

# **What Elementary Teachers Need to Know: College Course Outlines for Teacher Preparation**

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## **I. Introduction**

Since 1991, the [Core Knowledge Foundation](#) has worked with hundreds of schools and thousands of elementary school teachers in virtually every state in the nation. In the process, we have heard a lot about the pressures and demands that our teachers face. The feedback that we hear most often is expressed reluctantly, sometimes even in an embarrassed whisper, but the consensus is loud and clear. A significant majority of teachers confess to feeling underprepared to teach the material before them. They discover that they lack basic knowledge and skills needed for effective teaching in even the earliest grades. Many wonder why their teacher training proved to be so inadequate.

Teachers report feeling underprepared not just when tackling the rigorous content of the Core Knowledge curriculum, but also when trying to teach new state standards. The national standards movement, which is increasingly specific about what children should know and do, has produced considerable disquiet among teachers. A recent survey conducted by the National Center for Educational Statistics (NCES) found that only 36%

of new teachers feel "very well prepared" to teach to the challenging new academic standards being introduced in American schools.<sup>1</sup>

These results confirm the conclusions of an earlier study by the Council for Basic Education, which surveyed 1650 teachers to learn how well their education prepared them for teaching. The researchers found that many teachers have serious reservations about the quality of their own education. One of the complaints heard most often was that not enough attention was paid to the subject areas. "One cannot teach what one does not know," remarked one teacher: "Teacher education programs spend too little time preparing in the content area." Another lamented, "Not one of my undergraduate methods courses helped me know the content of my subject area." This was a repeated theme in teacher's comments: "The weakest part was content. My classes touched very little on detailed content in the various subject areas I was certified to teach in."<sup>2</sup>

In recent years a number of states have developed tests to ensure that teachers possess basic skills and rudimentary knowledge of the subjects they are asked to teach. The results of these tests are not encouraging. Even though the material covered by the tests is rudimentary, and passing levels are often set very low, an alarming number of candidates fail. When Massachusetts gave its Educator Certification Tests for the first time in April, 1998, 59% of the candidates failed the exam. Performance has improved somewhat since then, but almost 40% of Massachusetts test-takers still fail on the first try.<sup>3</sup> In Illinois several of the tests used from 1988 to 2001 were widely criticized as too easy. And yet 5,243 candidates failed at least one of these tests. 414 teachers failed the same test at least three times, while 868 never passed the basic skills test.<sup>4</sup> Other states,

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<sup>1</sup> Laurie Lewis, Basmat Parsad, Nancy Carey, Nicole Bartfai, Elizabeth Farris, and Becky Smerdon, et al., Teacher Quality: A Report on the Preparation and Qualifications of Public School Teachers (National Center for Education Statistics, 1999). Available online at <http://nces.ed.gov/pubsearch/pubsinfo.asp?pubid=1999080>

<sup>2</sup> "What Teachers Have to Say About Teacher Education," by Diana Wyllie Rigden, *Perspective* (Fall, 1996), Vol. 8, #2. Also available online ([www.c-b-e.org/articles/drperspt.htm](http://www.c-b-e.org/articles/drperspt.htm)). See also Harriet Tyson, "Who Will Teach the Children?" Council for Basic Education, SF: Jossey Bass, 1994.

<sup>3</sup> For old and current results, see the Massachusetts Department of Education website: <http://www.doe.mass.edu/teachertest/>

<sup>4</sup> As reported in The Chicago Tribune in August and September of 2001. Findings summarized in Brown's What's What in Education, (Winter 2002), p. 8.

including New York, Oklahoma, and Pennsylvania have posted similarly alarming results.<sup>5</sup>

In recent years the U.S. Department of Education has recognized that content knowledge is an essential ingredient of good teaching -- and one that many American teachers currently lack. Richard W. Riley, Secretary of Education during the Clinton administration, concluded that college and university teacher education programs need to do a better job educating teachers in the content areas:

Our college and university teacher education systems have . . . frequently fallen short. Our colleges of education . . . must have the support of the entire university, and enjoy much stronger links with the colleges of arts and science. Education students must achieve competence in the subject matter they will teach.<sup>6</sup>

President Bush's Secretary of Education, Roderick R. Paige, has made the same point. In June of 2002 Paige announced the findings of a new federal report on teacher quality. The report found that many classroom teachers lack solid content knowledge of the courses they are expected to teach. Paige called on states to address this problem by requiring prospective teachers to pass rigorous exams in the subjects they plan to teach. He also urged colleges and universities to "radically transform" existing teacher education systems by placing more emphasis on academic subjects and less emphasis on pedagogy and methods. Paige explained that, "We now have concrete evidence that smart teachers with solid content knowledge have the greatest effect on student achievement."<sup>7</sup>

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<sup>5</sup> Carl Campamile, "Certifiably Stupid?" New York Post, 16 January 2001; Diane Plumberg, "30% of Teachers Failing Skills Test" Sunday Oklahoman 9 July 2000; Both cited in At the Core of the Problem-- Reforming Teacher Preparation in Oklahoma (2001), a report by the Oklahoma Association of Scholars. "Up to Half of Teacher Candidates Failing Tests," Pittsburgh Post-Gazette, January 17, 2002. Available online at <http://www.post-gazette.com/regionstate/20020117teachersreg4p4.asp>

<sup>6</sup> Richard W. Riley, "Remarks at President's Conference on Teacher Quality," September 15, 1999. Available online at <http://www.ed.gov/inits/teachers/conferences/rwraddress.html>

<sup>7</sup> The report, entitled Meeting the Highly Qualified Teachers Challenge, and various press releases relating to it may be found on the Department of Education's website. See especially the press release dated June 11, 2002, online at <http://www.ed.gov/PressReleases/06-2002/06112002.html>

The surveys, statistics, and governmental findings noted above all indicate that there is a need for a richer academic curriculum for aspiring teachers. The materials on this website outline precisely such a curriculum. The website contains detailed course outlines for eighteen college-level semester courses in the humanities, sciences, and social sciences. These course outlines, drawn up by some of the nation's foremost experts, introduce prospective teachers to a range of subjects and a body of information that will be invaluable to them during their careers in the classroom. This rich academic content will be enlightening and empowering, not only for teachers who aspire to teach in Core Knowledge schools, but for all teachers who will be called upon to meet demanding new state standards.

The eighteen courses cover the following subjects:

- Biology
- Earth Science
- Physics
- Chemistry
- Math I and II
- US History I and II
- World History I and II
- Geography
- Art History
- Music
- Composition and Grammar
- British and World Literature
- American Literature
- Children's Literature
- Teaching Reading

We believe that these courses, taken together, will give aspiring teachers a solid grounding in the subjects at the center of the elementary curriculum. Teacher-training programs will doubtless wish to supplement these courses with the practical experience of student teaching and select courses in pedagogy, class management, child development, and educational theory. Pedagogy courses should be grounded in principles derived from cognitive psychology and research, and neither these nor the managerial and theoretical courses should be allowed to multiply to the point where they crowd out classes in the subject areas. While no one denies that pedagogical skills and class management tactics are valuable, the most consistent data we have about the characteristics of effective teachers show a reliable correlation between higher student achievement and greater general knowledge by the teacher. And this objective data is consistent with the self-reports of teachers themselves, who with great unanimity consider the most important part of their training to be a “focus on content knowledge.”<sup>8</sup> Since this is so, *the primary emphasis in teacher training should fall squarely on mastery of the academic subjects commonly taught in elementary school.*

## **II. About the Syllabi**

At the outset of this project, we asked ourselves what set of college courses would represent an ideal preparation for aspiring teachers. We knew that elementary teachers are asked to teach reading, writing, literature, history, geography, math, and science, and at least cooperate in the teaching of art and music. As an elementary and middle-school curriculum provider, we also had a good idea of which specific topics within these fields of study are likely to be most relevant for elementary and middle school teachers. After considering this information and discussing the question with knowledgeable people, we decided on a Core program consisting of the eighteen courses listed above.<sup>9</sup>

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<sup>8</sup> Michael Garet, Andrew Porter, Laura Desimone, Beatrice F. Birman, Kwang Suk Yoon, “What Makes Professional Development Effective? Results from a National Sample of Teachers,” American Educational Research Journal (Winter 2001) V. 38, pp. 915-45. The correlation between student outcomes and teachers’ vocabularies and hence their knowledge has been a consistent finding since the Coleman Report.

<sup>9</sup> This list is not meant to represent an exclusive list of all courses that will be useful to aspiring teachers. Implementing institutions may wish to supplement the list of required courses with a collection of

For each of these courses we asked a distinguished professor to draw up a detailed course outline, or syllabus. All of the professors chosen were experts in their fields, with demonstrated interest and experience in K-8 education. Each professor was given a copy of the Core Knowledge Sequence to use as a guide to help him or her choose topics of maximal relevance for aspiring elementary teachers. Each was charged with creating a course that would convey enough knowledge of the subject area to enable the teacher to teach the Core Knowledge topics for that area as well as any set of state standards for the area.

Each syllabus outlines a three-credit, thirteen-week course, tailored to the needs of pre-service teachers. Each contains detailed notes on topics to be covered during class sessions, as well as textbook recommendations, suggested reading assignments, and suggestions for papers and/or exams. In some cases the syllabi also contain additional supporting materials, such as exam questions, worksheets, transparencies for classroom use, and other appendices that will be useful to instructors.

Because we are committed to our status as a nonprofit, and because this project has been underwritten by the generous support of the Olin Foundation, we offer these syllabi free of charge to interested colleges and universities. We have chosen to make them available in digital form so they can be easily distributed by administrators and customized by professors at interested institutions. Although the syllabi are copyrighted by the Core Knowledge Foundation, and may not be marketed by third parties, anyone who wishes to use, reproduce, or adapt them for educational purposes is welcome to do so. However, we do ask individuals and institutions using or considering using the syllabi to notify us so we can assess the distribution and spread of the syllabi and serve as a repository of information about how they may be improved and more effectively used.

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recommended electives. Such a list might include courses on world religions, American government, mythology, Shakespeare, great books, etc.

### **III. Benefits of Implementation**

We believe that there will be numerous advantages to implementing such a carefully tailored and academically rich program.

**1. Better Prepared to Teach State Standards.** Graduates of this program design will be better prepared to meet the most demanding state standards across all subject areas, no matter what state they teach in. The Core Knowledge standards (on which these syllabi are partly based) overlap with most state standards, but tend to be more detailed, specific, and comprehensive. This means that a teacher who is prepared to teach the Core Knowledge curriculum will also be well prepared to teach the state standards in Virginia, Massachusetts, California, or any other state in the nation.

**2. Improved Passing Rates on State Teacher Tests.** This program design should help prospective teachers pass the new or upgraded teacher tests now required in most states. As part of Title II, the federal government is requiring teacher education programs to document how their graduates are faring on their state's teacher tests, and institutions are being ranked according to passing percentages. Better training in the subject areas should lead to higher pass rates, which would boost an institution's reputation, prestige, and drawing power.

**3. National demand for Core Knowledge-trained teachers.** Graduates of this program design will be in demand at Core Knowledge schools around the country. In the early 1990s there were only a handful of schools implementing Core Knowledge, but there are now more than 700 schools implementing, in 47 states and the District of Columbia. The Core Knowledge Foundation is currently developing a placement mechanism that will help graduates from implementing colleges and universities locate jobs at Core Knowledge schools.

**4. Greater readiness for NCATE standards and ABCTE certification.** This course design will prepare prospective teachers to meet the elementary standards for beginning

teachers now required by NCATE and/or take the new teacher tests developed by the American Board for Certification of Teacher Excellence ([www.abcte.org](http://www.abcte.org)). The ABCTE tests for the elementary grades were created with federal grant money and will be offered for the first time in the summer of 2003. The ABCTE exams for elementary education test both pedagogy and subject knowledge -- in math, science, history and geography, and language arts -- but with the primary emphasis on the subject areas.<sup>10</sup>

**5. Improved collaborative spirit within university.** Implementation will facilitate cooperation, dialogue, and mutual understanding between education faculty and arts and science faculty and help to reduce the isolation that prevails in many American schools of education.

**6. Supports Federal initiatives.** Finally, we believe that this project is in line with and will advance the goals articulated in the “No Child Left Behind” education bill, recently passed, and the Department of Education’s report “Meeting the Highly Qualified Teachers Challenge” (2002), both of which place great emphasis on the improvement of teacher training, particularly with regard to knowledge of subject matter. Because teacher education in the content areas is a top Department of Education priority, there may be some opportunities to secure funding for this initiative.

If your institution would like to discuss a possible implementation, please contact us at <http://coreknowledge.org/CK/contact.htm>. If you know of another individual or institution that might be interested, please feel free to pass this document to the interested parties.

#### **IV. Some Strategies for Implementation**

The guidelines that follow offer some suggestions as to how a content-rich strand of teacher education based wholly or partly on the courses outlined on this website might

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<sup>10</sup> For details, visit the website ([www.abcte.org](http://www.abcte.org)).

be implemented. The Core Knowledge Foundation understands that the exact details of implementation will depend on the circumstances and requirements of the individual institution, as well as on the nature of state certification requirements. We therefore offer only general guidelines and suggestions.

The courses outlined here cover material taught in Core Knowledge schools in grades K through 8. However, we recommend this academic program as optimal preparation for undergraduate students preparing to teach in the elementary grades (K-5 or K-6, depending on the school system). Teachers in these grades are called upon to teach history, geography, and English, as well as math and science. Sometimes they also teach or assist in the teaching of art and music. A broad liberal arts education such as the one outlined here will provide optimal preparation for such teachers.

The courses outlined on this website will also be useful for middle school teachers. However, middle school teachers and high school teachers tend to be specialists (or, perhaps, *should* be specialists) and would probably be better served by a broad general education plus a traditional major in the field they expect to teach. For example, an implementing institution might ask prospective middle school science teachers to take the Core science courses outlined here but also supplement these with more advanced coursework in the sciences. A history major might be asked to take the geography and history courses outlined here but also pursue a history major.<sup>11</sup>

Some institutions may wish to offer all eighteen of the courses outlined here. Others may wish to offer only some of the courses outlined here, supplementing these with existing courses that cover substantially the same material as the courses on this website. In the section labeled “Substitutions,” below, we offer some advice on how institutions might determine which courses would be appropriate substitutions.

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<sup>11</sup> The National Center for Education Statistics Science Report Card for 2000 seems to support the reasonableness of a broad education for teachers in the early grades and a more specialized education for middle school teachers. NCES found that “Eighth-graders whose teachers majored in science education had

The eighteen courses represent 56 credit hours, a fairly sizable portion of a typical college degree. However, since the courses are drawn from the sciences, social sciences, and humanities, students may be able to use some of the Core courses to satisfy distributive requirements, thus “killing two birds with one stone.” Some courses might serve as pre-requisites for a major or minor that builds on one of the Core subjects; or they might take their places alongside select pedagogy courses as part of a revamped education major.

Successful implementation of a program of this sort will almost certainly require cooperation between faculty in the arts and sciences and faculty in the education school. Children's Literature and Teaching Reading are perhaps the only two courses on this website that would typically be taught in a school of education. The other sixteen courses would typically be taught in a college of arts and sciences, though they might be co-sponsored by schools or departments of education.

While pedagogy courses can certainly be valuable, this program is premised on the belief that what teachers need, first and foremost, is a detailed knowledge of the subjects they intend to teach. As mentioned above, research suggests that competency in teaching depends primarily on knowledge of the material to be taught and only secondarily on knowing the best methods for teaching it.<sup>12</sup> Pedagogy may still be taught within this design, but pedagogy courses should not be allowed to overwhelm or push out content courses.

Pedagogy might be addressed by requiring a few separate pedagogy courses in addition to the subject area courses, or by incorporating a pedagogical element into the subject-area courses. If the pedagogy courses are added on, there will probably not be room for too of many of them, since so many hours will need to be spent on the subject areas. Colleges and universities may therefore wish to consider ways of incorporating a pedagogy element into some or all of the subject-area courses. For example, an aspiring

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higher scores than students whose teachers did not. At fourth grade there was not a relationship.” Available online at [http://nces.ed.gov/Pressrelease/rel2001/11\\_20\\_01.asp](http://nces.ed.gov/Pressrelease/rel2001/11_20_01.asp)

student studying American history might be asked to prepare a lesson plan for an American history unit for third graders, or might be asked to visit a classroom and teach a one-day unit on an American History topic; a student studying science might develop and present an experiment for young children; a student studying art might serve as a docent for a school field trip to a museum, explaining a work of art to visiting elementary school children; a student learning how to teach reading might work individually with a student having reading problems.

Each of these experiences could function as a sort of mini-practicum. Such mini-practicums would give students early exposure to the classroom environment: students would have a chance to “test the waters” and ascertain if they really like teaching young children. The mini-practicums would also introduce future teachers to one of the great challenges of teaching: translating an adult’s knowledge of a subject into an effective, teachable unit for young children.

Of course, the combination of subject matter instruction and practicums could pose a challenge from an institutional point of view, as arts and sciences professors may not feel that they have the skills or the time needed to set up, supervise, and evaluate such practicums. Here is where a cooperative endeavor between education faculty and arts and sciences faculty might be useful, with arts and sciences faculty teaching the arts and sciences content and education faculty supervising the practicum. Students might be awarded credits for the academic class and an additional credit or two for the practicum, as students are sometimes awarded 3 credits for the lecture part of a science course and an additional credit for the lab period. A 2 + 1 or 2 + 2 structure would ensure that both arts and sciences and education faculty members are given institutional and financial credit for their work preparing teachers.

The Core Knowledge Foundation would be pleased if any theory of education courses required as part of the program included consideration of some of the writings of E. D. Hirsch, Jr. -- perhaps Cultural Literacy, or The Schools We Need, or some articles.

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<sup>12</sup> E.D. Hirsch, Jr. The Schools We Need and Why We Don't Have Them (Doubleday, 1996), p. 116ff.

These might be taught in tandem with other, possibly dissenting voices on education. Teaching Hirsch's work would have real advantages: students would learn why education in the subject areas is so important and would also be prepared to question some of the currently fashionable ideas in education. However, the primary goal of this program is to train teachers in the subject areas, and the foundation would support a teacher-education initiative that emphasized the subject areas but did not require study of Hirsch's works.

Colleges and universities might wish to offer these courses as part of a 4-year B.A. program or as part of a 5-year program that would grant both a B.A. and an M.A. Five years would almost certainly be necessary to complete the Core courses, a full arts and sciences major, pedagogy courses, and student teaching. However, if the Core courses were allowed to constitute a separate major for prospective elementary teachers, like the humanities or liberal studies majors offered at many institutions, it might be possible to complete the Core courses, some pedagogy courses, and student teaching in four years.

In the past some educators have argued against offering a humanities or liberal studies major, feeling that such majors encourage superficiality and prevent in-depth study of any one subject. Whatever the general merits of this argument may be, in the specific case of elementary education there would seem to be compelling reasons for choosing to emphasize breadth rather than depth. Teachers in the early grades need knowledge in a wide range of fields more than they need expertise in any one field.

A content-rich program like the one sketched here might be implemented in various ways. On the most ambitious level a college or university might wish to revamp its entire teacher education program according to this model. Or, an institution might wish to develop an alternative strand of teacher development that could operate in parallel with a more conventional teacher education curriculum.

The program might be implemented at a large university or at a small college that does not have an education department or ed school. Indeed, because the program

emphasizes the subject areas, it might enable a small college to add a teacher education major relatively painlessly, by drawing on the expertise of arts and science faculty members already on site. The resulting program might be structured as a department or as a “studies” program, on the model of American Studies, or African-American Studies. Such programs typically draw on faculty members from various departments, as this program would doubtless do.

Although it would require some determination, it might even be possible for an individual student, or small group of students, to use the philosophy outlined here as a blueprint for a self-designed major, something most institutions allow.

If institutions wish to decrease the number of required courses, they might consider *recommending* rather than *requiring* the art and music courses, or asking students to choose one of these two courses. These two classes are probably less essential for aspiring elementary teachers, since many schools have art and music teachers who handle these subjects. On the other hand, these subjects are integral parts of a liberal arts education, and knowledge of art and music will enable teachers to make useful interdisciplinary connections and participate more fully in the educational experiences of their students.

Although the Foundation believes that all of the courses listed here are important, an institution might also design a very strong program that required students to take ten or twelve of the courses listed but allowed some freedom of selection as to which are chosen.

Another tactic that could ease the load would be to allow students to use well-validated standardized tests to satisfy a certain number of the requirements. For instance a score of 4 or 5 on an American History AP test might be deemed an adequate substitute for taking an American History survey. It is possible that GRE subject tests, SAT II Achievement tests, and other standardized tests could be used in the same way. However, implementing institutions will want to think carefully about which subjects are

most appropriate for this kind of substitution and how many such substitutions should be allowed.<sup>13</sup>

Institutions will probably also want to address other questions. For instance, how can the intellectual content in the program be most effectively combined with the student teaching experience? Are there Core Knowledge schools or other schools in the area that might be willing to partner with the college or university and provide sites for student teaching and possibly also for other kinds of cooperation? Would it be worthwhile for students in the program to have, as a culminating experience, some training provided by the Core Knowledge Foundation? Also, how can the institution measure the successes and/or shortcomings of its graduates and of the program as a whole? Would it make sense to require students pass an exit exam or perhaps the ABCE tests as a graduation requirement? Will the institution track graduates and evaluate their success in locating jobs and increasing student achievement? If so, how will success be measured and evaluated? Will the institution survey teachers to determine how well the program prepared them for teaching? Will it use the “value-added” methods pioneered by William Sanders in Tennessee to see if teachers are boosting student achievement?

## V. Substitutions

Institutions may wish to substitute already existing courses for the ones outlined here. In that case, these detailed syllabi could be the bases for evaluating current offerings. If an institution decides to use an existing course or develop a new one, we suggest that the Core Knowledge syllabus and a copy of Core Knowledge Sequence be sent to the course instructor, so that he or she can make use of the valuable guidelines these documents contain.

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<sup>13</sup> AP exams (<http://apcentral.collegeboard.com/>) are offered in many relevant subjects, including Art History, Biology, Chemistry, Physics, Human Geography, World History, and American History. GRE subject tests ([www.gre.org](http://www.gre.org)) include Biology, Physics, Chemistry, Math, and Literature in English. SAT II Subject Tests ([www.collegeboard.com](http://www.collegeboard.com)) include Literature, U.S. History, World History, Biology E/M, Chemistry, Physics, Math Level IC, and Math Level IIC. Implementing institutions should ask members of

**Art History** -- an existing art history survey course might be substituted, but not a period or single-artist course.

**Music** -- A music appreciation course in which the primary emphasis falls on classical music would be an acceptable substitute. Survey courses on jazz or world music would cover only a sliver of what is taught in the elementary curriculum and would therefore not be good substitutions.

**U.S. History I and II** -- an existing two-semester survey course might be an adequate substitute, but courses on specific periods or subjects should not be substituted.

**World History I and II** -- Again, an existing two-semester survey course might be an adequate substitute.

**Geography** -- The geography course covers physical, human, and regional geography, subjects that are often treated in separate courses. A class that combines these three sub-fields, with a primary emphasis on the fundamental concepts of physical and human geography, would be the best substitute. A world regional geography course, or “geography for teachers” course, might also be an adequate substitute. Neither a regional course (focusing on one continent or culture region), nor a topical physical or human/cultural geography courses would be an appropriate substitute.

**British and World Literature** -- Few university courses combine world and British literature, as this one does. A survey of World Literature (one or two semesters) or a survey of British Literature (one or two semesters) would be imperfect but acceptable substitutions.

**Composition and Grammar** -- this course presents a distinctive approach to grammar that may be useful to aspiring teachers; however, if an existing composition

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the relevant department to assess whether the AP exam in a particular subject would be an appropriate substitution for the proposed course, and what the minimum score should be.

course includes a solid grammar component and extensive writing, it might be substituted.

**Children's literature** -- This course covers many children's classics that figure largely in the Core Knowledge curriculum and other curricula for grades K-6. An existing survey course on children's literature might be substituted, provided it includes some examination of children's literature as a historical phenomenon and touches on a wide range of children's literature, including not only contemporary works but also some children's classics, works of poetry as well as prose, fantastic and realistic literature, as well as fables, folk tales, fairy tales, and mythology. Courses that focus exclusively on contemporary children's literature are not appropriate substitutes.

**Teaching Reading** -- A similar course might be substituted, provided it is based on current research, which points to the advantages of a balanced approach to teaching reading -- one that includes not only exposure to children's literature but also systematic instruction in decoding and phonics.

**American literature** -- an existing survey of American literature might be substituted, provided it includes works by several major authors who figure largely in children's literature and/or American history (e.g., Franklin, Jefferson, Irving, Emerson, Thoreau, Hawthorne, Melville, Poe, Stowe, Douglass, Lincoln, Twain, Whitman, Dickinson, Booker T. Washington, W.E.B. DuBois, Fitzgerald, Frost, Langston Hughes, Martin Luther King, Jr.).

**Math I and II** -- Math I covers properties of sets, Roman numerals, integers, rational and real number systems, concepts behind arithmetic algorithms, fundamentals of number theory, and probability. Math II covers basic geometric concepts, development of middle school algebra through the quadratic formula, and fundamentals of statistics. Math courses designed for prospective elementary and middle-school teachers and covering these topics might be substituted. Higher-level math courses, like calculus,

although desirable for increasing one's overall knowledge of mathematics, are not appropriate substitutes for these courses.

**Chemistry** -- A comprehensive chemistry class with a lab might be substituted, but non-lab classes and completely non-quantitative courses (e.g. "Chemistry for the Citizen") should not.

**Biology** -- A comprehensive college biology course could be substituted, provided it includes a lab.

**Physics** -- The two main distinguishing features of this syllabus are: 1. the selection of topics chosen to specifically correspond to the Core Knowledge curriculum, and 2. the set of accompanying experiments that demonstrate these topics, using simple materials that should be available to elementary teachers. These two factors should guide substitution choices. On point 1: the Core Knowledge curriculum emphasizes classical physics, and includes only a limited amount of what is generally described as Modern Physics. Many common one-semester general education courses take a selected topics approach, often emphasizing more modern topics. Courses of this type would not provide teachers with the range of knowledge needed to teach the Core Knowledge curriculum, or other, similar elementary physics standards. On point 2: it is important that teachers be capable of providing basic demonstrations of physics concepts. Therefore, no course that lacks an accompanying lab should be considered as a substitute.

**Earth science** -- This course contains sections on geology, astronomy, meteorology, and oceanography. Because it combines several topics that are usually taught separately, it might be difficult to find an appropriate substitute for this course. Substitutions are therefore discouraged.

**A note on science sequencing:** The science courses would be most effective if taken in the following order: chemistry first, then either biology or physics, and earth science last.

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