

Curriculum Development for Gifted Learners in Science at the Primary Level

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1. Introduction

Curriculum designed for gifted learners specifically is a rare commodity in schools. In the United States, we have been most fortunate to have the Jacob Javits Program provide funding for curriculum development and pilot and field testing of that curriculum in schools to show its efficacy over the past decade. The curriculum designed and implemented has been based on the Integrated Curriculum Model (ICM) (see table 1), initially developed to provide a

theoretical framework for new curriculum work in the field (VanTassel-Baska, 1986) that provided an equal emphasis on the need for advanced content, higher level process skill development and product generation, and developing concept-based learning. Each unit of study developed using the model has been in the core areas of learning—language arts, science, social studies, and mathematics. Our most recent work also uses this framework to develop curriculum for young K-3 learners in the area of science.

TABLE 1: ICM Features

Overarching Concepts	Advanced Content	Process-Product
Change	In-depth	Elements of Reasoning
Systems	Advanced reading	Research
Patterns	Primary Sources	Problem-based Learning
Cause & effect	Advanced skills	Inquiry skills

VanTassel-Baska, J. (2003). Content-based curriculum for high-ability learners: An introduction. In J. VanTassel-Baska & C. A. Little (Eds.), *Content-based curriculum for high-ability learners* (pp. 1-23). Waco, TX: Prufrock Press.

For purposes of brevity, I shall only review the specific studies related to the use of ICM curriculum, developed from the theoretical model just described. While both Stanley and Renzulli have models for curriculum, they are best known for the megamodels of program development used for over 30 years in schools and universities to promote talent development. A large body of research exists to support the use of acceleration as an approach with gifted learners, for example, with a smaller group of studies supporting the use of fast-paced classes using compressed curriculum (see Lubinski & Benbow, 1994 for example). In the Renzulli case, the research is more diverse, with studies supporting the use of the Enrichment Triad with different populations (see Baum, 1996), the School-wide Enrichment Model as a programmatic thrust for all learners (see Renzulli & Reis, 1985), and compacting as a curriculum approach that brings no harm (see Reis et al., 1998). In addition, Sternberg, Torff & Grigorenko (1998) have conducted studies showing that the use of units crafted for analytical, creative, and practical task demands in each content area have suggested that students respond better to the units that use their tested ability strength in a relevant area. Older models suggests that teaching higher level thinking and problem solving, without strong content emphases, can also positively impact the learning of all students (Schlicter, 1986) and of gifted learners (Moon & Feldhusen, 1994).

Research, however, has been conducted on using both accelerative and

enriched curriculum to support the effectiveness of specific intervention with gifted populations within a variety of educational settings. Specifically, in the case of the Integrated Curriculum Model (ICM), significant growth gains in literary analysis and interpretation, persuasive writing, and linguistic competency in language arts have been demonstrated for experimental gifted classes using developed curriculum units in comparison to gifted groups not using them (VanTassel-Baska, Johnson, Hughes, & Boyce, 1996; VanTassel-Baska, Zuo, Avery, & Little, 2002). Other studies have shown that using the problem-based science units embedded in an exemplary science curriculum significantly enhances the capacity for integrating higher-order process skills in science (VanTassel-Baska, Bass, Reis, Poland, & Avery, 1998) regardless of the grouping approach employed.

Findings from a six-year longitudinal study which examined the effects over time of using the William and Mary language arts for gifted learners in a suburban school district suggest that gifted student learning at grades 3 to 5 was enhanced at significant and educationally important levels in critical reading and persuasive writing. Repeated exposure over a 2 to 3 year period demonstrated increasing achievement patterns and the majority of stakeholder reporting the curriculum to be beneficial and effective (Feng, VanTassel-Baska, Queck, Bai & O'Neill, 2005). An earlier study had documented positive change in teacher attitude, student motivational response, and school and district change

(VanTassel-Baska, Avery, Little & Hughes, 2000) as a result of using the ICM science and language arts curriculum over three years.

A subanalysis of the language arts data across settings suggested that it is successful with low income students, can be used in all grouping paradigms, and that learning increases with multiple units employed (VanTassel-Baska, Zuo, Avery, & Little, 2002).

Research on the use of comparably developed social studies units suggests that unit use significantly impacts critical thinking and content mastery, using comparison groups (Little, Feng, VanTassel-Baska, Rogers, & Avery, 2007). Moreover, positive changes in teacher behaviors for using differentiated strategies were noted in this study as well.

Newer studies have been conducted that show the curriculum to be effective with a full range of learners, especially in language arts and science although most effective with gifted and promising learners (Van Tassel-Baska & Brown, 2007).

Teacher training and development in the use of specific teaching models is an integral component of the ICM model. Training workshops have been conducted in 30 states, and the College of William and Mary offers training annually. There is a strong relationship to core subject domains, as well as national standards alignment. The curriculum, based on the model, was developed using the national

standards work as a template. Alignment charts have been completed for national and state standards work in both language arts and science. The ICM model has been used for specific school and district curriculum development and planning in Australia, Canada, New Zealand, Japan, Korea, and Taiwan as well as selected districts in the United States and international schools abroad.

There is evidence of broad-based application, but some questions remain regarding the ease of implementation of the teaching units and the fidelity of implementation by teachers. Some districts use the units as models for developing their own curricula. The developer reported that 100 school districts are part of a National Curriculum Network using multiple content area units. Data on student impact have been collected from over 150 classrooms nationally.

2. Project Clarion

Project Clarion is a five-year scale-up Javits project that is in its fourth year of implementation. The purpose of this grant is to target low income, high ability learners and measure the effects of higher level, inquiry based science curricula. Specific project objectives include: 1) implement instrumentation sensitive to low socio-economic learners for purposes of enhanced identification and assessment of learning, 2) write, implement, refine, and extend research-based concept curriculum units of study in grades Pre-Kindergarten, one, two, and three, 3) to develop and implement professional training models for teachers,

administrators, and broader school communities, and 4) to conduct research on short term and longitudinal student learning gains, as well as investigate the mechanisms that promote institutionalization of innovation through curriculum scaling up.

Year One of the project consisted of curriculum writing and securing school district participation. During Years Two and Three the intervention curriculum was piloted in classrooms. Feedback on unit implementation was solicited and revisions to the curriculum were made based on data from reviewers and teachers. Pre/post and baseline assessments were administered in comparison and experimental classrooms and data were analyzed. Ongoing professional development also occurred formally for experimental teachers at least two times per year as well as informally through visitations to schools and job-embedded training based on teacher needs. Observations in classrooms were conducted for treatment fidelity and to guide professional development. Year Four will continue the implementation of the curriculum intervention, ongoing professional development, and pre/post assessment data collection and analysis.

2.1. Curriculum unit development

This project incorporates a quasi-experimental research design to measure the effects of inquiry-based science curriculum units on student achievement and critical thinking with a focus on developing the science talents of economically disadvantaged students in

Title I schools. Inquiry-based science curriculum have been written and piloted in at least two different school districts throughout the course of the grant. The curriculum units have been designed based on a research-based curriculum framework, the Integrated Curriculum Model (VanTassel-Baska, 1986), and empirical evidence regarding how students learn science from the National Research Council (2000). The Integrated Curriculum Model (ICM) has been researched since inception and used as a template for writing curriculum for advanced learners in multiple content areas with notable success in student achievement and teacher change. The model includes a linkage of an overarching concept to frame the outside world, advanced processes inherent to the discipline, and advanced content within that discipline. By interweaving these components into a curriculum, student growth is more likely to occur. In addition, the National Research Council (2005) has outlined three key practices for teaching science: 1) address preconceptions and concepts by connecting the content to the outside world and outline appropriate content and understanding, 2) engage students in practice as to what it means to “do” science through inquiry and investigation, and 3) encourage metacognition and reflection through guided teacher feedback, student discussion, and personal reflection.

All units designed for this intervention incorporate the ICM as the curriculum framework and empirical findings from

the NRC. Each unit includes an inquiry-based approach to learning science that focuses on an overarching concept of either change or systems and an emphasis on advanced processes that help students “do” science. In each of the units, students take on the role of a scientist by learning the scientific process in order to answer a question or solve a real-world problem. All units also integrate critical thinking and metacognition by emphasizing higher level questions, science reflection journals and prompts, and teacher-student discussion.

The units have undergone multiple revisions. In Years One and Two eleven units were written and piloted in a variety of PreK, first, second, and third grade classrooms. Teacher feedback was solicited and major revisions were made that resulted in combining or omitting different units. In Year Three eight units were significantly revised and underwent external reviews by content experts as well as solicitation of feedback from experimental teachers through focus groups and teacher journals. Minor changes to each unit were made based on reviews from content experts. A description of each revised and reviewed unit is included below.

During the inception of the units each was aligned to national and state standards. Recently, units were also aligned to the state science assessment (3rd grade Standards of Learning) as well as one of the standardized assessments administered: the Metropolitan Achievement Test 8, science subtest.

The Clarion Science Units for Primary Grades have been designed to introduce young students to science concepts, science processes, and overarching concepts. A hands-on, constructivist approach is used to allow children to build their knowledge base and their skills as they explore science topics through play and planned investigations. Students are engaged in creative and critical thinking, problem finding and solving, process skill development, and communication opportunities. Each unit is designed to strengthen essential concepts including quantity, direction/position, comparison, colors, letter identification, numbers/counting, size, self-/social awareness, texture/material, shape, and time/sequence. The units also focus on overarching concepts of systems, patterns, change, and cause and effect.

2.1.1. Budding Botanists at Work

Budding Botanists at Work, a second grade life science unit, engages students in a scenario-based approach to investigating plant life. Students assume the role of botanists working as a team to investigate plant life. While working to understand the structure, nature, and life cycle of plants, the team members seek to answer questions such as “How can plants be used to fuel cars?” The Budding Botanists at Work unit builds upon students’ prior knowledge of plant life and encourages them to use inquiry skills to observe, gather evidence, analyze data, and make inferences.

Essential Understandings

1. Understand that plants have basic needs including air, water, nutrients, and light.
2. Understand that different parts that serve different functions in growth, survival, and reproduction.
3. Understand that plants are dependent on other living things and their surroundings for survival.
4. Understand that plants undergo many changes during their life cycles.
5. Understand that plants have different characteristics.
6. Understand that plants inherit many characteristics but some come from their interaction with the environment.
7. Understand that plants cause changes in the environment where they live.
8. Understand that plants produce their own food.

2.1.2. *Dig it!*

Dig It! is a third grade Earth & Space science unit. Students are encouraged to investigate man's effects on the environment, the importance of Earth's natural resources, and sound conservation practices. Using a scenario-based approach, the unit builds upon students' prior knowledge by providing opportunities to relate local examples of environmental pollution and conservation with hands-on scientific experiments and demonstrations. *Dig It!* also includes literary and math components to engage students in discussions and to reinforce the concepts addressed in the unit.

Essential Understandings

1. Sources of energy on Earth include sunlight, water, and wind.
2. Fossil fuels are formed from decayed plants and animals.
3. Human activity affects the quality of air, water, and habitat.
4. Conservation and resource renewal protect the quality and quantity of natural resources.
5. Humans depend on several major sources of energy found on Earth.
6. Some natural energy resources are renewable and some are not.
7. Soil provides support and nutrients for plants.
8. Over time, weather, water, and living things help break down rocks and create soil.
9. Rock, clay, silt, sand, and humus are components of soil.
10. Topsoil is the upper soil surface and a natural product of the subsoil and bedrock.
11. Subsoil and bedrock are layers of soil under the topsoil from which topsoil is formed over a long period of time by the action of water.

2.1.3. *How the Sun Makes Our Day*

How the Sun Makes Our Day, a kindergarten and first grade unit, engages students in investigations and observations that support their learning about the Sun as a source of light and energy, the nature of shadows, and the need for humans to conserve natural resources. Students explore natural and man-made sources and develop a conservation plan for their home, school,

or community. The overarching concept of *Change* is used to deepen understanding of the scientific concepts in the unit.

Essential Understandings

1. Shadows occur in nature when light is blocked by an object.
2. Shadows can be produced by blocking artificial light.
3. Shadows can occur whenever light is present.
4. Natural and human-made things may change over time.
5. Changes can be noted and many changes can be measured.
6. Recycling, reusing, and reducing consumption help to save our natural resources.
7. The sun is a natural source of heat and light.
8. Natural resources help humans.
9. Night and day are caused by the rotation of the Earth.
10. Natural resources are limited and many cannot be renewed.

2.1.4. *Invitation to Invent*

Invitation to Invent, a third grade unit, engages students in investigations and observations that support their learning about simple machines and their uses. Students explore force, motion, and friction as they learn about the six simple machines and how they are put together to form compound machines. The overarching concept of *Systems* is used to deepen their understanding of the scientific concepts in the unit.

Essential Understandings

1. Simple machines are tools that make work easier.
2. There are six different simple machines.
3. Compound machines combine two or more simple machines.
4. Motion is an object's direction and speed.
5. Changes in speed or direction of motion are caused by forces.
6. Friction is a force that opposes motion.

2.1.5. *Survive and Thrive*

Survive and Thrive, a kindergarten and first grade unit, engages students in a study of animals, their characteristics, and their natural environments. Students learn how to distinguish features and life needs of animals. Students observe animals in their habitats via webcams. Students learn to classify animals according to whether they are tame or wild and live on land or in water. Students raise mealworms in the classroom and observe their life cycle. The concept of *Change* is used to deepen understanding of the scientific concepts in the unit.

Essential Understandings

1. Plants and animals have basic needs for air, food, and water.
2. Animals need a suitable place to live.
3. Animals are similar to their parents.
4. Animals have different body coverings such as hair, fur, feathers, scales, and shells.

5. Animals have different appendages such as arms, legs, wings, fins, and tails.
6. All plants and animals undergo changes in their life cycle.
7. As animals and plants grow, they get larger according to a pattern.
8. Animals move in different ways such as walking, crawling, flying, climbing, or swimming.
9. Animals can be classified in different ways.
5. Water evaporates into the air.
6. Water condenses on cold surfaces.
7. Some liquids will separate when mixed with water. Others will not.
8. Some substances will dissolve in water. Others will not.
9. Certain objects float in water while others do not float.
10. Density is the relationship between the volume of an object and its weight.

2.1.6. Water Works

The unit *Water Works* engages kindergarten and first grade students in close observations and experimentation about water. The overarching concept of K is reinforced as students notice, react to, reflect on, and discover more about force and change. Students ask questions and design experiments to reinforce their learning. Generalizations about how things change are developed through students' analysis of their findings. Students explore the characteristics, discover which objects sink and which objects float, experiment to make things float, and examine materials and their interactions with water.

Essential Understandings

1. Our senses help us to seek, find, and react to information.
2. Water can take different forms (solid, liquid, gas) but it is still water.
3. The state of water can change by heating or cooling.
4. The natural flow of water is downhill.

2.1.7. The Weather Reporter

Scientific Investigators, Inc.: The Weather Reporter, a Second Grade Earth/Space Science unit, provides students with opportunities to observe, measure, and analyze weather phenomena. *The Weather Reporter* includes a scenario-based approach to allow students to make decisions about observing, predicting, and forecasting the weather. Building upon students' prior knowledge of weather and their newly acquired understanding of meteorology, *The Weather Reporter* promotes life-long learning by encouraging students to investigate naturally occurring weather patterns after the completion of the unit. Finally, *The Weather Reporter* includes literary and math components to engage students in discussions and to reinforce the concepts addressed in the unit.

Essential Understandings

1. The Earth's weather changes continuously.
2. Changes in weather are characterized by differences in wind, temperature, and precipitation.

3. Extremes in weather can result in droughts or floods.
 4. Several factors influence the weather.
 5. Weather data is collected and recorded using instruments.
 6. Data collected about the weather is useful for predicting weather and determining weather patterns.
 7. Fundamental components of weather forecasting include air pressure, temperature, wind direction, and cloud type.
 8. Living things respond to weather and seasonal changes.
 9. Adverse weather conditions may slow growth and optimal conditions accelerate growth.
 10. Unusual or severe weather phenomena require emergency planning and preparation.
2. Matter is anything that has mass and takes up space.
 3. There are three main states of matter: solids, liquids, and gases.
 4. Objects can be described by color, shape, texture, relative size and weight, and position.
 5. Matter can change from one state to another; these changes are referred to as physical changes.
 6. Volume is the measure of the amount of space occupied by matter.
 7. *Mass* is a measure of the amount of matter.
 8. Materials are composed of parts that are too small to see without magnification.
 9. Physical properties remain the same when a material is reduced in size.
 10. Some liquids separate when mixed with water.
 11. Some solids will dissolve in water, and more quickly in hot than cold water.
 12. Temperature and energy can create physical changes in matter.

2.1.8. *What's the Matter?*

What's the Matter? is a second-third grade unit that focuses on the properties of solids, liquids, and gases and the processes by which matter changes states. Students work on problem-solving scenarios where they use their new knowledge of matter, change in physical properties, and the measurement of matter to prepare a presentation to share new ideas and discoveries about matter for a "science conference." The overarching concept of *Change* is used to deepen understanding of the scientific concepts in the unit.

Essential Understandings

1. All common substances are made of matter.

3. Implementation

The units have been implemented in Title I classrooms in three school districts, meaning that low income students and minority learners make up the majority of the student participants. Random assignment of students to 76 classrooms comprises the sample. Teachers use the units as part of their science program across 12 weeks of instruction, some daily and others twice

per week. Project staff is on site once a week to monitor implementation, to provide embedded professional development, and to offer technical assistance with aspects of project implementation. Assessment measures used include a standardized achievement test in science, a test of critical thinking, assessed at the end of the project to third grade students, and performance-based measures that assess content mastery, higher level research process skills, and higher level concept mastery. An attitudinal scale on science will be used in this last year of formal implementation.

4. Results

Results from all three types of measures suggest that students using the curriculum show significant and important growth in science achievement, critical thinking, and in the components of the curriculum itself after as little as 24 hours of instruction. Significant gains were posted for all ability levels and all units. Some grade level variations were found on some of the measures. Treatment fidelity results suggest that there is unevenness among teachers in their capacity to implement the material faithfully.

5. Discussion

The consistent use of a theoretical and practical framework for development of curriculum has been an essential part of the success in the William and Mary curriculum development endeavor. While the studies to date do not validate the ICM model, they do lend credence to its utility in organizing a balanced and well-

differentiated curriculum for the gifted with strong capacity for use with a broader range of students. Moreover, the use of a design blueprint that designs in key features of content pedagogy as well as differentiation heightens the credibility of the work with subject matter specialists, who were a part of the design team and review process for the work.

Another aspect of this project that bears mentioning as a key feature is the careful development and use of performance-based assessment tasks, used pre and post to assess higher level learning. These tasks, calibrated to be advanced, open-ended, and require critical thinking and problem solving to do, represent an authentic picture of student learning within the units, thus providing a more complete picture of the nature and extent of growth accrued through unit use. No curriculum project for the gifted can neglect to collect these more authentic measures of performance as they portray a more meaningful view of learning rather than just short term achievement.

Consistently over past projects as well as Project Clarion, we have incorporated powerful inquiry-based tools for learning that scaffold instruction for students. In these units we have included a Wheel of Scientific Investigation to ensure that students both graphically and verbally internalize the iterative process of doing science from observation as the basis for question-asking to meaning-making as the basis for rendering conclusions. Moreover, we have employed problem-based learning episodes in these units to

spur student motivation and engagement in the lessons. These episodes require students to take the role of a scientist in solving a mystery situation related to the topic of each unit and to bring the mystery to resolution by the end of the unit.

The nature of professional development has also evolved in this project to a more work-embedded model, even though some training is provided onsite at William and Mary. Our school-based ambassadors have been quite successful at providing needed professional development in a teacher's room or in a small group at the school, based on perceived need. For example, we noticed a number of the teachers not using flexible grouping in the classroom to deliver instruction. Thus our project ambassadors provided a workshop on strategies to do so to aid in the implementation within a week of observing the problem. The use of such follow-up approaches to professional development is critical to project success.

6. Conclusion

The use of the ICM model for curriculum development has proven highly effective to craft units of study in all areas of learning. Project Clarion, funded by the Javits Act, represents one more effort that has shown positive learning gains for students, this time at the primary level in science.

7. Implications

Educators must become more careful consumers of curriculum, noting the presence or absence of research evidence

for use with different kinds of learners. Educators of the gifted must recognize the power in using curriculum already piloted and field tested with this population as the best avenue for use in schools rather than reinventing the wheel by having teachers, ill-prepared in curriculum development skills or differentiation, to do the task in a few weeks. Our work over 15 years suggests that it takes two years or more to create strong curriculum for the gifted that has effectiveness research behind it.

There is also a need for more intervention studies that suggest what works with gifted learners in different content areas. Our studies in the field to date are a good start, but insufficient to make the case that differentiated curriculum, optimally matched to the nature of the learner, is a sine qua non of strong education in all settings everywhere.

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Resumen:

Desarrollo del currículo para alumnos de primaria con altas capacidades en las enseñanzas de ciencias

Este artículo analiza el desarrollo de un currículo de ciencias para alumnos avanzados y para el logro de aprendizajes de alto nivel, basado el modelo de Currículo Integrado desarrollado por la autora, que pone el énfasis en la adquisición de conceptos y de destrezas de investigación para estudiantes de enseñanza primaria. Los resultados de un estudio de intervención llevado a cabo sugieren que los alumnos de enseñanza primaria, con bajo nivel de recursos económicos, incrementan su adquisición de conceptos y las destrezas asociadas a la investigación como consecuencia de la exposición a esta innovación curricular. Se ponen de manifiesto algunas posibles deficiencias respecto a la correcta implementación del mismo en las escuelas, así como respecto a la investigación en las mismas.

Descriptores: Diseño curricular, Educación de los más capaces, Modelo de Currículo Integrado.

Summary:
Curriculum Development for Gifted Learners in Science at the Primary Level

This article explores the development of a science curriculum for high end learners and learning, based on the Integrated Curriculum Model, that emphasizes concept attainment and research investigation skills for students at the primary level of schooling. Findings from an intervention study suggest that primary age students in low income schools increase content and scientific process skills as a result of the curriculum innovation. Issues of fidelity of implementation and concerns about conducting research in schools are also explored.

Key Words: Curriculum design, gifted education, Curriculum Integrated Model.