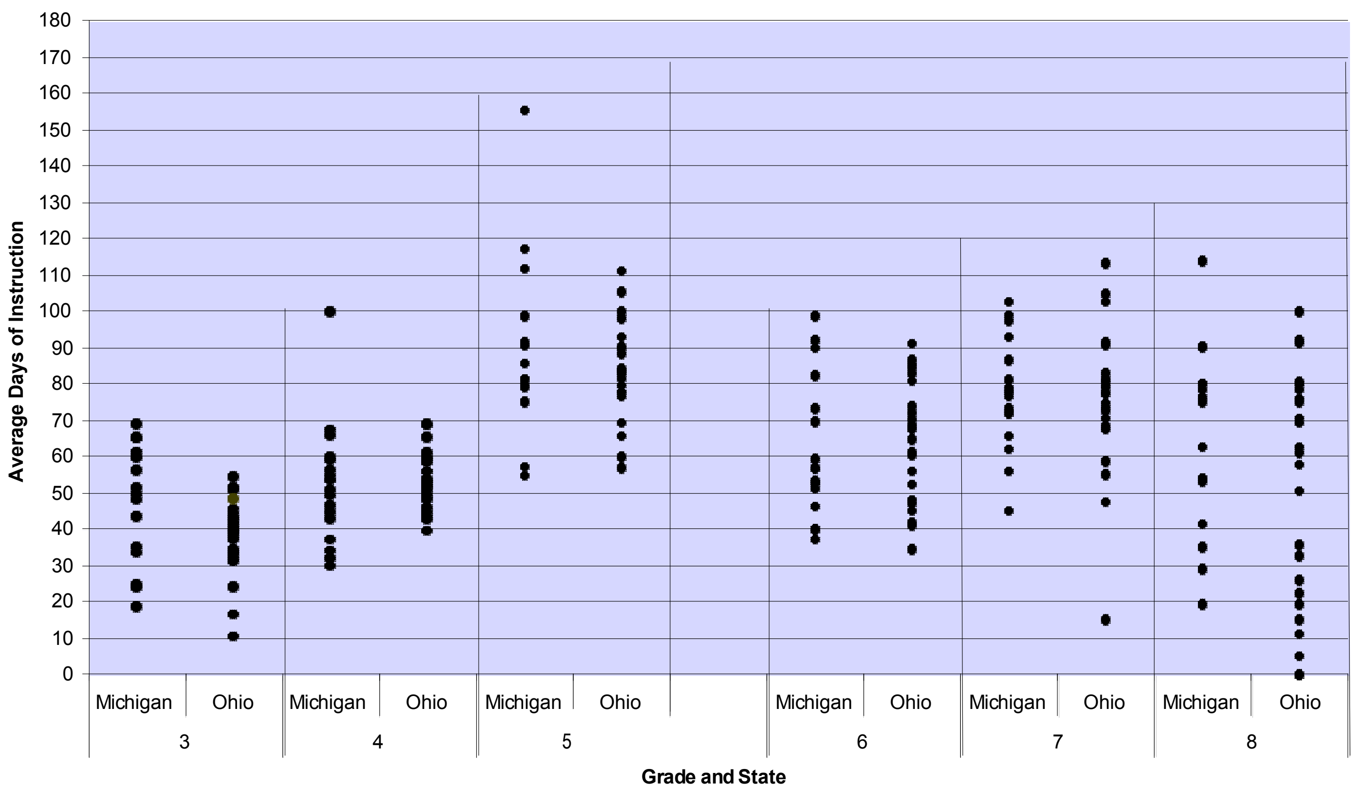
instructional days being allocated to the topics defining the coherence model at that grade level than districts in Ohio.

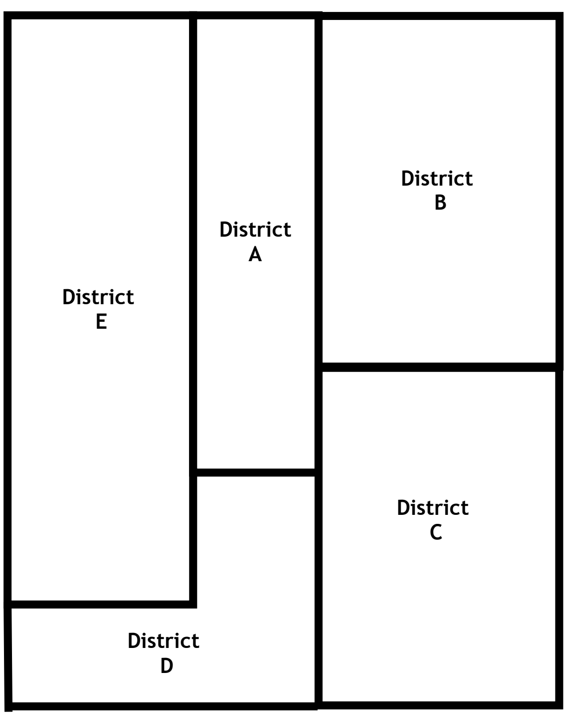
At sixth grade, the range of average instructional days is similar for districts in both states. At eighth grade the spread is the greatest not only among the middle school grades but also across all the grades – Ohio had some districts with no time devoted to the topics defining the coherence model and one district with schools that devoted 100 days to the same topics. This amount of variation occurring at such a critical juncture seems particularly important especially to the students in these districts and raises all kinds of questions related to issues of equality.

Figure 2. Average Number of Days Elementary and Middle School Teachers in Selected Michigan and Ohio Districts Spent on Science Topics Covered by Top Achieving Countries



To illustrate the impact of such variability in average instructional days we focused on data from a large urban school district (District E), along with data from four contiguous school districts (Districts A-D). District E is the largest school district and is located in a geographical area that houses many employers- industry, government and education. Although employment opportunities might be availed in District E, the population often makes the choice of residing in neighboring suburban areas (Districts A-D) and consequently, providing children in the family with educational opportunities in these suburban districts. A non-geographically correct representation of the districts is depicted in Figure 3.

Figure 3. School Districts Neighboring an Urban District



Across Districts A - E, in grades three and four, the range of average instructional days varied by about 30 days. In grade five the range was considerably greater – District B devoted on average about 57 instructional days to topics in the model of coherence whereas District A spent 86 percent of the instruction year – or 155 days – on the same topics. Other similarly large differences existed between the districts. Given the close physical proximity and the integration of the suburban districts' population with that of the urban district in terms of employment, it is difficult to imagine one district (A) allocating almost three times more coverage than district B. This is especially the case as the five districts belong to the same county-based educational organization established to foster cooperation on matters such as curriculum.

Life, Earth, and Physical Science Topics. The data indicate that in the first five grades the school districts in both Michigan and Ohio had a wider range of average instructional days devoted to Life Science than to Earth Science. In Life Science, Michigan districts had greater variation in the average number of instructional days than did districts in Ohio.

Michigan's districts continue to be extremely divergent in average time allocations for Life Science topics into the middle grades – schools in one district spending no time at all while schools in another district allocated an average of 109 days to the same topics. Districts in Ohio reflect the same extreme variability in allocation of time to Earth Science topics.

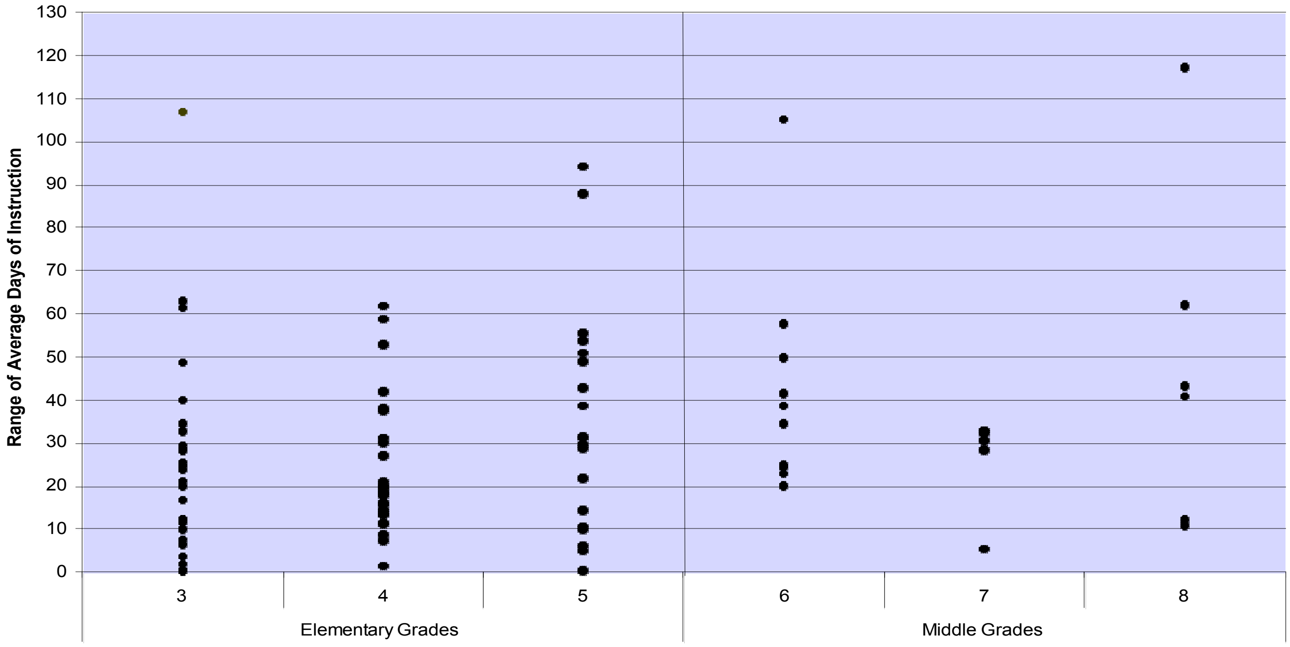
Based on the reported variability in instructional time devoted to Life, Earth and Physical Science topics, it is apparent that school districts within the same state provide students with very different and unequal opportunities to learn science content. This variability is even evident for school districts that may be separated by one or two miles. The differences among districts within a state are of particular concern because both states in this study have articulated standards for science. Clearly the state level intentions have not been consistently implemented by the districts, once again pointing to the importance of instructional leadership by the state and district superintendents. Left unattended such curriculum gaps lead to inequalities in opportunity but also most likely to achievement gaps.

Schools Within Districts

Topics Covered in the Coherence Model. When schools within the same district allocate different amounts of time to the topics in the coherence model it is indicative of "loose-coupling" between district-level curriculum policies and school level implementation of those policies. In the present study (see figure 4), in the elementary grades, there is at least one school district at each grade level whose schools demonstrate a consistency in instructional days allocated to topics in the coherence model – the difference of the average instructional days is zero or close to zero. A majority of the districts have schools that on an average differ in their allocation of time devoted to topics in the coherence by at least two weeks. Furthermore, there are districts where schools within the same district and at the same grade level varied by about 100 instructional days – a difference of around 20 weeks of schooling. The outlier districts in Figure 4, including the one just described, are large urban districts where such differences are often related to SES differences. Differences of that magnitude make it difficult to imagine that these two schools are in the same district within the same state.

At the middle school level, in sixth and eighth grades, the largest difference in average instructional days between schools in the same district on covering topics in the coherence model was 105 and 120 days, respectively. Thus, two middle schools within a single school district may be implementing very different science curricula, especially since there are only 180 days in a typical school year.

Figure 4. Range of Average Instructional Days Elementary and Middle School Teachers Spent in Schools within Districts on Science Topics in the Coherence Model



Life, Earth, and Physical Science Topics. The variability in topic coverage between schools within the same district mirrors the variability observed between districts within the same state. Schools in some districts do not differ in average instructional time allocated for Life, Physical or Earth Science topics – the difference in the average instructional days might be three or fewer days. Other districts have schools whose average days of instruction might differ by 80 or more days. At the elementary grades the greatest spread of differences in time allocation on science topics between schools in the same district seems to occur in grades one and three.

In middle school, variability in average time spent on topics is a function not only of the grade level but also of the specific topics being covered, i.e. Life, Physical or Earth Science. At the seventh grade, districts seem to have the greatest spread of ranges in average instructional days. For example, in coverage of Earth Science topics, two schools within a particular district were so variable in their time allocations that the difference in instructional days devoted to Earth Science topics was almost 120 days. Thus, at one seventh grade school within a school district students received 24 more weeks of instruction in Earth Science than seventh graders attending another school in the <u>same</u> district.

Classrooms Within Schools

Topics Covered in the Coherence Model. The box plots for the range (difference between classrooms in the same school) of instructional days teachers spent on the topics in the coherence model are depicted in Figure 5. In the elementary grades, the median difference between two classrooms in the same school in the number of days allocated to these topics was between 17 and 21 days or between two and three weeks.

In middle school, the time teachers spent on science topics in the coherence model indicates that in the lowest 5% of the distribution of schools the classrooms did not differ in content coverage by more than five instructional days at grade 6; 2 days in grade 7; and less than two days in grade 8. However, the top 5% of the distribution revealed considerable differences between classrooms in the coverage of science topics. For the sixth through eighth grade the largest differences in content coverage between classrooms in the same school was 92, 61 and 102 days of instruction, respectively. Ignoring those schools with the most extreme differences, there is still substantial variation as half of the schools at each of grades six through eight had differences equal to or greater than three to six weeks – still substantial variation with important consequences for student learning in science.

Life, Earth and Physical Science Topics. At the elementary grades the median differences between two classrooms in the same school in instructional days spent on Life, Earth and Physical Science topics ranged from 17 to 21 days for Life Science topics, 15 to 24 days for Earth Science topics and 9 to 17 days for topics related to Physical Science. There seemed to be little consensus regarding instructional time for content coverage in Life and Earth Science topics between teachers, who teach at the same grade level in the same schools. These data are presented in Figure 6.

At the middle school level the median differences between two classrooms in the same school is greatest for Life Science topics (Figure 7). In seventh and eighth grade there is at least one school where classrooms differ by 94 and 152 days, respectively, in the coverage of these topics. Such a large difference in the number of days devoted to Life Science topics suggests that students in two classrooms within the same school are experiencing distinctly different science curricula even though the parents of the students in the two classes expect that their children are having the same opportunities to learn science. This could adversely impact their readiness for the high school science curriculum.

How to Read a Box and Whisker Plot

A box and whiskers plot, sometimes called a box plot, provides a visual summary of many important aspects of a distribution. The "box" stretches from the 25th percentile to the 75th percentile, thus containing the middle half of the scores in the distribution. The Median, or 50th percentile, is shown as a line across the "box". The "whiskers" stretch from the 25th and 75th percentiles to the 5th or 95th percentiles, respectively.

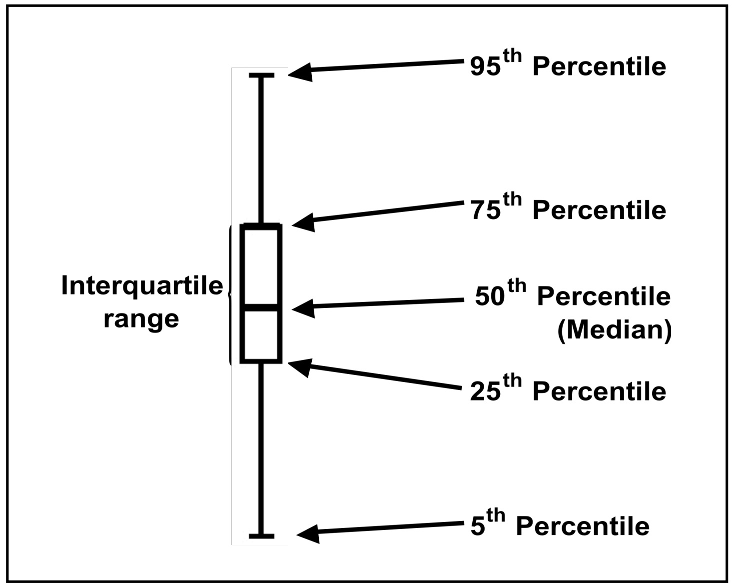


Figure 5. Box Plot of Range of Instructional Days Elementary and Middle School Teachers Spent on Science Topics Covered by TIMSS' Top Achieving Countries: Classrooms within Schools

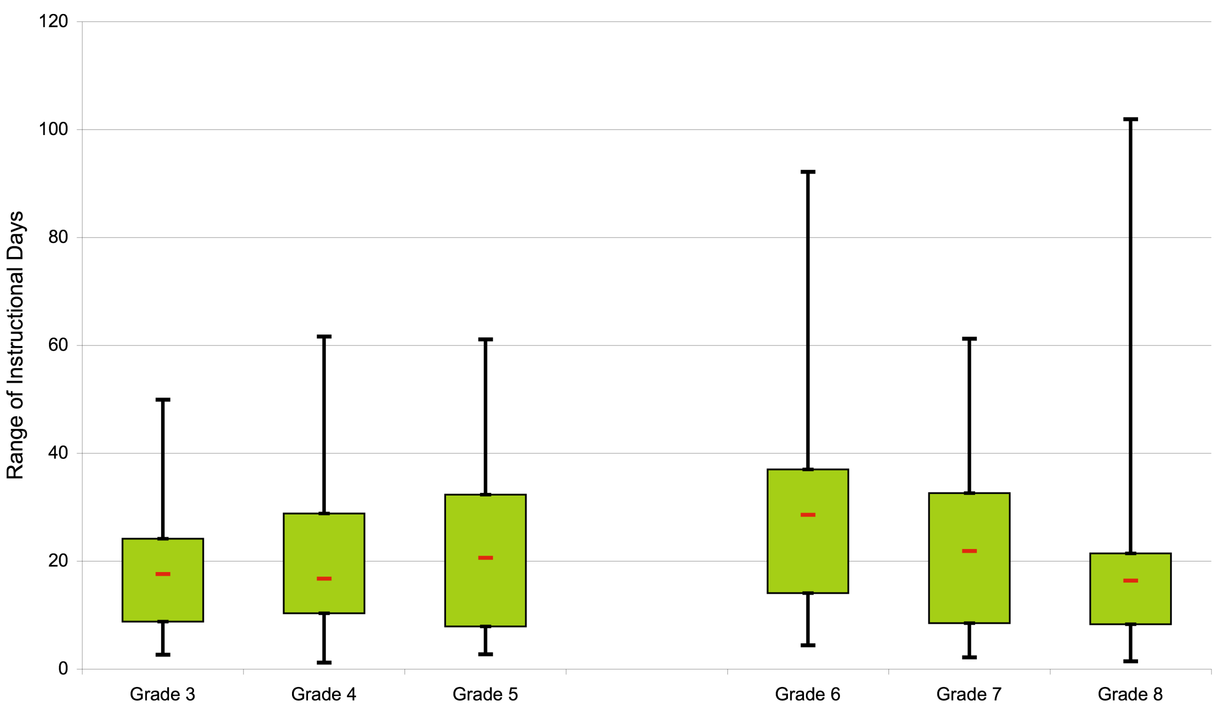


Figure 6. Box Plot of Range of Instructional Days Elementary Teachers Spent on Life, Earth and Physical Science Topics: Classrooms within Schools

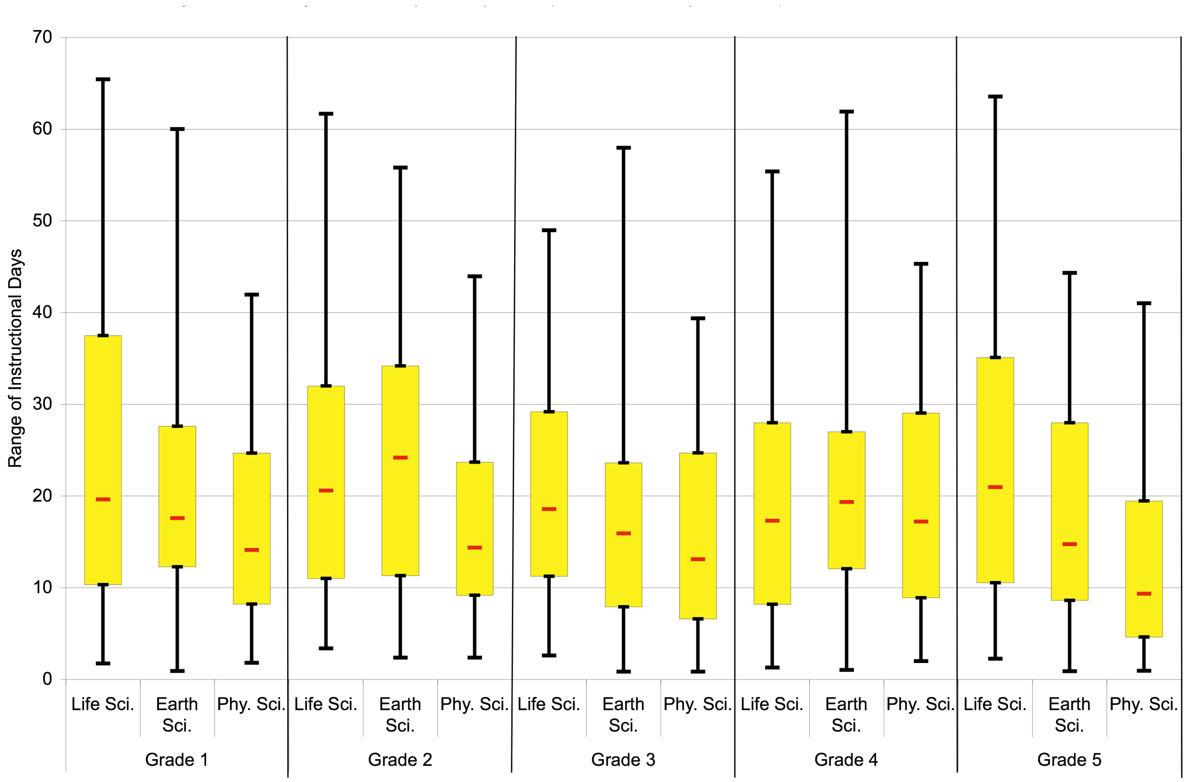
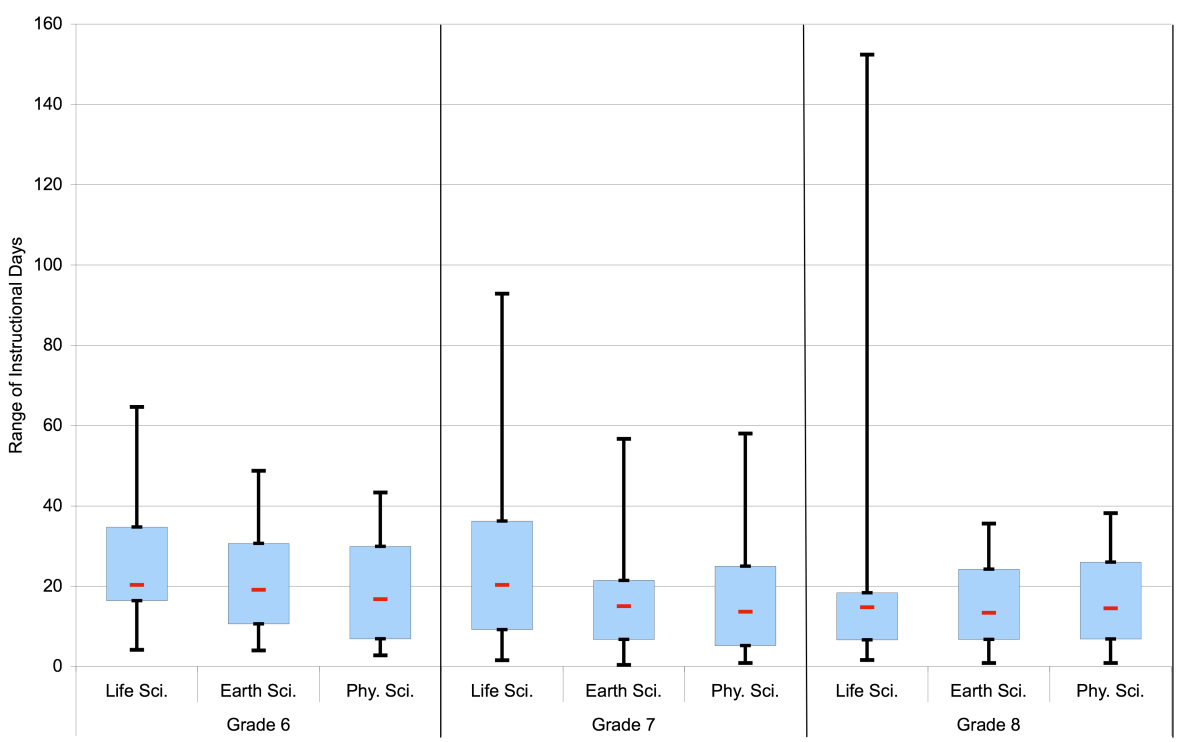


Figure 7. Box Plot of Range of Instructional Days Middle School Teachers Spent on Life, Earth and Physical Science Topics: Classrooms within Schools



DISCUSSION AND IMPLICATIONS

There is extensive variation in the amount of time allocated to science instruction at district, school and classroom levels across elementary and middle grades in the 53 districts studied. This is true whether the definition of topics is given by the model of coherence, empirically derived from the science curriculum of the TIMSS high achieving countries, or by the traditional categories of Life, Earth and Physical Science. This all suggests the enormous importance of instructional leadership from state superintendents, district superintendents and principals.

State standards for science do differ, leading to differences between the two states in the content covered in Life and Earth Science and the grade level at which it is intended. Schmidt et al. (1997), in their analysis of 50 state science standards, had reported a lack of uniformity in content and quality. However, when sharp differences between districts within the same state are observed (as evident in the data presented), it may be indicative of either differences in interpretation and implementation of state standards at the district level or a disconnect between state and district curricular intentions. This becomes a leadership issue both for state leaders who should be concerned about district level variability as well as district superintendents who have to provide instructional leadership for the schools in their jurisdiction.

Wide variation in reported Life, Earth and Physical Science content is also evident among schools within the same school district. Districts may influence curriculum implementation in a variety of ways – textbook selection, articulation of instructional objectives, and assessments aligned with these objectives (Floden et al., 1988). Meyer and Rowan (1977) found considerable variability in implementation of district policy at the classroom level. Our data corroborate these findings. The findings from our data reflect the view that schools are indeed "loosely coupled" organizations, so that district intentions and school-level implementation of the curriculum may reflect a wide variation. Instructional leadership of district superintendents and principals is particularly valuable in promoting coherent and consistent implementation of rigorous standards.

Loose-coupling is particularly challenging for students who are highly mobile and may be moving from one school to another during the course of an academic year. A recent report from the Wisconsin Center of Education Research (WCER, 2008) suggests that such mobility is seen disproportionately in low-income families.

Thus, curricular variability across schools in the same district may have the greatest adverse impact on a subgroup that districts may view as "hardest to reach".

When variation in reported topic coverage occurs at the classroom level, we have evidence that students within the same school at the same grade level may not be experiencing the same science curriculum. As Craig (2006) points out, teachers do not simply implement a prescribed curriculum but shape it. This study indicates the widely divergent choices made by individual teachers which shape the science curriculum for students within a classroom. Teachers may differ in their content coverage due to individual differences in their understanding of science content and district/state level expectations. However, school-level policies (or lack thereof) may also be a contributing factor. Instructional leadership provided by the principals, coupled with content related professional development and policies such as common planning periods for teachers at the same grade level of instruction, may shrink the variation in content coverage across classrooms and offer students in different classrooms within the same school similar opportunities to learn.

In our analysis of teachers' reported content coverage of science topics in the TIMSS high-achieving curriculum, it is clear that there is considerable variation at state, district and school levels. This variation seems to emerge in the early grades and persists (and widens) at the middle school level. The TIMSS high achieving curriculum may be considered <u>one</u> instantiation of a coherent curriculum. Research indicates that students' understanding of content is facilitated and enhanced when topics are presented in a logical sequence so there is opportunity for students to connect disparate scientific ideas into coherent conceptual frameworks.

International assessments such as TIMSS and PISA have highlighted a decline in U.S. students' performance as they progress from elementary to higher grades. The variability in the implemented curriculum both in terms of topics covered and the depth of topic coverage may not only have an impact on students' opportunity to learn science topics in a focused and coherent way but also place them at a comparative disadvantage in the global workplace.

Numerous studies have established the connection between teacher time spent on content and student achievement (Bloom, 1971; Carroll, 1989; Wiley & Harishfeger, 1974). These findings have also been substantiated in TIMSS studies (Schmidt et al., 2001) where more time spent on topics was related to higher achievement scores. The wide variability in instructional time devoted to science topics described in the present study creates inequality in opportunity to learn science. This variation and inequality has the consequence of reducing the mean performance of students as well as increasing the variation in performance. The role of instructional leaders is critical in keeping the institution's focus on the central mission of educational institutions – promoting practices and policies that support positive student learning outcomes. Research clearly indicates that we cannot improve our national performance without a coherent and rigorous set of standards that are consistently implemented at the district, school and classroom level. Variability in implementation results in huge inequality of opportunity to learn science.

To "create a normative climate in which the improvement of instruction and performance is the central task," instructional leaders at the school and district level need to provide "direct oversight of classroom practice" (Elmore, 2001, p.28). Oversight related to coverage of specific content is critical to the success and realization of the vision of NCLB. The consequences of unequal opportunities to learn are far too serious for student learning and attainment.

With the call for large-scale improvement in the content and quality of instruction, it is imperative that we focus on "the way public schools define and practice leadership" (p.2). What is needed is strong leadership at the state, district and, especially, school levels. This leadership, unlike the way it has been traditionally defined, needs to center around curricular content. The leadership needs to define their central mission in terms of educational outcomes for students and promote the policies and practices that support consistent, coherent, focused and rigorous implementation of curriculum in all classrooms so that all students have an opportunity to improve learning.

Appendix A: Elementary Science Areas Key

Class periods taught this year

(Check One Only)

EARTH SCIENCE	*0*	*1 or <1*	*2 - 5*	*6 - 10*	*11 - 15*	*>15*
Earth Features – Earth's crust, mantle, & core; mountains, valleys, continents; oceans, lakes, rivers; atmosphere; types of rocks & soils	☐	☐	☐	☐	☐	☐
Weather – Weather maps; cloud formation; seasons of the year; types of precipitation; hurricanes & tornadoes	☐	☐	☐	☐	☐	☐
Earth Processes – Volcanoes & earthquakes; water & rock cycles	☐	☐	☐	☐	☐	☐
Historic Earth Processes – Fossil formation; fossil fuels; geologic timetable	☐	☐	☐	☐	☐	☐
Earth & the Universe – Planets, sun, & their effects on the Earth; features of the solar system & universe; origin & history of the universe	☐	☐	☐	☐	☐	☐
LIFE SCIENCE						
Diversity of Living Things – Types & classification of plants, animals, & microorganisms	☐	☐	☐	☐	☐	☐
Human Health – Nutrition; types, causes, & prevention of disease	☐	☐	☐	☐	☐	☐
Human Biology – Structures & functions of organs & tissues; metabolism, respiration; reproduction & inheritance	☐	☐	☐	☐	☐	☐
Structure & Function of Living Things – Types & features of cells; functions of organs & tissues (e.g., bird's wings, plant leaves, earthworm's circulatory system)	☐	☐	☐	☐	☐	☐
Life Processes & Systems – Respiration; digestion; reactions of living things to stimuli; photosynthesis	☐	☐	☐	☐	☐	☐
Life Cycles & Genetics – Life cycles of plants & animals; plant & animal reproduction; inheritance & variation; evolution & diversity	☐	☐	☐	☐	☐	☐
Interactions of Living Things – Ecosystems; habitats, niches; food webs, food chains; oxygen, carbon dioxide cycle	☐	☐	☐	☐	☐	☐
Animal Behavior – Migration; hibernation; social organization (e.g., elephant herds, beehives); communication	☐	☐	☐	☐	☐	☐

PHYSICAL SCIENCES

Matter – Classification & structure of matter (e.g., elements, compounds, mixtures, atoms, molecules); physical & chemical properties (e.g., solids, liquids, gases; acids/bases)	☐	☐	☐	☐	☐	☐
Energy Types, Sources, & Conversions – Types of energy (e.g., mechanical, chemical); sources of energy (food, oil, wood); simple machines (e.g., levers, pulleys); work, efficiency	☐	☐	☐	☐	☐	☐
Energy Processes – Heat & temperature; sound, electricity, magnetism; light	☐	☐	☐	☐	☐	☐
Physical & Chemical Transformations – Changes in states (e.g., freezing, boiling, evaporation); chemical changes (e.g., burning, rusting, batteries, radioactivity)	☐	☐	☐	☐	☐	☐
Forces & Motion – Gravity & friction; speed; acceleration	☐	☐	☐	☐	☐	☐

ENVIRONMENTAL & RESOURCE ISSUES

Environmental & Resource Issues – Pollution; saving the rain forests; recycling garbage; effects of natural disasters; food supply & demand	☐	☐	☐	☐	☐	☐

NATURE of SCIENCE & SCIENTIFIC INQUIRY

Science, Technology, & Society – Designing or making things (e.g., tools, bridges); use of technology in science (e.g., computers, microscopes); interactions among science, technology, & society	☐	☐	☐	☐	☐	☐
History of Science & Technology – Famous scientists; classic experiments; development of scientific ideas; scientific discoveries	☐	☐	☐	☐	☐	☐
Nature of Science – Methods scientists use (e.g., problem identification, observation, creating & testing hypotheses); basis & ways of making decisions	☐	☐	☐	☐	☐	☐
Scientific Measurement – How to use measurement tools; measurement procedures; making measurements	☐	☐	☐	☐	☐	☐
Data Analysis – Classifying, organizing, & representing data; having students interpret provided data; having students interpret data they've gathered; drawing conclusions from data gathered	☐	☐	☐	☐	☐	☐

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