AC 2008-2484: A VISION FOR P-16 STEM EDUCATION AND THE RELATIONSHIP BETWEEN

James Nelson, University of Texas at Tyler

Dr. James K. Nelson received a Bachelor of Civil Engineering degree from the University of Dayton in 1974. He received a Master of Science and a Doctor of Philosophy degree in civil engineering from the University of Houston. During his graduate study, Dr. Nelson specialized in structural engineering. He is a registered professional engineer in four states and a fellow of the American Society of Civil Engineers. He is also a member of ASEE and the SAFE Association.

Prior to receiving his Ph.D. in 1983, Dr. Nelson worked as a design engineer in industry and taught as an adjunct professor at the University of Houston and Texas A&M University at Galveston. In industry he was primarily involved in design of floating and fixed structures for the offshore petroleum industry. After receiving his Ph.D., Dr. Nelson joined the structures faculty at Texas A&M University. He joined the civil engineering faculty at Clemson University in 1989 as Program Director of the Clemson University Graduate Engineering Programs at The Citadel and became chair of Civil Engineering in 1998.

In July 2002, Dr. Nelson joined the faculty at Western Michigan University as chair of civil and construction engineering. At Western Michigan he started the civil engineering undergraduate and graduate degree programs and also chaired the Departments of Materials Science and Engineering and Industrial Design. In summer 2005 he joined the faculty at The University of Texas at Tyler. At UT Tyler he was the founding chair of the Department of Civil Engineering and instituted the bachelor's and master's degree programs. In 2006 he became the Dean of Engineering and Computer Science.

Dr. Nelson's primary research interests are in the behavior of structural systems. For the past several years he has been actively involved in evaluating the behavior of free-fall lifeboats and the development of analytical tools to predict that behavior. He has authored many technical papers that have been presented in national and international forums and co-authored three textbooks. Dr. Nelson has served as a technical advisor to the United States Delegation to the International Maritime Organization and in that capacity is a primary author of the international recommendation for testing free-fall lifeboats and many of the international regulations regarding the launch of free-fall lifeboats.

Michael Odell, University of Texas at Tyler

Dr. Odell began his career in education as an Earth Science teacher in Irving, Texas (1984-1990). He received his B.A. in Geoscience (1984) and M.A.T. in Science Education (1989) from the University of Texas at Dallas. He went on to earn his Ph.D. in Curriculum and Instruction/Science Education (1993) from Indiana University.

Prior to coming to UTT he was an Associate Professor of STEM Education at Illinois State University where he also served as an Assistant Dean of the College of Education (2005-06).

Before ISU, Dr. Odell served as an Associate Professor of Science/Technology Education and Director of the Division of Teaching, Learning and Leadership at the University of Idaho (1993-2005). He was also a member of the Environmental Science Faculty. He served as an Associate Director of the Idaho Space Grant Consortium and the Project Director for the Idaho Virtual Campus. He also served as the Director of the Institute for Mathematics, Interactive Technologies and Science (IMITS) where he was involved in the development and implementation of numerous externally funded projects.

He is best known for his work with the NOVA program (NASA Opportunities for Visionary Academics), the Virtual Center for Online Learning Research (VCOLR), the GLOBE Program, and the National Space Grant College and Fellowship program.

He has served as a National Space Grant Fellow at NASA Headquarters in Washington, D.C. (1995-97) and as a Faculty Fellow at NASA Kennedy Space Center (2003) in Florida.

Currently Dr. Odell is involved in the research and development of online tools and strategies to improve achievement in science education. He currently serves on the National Science Teachers Association (NSTA) Aerospace Education Committee and the Association for Science Teacher Education (ASTE) Technology Education Committee.

William Geiger, University of Texas at Tyler

William Geiger is Dean of the College of Education and Psychology at the University of Texas at Tyler. Dr. Geiger holds a degree in philosophy from Marquette University and degrees in special education from the University of Florida and the University of Alabama.

Dr. Geiger's research interests have focused on aspects of the infrastructure that supports the preparation of special educators. He participated in the preparation of three national directories of special education personnel preparation programs. He has been active in the development of national standards for the preparation of special education teachers and for the preparation of general educators to provide instruction to students with disabilities. Dr. Geiger has conducted research on the supply of special education teachers, and recently he completed a comprehensive study of states' licensure requirements for special education teachers.

Dr. Geiger has served frequently as a consultant to schools, school districts, and state departments of education. He also consults with the Office of Special Education Programs of the U. S. Department of Education. He has worked with local organizations in Bolivia and Russia to improve service delivery for children and youth with disabilities in those countries.

Kristian Trampus, University of Texas at Tyler

Kristian Trampus received a Bachelor of Science in Oceanography from the University of Washington in Seattle in 1992. She received a Master of Education degree in Curriculum & Instruction from the University of Texas at Tyler. She is currently working on her doctoral studies with Texas A&M - Commerce in Curriculum & Instruction. During her graduate studies, Ms. Trampus has specialized in metacognitive studies and STEM (science, technology, engineering and math) reform in secondary and higher education. She is also a member of the ASEE, AAUW, ACS, NSTA, and STAT.

Prior her current appointment, Ms. Trampus conducted oceanographic research through an NSF grant at the University of Washington, and taught secondary Chemistry and Physics. In addition, she has worked in curriculum development and alignment, science remediation and state assessment evaluation.

In August of 2007, Ms. Trampus joined the faculty of the University of Texas at Tyler as a lecturer in Curriculum & Instruction and as the Assistant Director of the East Texas STEM Center. She currently works as the Director of the East Texas STEM Center implementing numerous STEM reform initiatives.

Ms. Trampus' primary research interests are in STEM reform. She has been actively involved in evaluating and implementing best practices in recruitment and retention of historically underserved student populations into the STEM fields, evaluation of P-16 alignment in Texas in STEM, implementing reform initiatives in secondary STEM curriculum and pre-service/in-service training for secondary STEM teachers. Ms. Trampus currently serves as the American Association of University Women's Southwest United States Liaison to the National Girls Collaborative Project and has presented nationally on issues in STEM education and metacognitive strategies.

A Vision for P-16 STEM Education and the Relationship Between Secondary and Higher Education in STEM Education

Abstract

The United States is at a critical crossroads in regard to science and technology education. The pressures for reform are many. Professional engineering societies are addressing the prerequisites necessary for professional practice, *i.e.* the bodies of knowledge necessary for professional practice. In a recent report, the National Academy of Engineering calls for education reform to restore the nation to its competitive technological edge. Numerous states are increasing educational standards and are requiring more science and mathematics to be part of the secondary school curriculum. None of these, however, provides a unified vision for STEM education across the P-16 curriculum, and in particular for the relationship between secondary and higher education in furthering STEM education. Further, measures must be implemented to attract more students into the STEM fields, both as practitioners and as educators.

Presented in this paper is a vision for educational reform across P-16 education that can address these critical issues. A framework is provided for STEM education that will better prepare all students so that they can pursue a STEM career, possibly in education, if that is their eventual choice. Students' options and preparedness will not be limited based on curricular choices or lack of preparedness. Those students not choosing a STEM career will have a better understanding of technology which is essential in the 21st century. Within the framework presented, the following issues are addressed:

National STEM Education Landscape

Many policymakers, business leaders, and education experts believe that the progress and prosperity of the United States is dependent on a knowledge-based economy requiring a dynamic, motivated, and well-educated workforce with superior science, technology, engineering, and mathematics (STEM) skills. Thomas Friedman (1), in the book *The World is Flat*, makes a case that other nations such as India and China are rapidly catching up to the U.S. The title is a metaphor for viewing the world as flat or level in terms of commerce and competition, as in a *level playing field*—or one where all competitors have an equal opportunity. Friedman suggests that there must be a shift in education if countries, companies and individuals want to remain competitive in a global market where historical, regional and geographical divisions are becoming increasingly irrelevant.

In the report from the National Academy of Engineering (2) *Rising Above the Gathering Storm: Energizing and Employing America for a Brighter Economic Future*, four recommendations that policy-makers should implement to create high-quality jobs and focus new science and technology efforts on meeting the nation's needs were provided, namely:

1. Increase America's talent pool by vastly improving K-12 mathematics and science education;
2. Sustain and strengthen the nation's commitment to long-term basic research;
3. Develop, recruit, and retain top students, scientists, and engineers from both the U.S. and abroad; and
4. Ensure that the United States remains the premier place in the world for innovation.

In a world where advanced knowledge is widespread and low-cost labor is readily available, prior advantages of the United States in the marketplace and in science and technology have begun to erode. A comprehensive and coordinated federal effort has begun in an effort to bolster U.S. competitiveness and pre-eminence in these areas. Initiatives include the Bush administration's *American Competitiveness Initiative (ACI)* that committed \$5.9 billion in FY 2007 to increase investments in research and development, strengthen education, and encourage entrepreneurship and the *Protecting America's Competitive Edge Act (PACE)* that intended improve P-12 Science/Math Education by providing:

- Scholarships for future teachers of math and science;
- Math and science teacher training programs;
- Summer academies for teachers;
- Advanced placement courses in math and science;
- Specialty math and science high schools; and
- Internships and summer programs for middle and high school students.

According to the STEM Ed Caucus Steering Committee website (2007), maintained by the National Science Teachers Association, STEM education is responsible for providing the United States with three kinds of intellectual capital:

- Scientists and engineers who will continue the research and development that is central to the economic growth of our country;
- Technologically proficient workers who are capable of dealing with the demands of a science-based, high-technology workforce; and,
- Scientifically literate voters and citizens who can make intelligent decisions about public policy and who understand the world around them.

Given this landscape, the demand for scientists and engineers in the United States is expected to increase at four times the rate for all other occupations. But today's high school students are

not performing at the level of other developed nations in math and science, and fewer are pursuing degrees in technical fields. These trends are indicated in Figures 1 and 2 (10). An aggressive pursuit of improved STEM education must take place if the United States is to maintain global economic leadership.

Figure 1—Projected science and engineering positions

Figure 2—Engineering, computer science and IT bachelors awarded annually

In the recently released 2006 Program for International Student Assessment (PISA) results of which were issued by the Organization for Economic Cooperation and Development (OECD), the United States was not one of the top performing countries among 15 year olds tested. The 2006 assessment focused on “science competencies for tomorrow’s world.” The best performing countries included (7):

- Finland, with an average of 563 score points, is the highest performing country on the PISA 2006 science assessment.

- Six other high-scoring countries have mean scores of 530 to 542 points: Canada, Japan and New Zealand and the non-OECD countries/economies Hong Kong-China, Chinese Taipei and Estonia.
- Australia, the Netherlands, Korea, Germany, the United Kingdom, the Czech Republic, Switzerland, Austria, Belgium, Ireland and the non-OECD countries/economies Liechtenstein, Slovenia, Macao-China also score above the OECD average of 500 score points.
- In contrast, 15-year-olds in the United States achieved a mean score of 489 points in science, on a scale that has an OECD average of 500 points and for which two thirds of the OECD student population perform between 400 and 600 points.
- Among OECD countries:
 - Italy, Portugal, Greece, Turkey and Mexico have lower mean scores than the United States;
 - Sweden, Hungary, Ireland, Belgium, Austria, Switzerland, the Czech Republic, the United Kingdom, Germany, Korea, the Netherlands, Australia, New Zealand, Japan, Canada and Finland, as well as students in the combined area of the European Union, have higher mean scores than the United States.
 - Denmark, France, Iceland, the Slovak Republic, Spain, Norway and Luxembourg are not significantly different from Finnish performance, which was superior to the United States performance.

In relative terms, the US ranks 21st among the 30 OECD countries, but the confidence interval ranges from the 18th to the 25th rank. In 2003, the US had ranked 19th among 29 OECD countries with comparable data and in 2000 14th among 27 OECD countries with comparable data. Less than one-third of students in grades 4, 8 and 12 in the United States performed at or above the proficient level in mathematics and science in the 2000 National Assessment of Education Progress. Only 16 percent of the 12th graders could be considered proficient or advanced in mathematics and only 18 percent could be considered proficient in Science, while 47 percent were below partial-proficiency in science and 35 percent were below partial-proficiency in mathematics.

According to the Third International Math and Science Study, significant improvements in Math and Science were made between 1995 and 2003. Still, American students were outperformed by 7 of 13 other countries in math, and 5 of the 13 other countries in science. Teenagers in the United States lag behind most developed countries in math and science literacy (4).

In terms of demand, projections show a need for over 2 million new teachers in this decade, of which 240,000 will be middle and high school mathematics and science specialists. A sizeable number of mathematics and science teachers do not have a major or minor in their field, especially those who teach in high-poverty and high-minority schools. Rural schools also have a

difficult time in finding highly qualified teachers with sufficient STEM backgrounds to teach in multiple disciplines.

In terms of supply, over 28 percent of students in the United States entering college need remediation. The U.S. has fallen from first to eighth in the percentage of the population receiving a college degree. The United States has also fallen behind in the number of undergraduate natural science and engineering degrees awarded, in relation to the total population. The proportion of students obtaining degrees in Science, Technology, Engineering, and Mathematics fields has fallen from 32 percent to 27 percent. The number of Natural Science and Engineering Ph.D.'s granted in Asian countries is climbing while the rate in the United States remains flat (3).

Currently, demand for STEM professionals is growing larger than the number individuals choosing these professions. Further, the gap appears to be widening. Critical curricular action need to be taken to reverse this trend.

State of STEM Teacher Preparation

There are several key reports concerning teacher preparation. These include:

- Before It's Too Late: A Report to the Nation by the National Commission on Mathematics and Science Teaching for the 21st Century;
- Educating Teachers of Science, Mathematics, and Technology: New Practices for a New Millennium from the National Research Council; and
- A National Action Plan for Addressing the Critical Needs of the U.S. Science, Technology, Engineering, and Mathematics Education System from the National Science Board.

The three reports describe an extensive set of characteristics of "high-quality teaching." When they are viewed through the lens of exemplary teacher preparation and focused within an integrated system of professional development, an enormous potential for empowering teachers and improving instruction is apparent.

The positive effect of better teaching is unequivocal; indeed, the most consistent and powerful predictors of student achievement in mathematics and science are teachers with full teaching certification and a college major in the field being taught (5). Better mathematics and science teaching is therefore grounded, first of all, in improving the quality of teacher preparation and in making continuing professional education available for all teachers. A closer look at the teaching that goes on in mathematics and science classrooms today puts the performance of U.S. students on national and international assessments in sharper focus. The basic teaching style in too many mathematics and science classes today remains essentially what it was two generations ago (2). By contrast, teaching innovation and higher student performance are well documented in other countries, where students' improvements are anchored to an insistence on strong professional development for teachers (7).

In the report *Before Its Too Late*, a roadmap for improving STEM teacher preparation is provided. Seven interdependent action strategies are offered to establish an ongoing system to improve STEM teaching that include:

- “Undertake a full needs assessment to determine what teachers require, both in their schools and their professional lives, if they are to routinely deliver high-quality teaching;
- Summer Institutes must be established to address the professional development needs identified;
- Campus-level and district-level Inquiry Groups can provide venues for teachers to engage in common study to enrich their subject knowledge and teaching skills;
- Leadership Training is needed to prepare facilitators for the Summer Institutes and Inquiry Groups;
- A dedicated Internet Portal must be available to teachers so they can make use of and contribute to an ever-expanding knowledge base about mathematics and science teaching;
- A non-governmental Coordinating Council is needed to bring together the above initiatives and those that follow to assess accomplishments; and
- All states and local districts should initiate reward and incentive programs, both to support exemplary professional development that results in higher student achievement and to increase the attractiveness of teaching as a profession”.

In addition, to improving teacher preparation, there is a need to increase the number of STEM teachers. Three action strategies are offered by *Before It Is Too Late* for this goal: “(1) a direct strategy that identifies *exemplary models of teacher preparation* whose success can be widely replicated; (2) an overarching strategy of finding ways *to attract additional qualified candidates into teaching* from among high school and college students, recent college graduates, and people at mid-career; and (3) creating competitively selected *Mathematics and Science Teaching Academies* to annually train Academy Fellows, who will be nationally recruited for a one-year, intensive course on effective teaching methods in mathematics or science”.

To retain teachers, *Before It Is Too Late* identifies four action strategies: “(1) focused *induction* programs are required to help acclimate beginning mathematics and science teachers to the profession, create formal mentoring relationships, and introduce teachers to Inquiry Groups; (2) *district/business partnerships* are needed to provide support for a broad range of efforts that can help create professional working environments for teachers. These efforts can enhance teaching by providing materials, facilities, equipment, and mentor stipends; (3) *incentives* -- whether in the form of cash awards, salary increases, support for further education, or community-wide recognition -- are needed to encourage deserving mathematics and science teachers to remain in teaching and improve their skills; and (4) *salaries* of all teachers must be

made more competitive, but especially for mathematics and science teachers, whose combined preparation and skills command high wages in the private sector.”

Pressure on Secondary and Higher Education

While the preparedness of the students is declining in relation to much of the developed world, the United is facing severe pressures on its educational system from primary school through higher education. These pressures are especially critical for engineering as they are likely to cause further decrease in student preparedness.

In higher education there is continual pressure to reduce the total number of credit hours in an engineering degree program. This decline is shown graphically in Figure 3. The typical engineering degree program at public institutions is about 128 hours. At least three states—Texas, Arizona, and Florida--have mandated that all degree programs, including engineering degree programs, contain no more than 120 credit hours. At the same time, the content of the core curriculum in colleges and universities is tending to increase, which will further erode the technical content of engineering degree programs. In Texas, the State-mandated core curriculum is 42 credit hours with another 5 credit hours at the discretion of the institution—over one-third of the number of credit hours permitted in a degree program.

Figure 3—Decline in engineering program credit hour requirements

The pressures are not just in higher education as there is significant compression in mathematics and science courses in middle and secondary schools as indicated in Figure 4. Because of the rising cost of education, and because perceived or real duplication in course content, students in secondary education are taking courses for dual-credit, receiving both high-school and college credit for the course, and advanced placement courses. These courses range from pre-calculus and calculus to chemistry and physics—all of which are fundamental to the study of engineering.

Figure 4—Compression in middle and secondary schools

While this is occurring, and to make room for these courses in the secondary education curriculum, algebra and geometry, as well as some science, is being moved to the middle school curriculum. As more is being put into a smaller period of time, something is being lost. Based on student performance previously discussed, that which is being lost appears to be student preparation in and assimilation of fundamental knowledge and skills. Without solid foundational skills, students will not feel comfortable pursuing careers in engineering and those that do will have difficulty completing the program of study. A gap is being created between actual preparation for study in engineering and the necessary foundational knowledge.

Some argue that this compression is acceptable as there is duplication of curricular content. For example, Algebra II and College Algebra are considered to be the same course, as is the history taught in secondary education and in the higher education core curriculum. If this duplication does indeed exist, and the authors believe that it does, there is considerable lost educational opportunity that could be mitigated through curriculum alignment and revamping.

The Proposed Integrated Curriculum

Four elements are necessary when developing a curriculum to provide for success in a flat world. These elements are:

- The secondary education curriculum must provide a balanced education grounded in fundamental principles that will enable a student to pursue a career of their choice in higher education.
- The curriculum must provide the necessary skills for success in an increasingly technological environment.
- The curriculum must enable the student to function in a global community on par with students of other nations.
- The curriculum must develop within the student an ethos of critical thinking and evaluation.

Presented in Figure 5 is a graphical representation of the content of the envisioned curriculum. Within the curriculum, the courses shaded in blue are taught by faculty with

secondary education certificates. Those courses shaded in orange are taught by faculty with credentials for teaching in higher education (at least a master’s degree and 18 semester hours in the teaching field). The broad educational objectives of the blocks of courses are shown in Tables 1 and 2 for secondary and higher education, respectively.

There is a fundamental assumption regarding the curriculum as posed: the curricula are aligned with each other. The content as well as the beginning and ending points in courses are established and known by all. Achieving this alignment will require coordination of course content across a multitude of institutions and schools, most likely at a state level.

Figure 5—Proposed Aligned Curriculum

Within this curriculum there are two overarching goals that likely will require new teaching methodologies and probably new textbooks will need to be developed. Those goals are:

- To provide relevancy to all curricular content so that students can better assimilate information through recognition of application.
- To provide an understanding of the impact of classical literature and history on society today, on the disciplines today.

Possible methods for teaching this curriculum are presented in the following section of this paper.

Table 1—Broad Educational objectives of the secondary education program

Course Subject Area	Educational Objective
Literature	Provide the students with a review of classical literature with emphasis on the relevance of that literature to events of today.
History and Government	Develop within the student the understanding of the events of today, of the formation of the world today, in the context of the changes that occurred throughout history. The emphasis is the development of an understanding of current events in the context of history.
Modern Language	Develop within the student a basic conversational ability in a modern language to provide the ability to succeed in a global multi-lingual environment.
Grammar and Composition	Develop within the students the ability to convey information orally and in writing over a broad range of forums (e.g. reports and letters).

Table 2—Broad Educational objectives of the higher education engineering program

Course Subject Area	Educational Objective
Language and Composition	Provide the students with broad discipline oriented instruction in written and oral communication.
Literature	Develop within the student, knowledge of current and classical writings that have an impact on their broad discipline (e.g., science and technology, the arts, or business environment).
Leadership and Human Thought	Develop within the student, a fundamental understanding of leadership and organizational behavior as well as an understanding of the processes of diverse human thought from a psychological as well as a cultural level so that they can effectively function as members of a team as well as leaders of teams.
Business and Public Policy	Develop within the student, an understanding of fundamental business principles, such as finance, marketing, and contracts.
History and Government	Develop within the student, the understanding of the events of today, of the formation of the world today, in the context of the changes that occurred throughout history. The emphasis is the development of an understanding of current events in the context of history.

On the surface these curricula appear to be similar to what is taught today. The difference, however, is in the expected outcomes. The intent of the proposed curricula is to integrate and extend content, rather than duplicate content, at the different educational levels, and to provide current relevance of the material. For example, classical literature is studied in secondary education to provide a broad understanding of the formation of thought today, while in higher education the literature studied is intended to provide understanding of current professional issues. If done correctly, this approach provides the broad cultural understanding of the world expected of an educated person.

Methods for Teaching the Proposed Curriculum

In the National Research Council of the National Academies publication *How Students Learn History, Mathematics, and Science in the Classroom*, Bransford and Donovan (5) recommend three critical guiding principals for knowledge acquisition in History, Mathematics and Science. These three principals include:

- Addressing Preconceptions
- Providing Factual knowledge in a conceptual framework (and specifically for science; What it means to “Do Science”)
- Metacognition

In order to adequately address preconceptions and misconceptions with which the students enter the classroom, it is imperative that teachers are well versed in their content area. Rigorous, ongoing support in pre-service education and on-going professional development with a strong emphasis on research-based, data driven best practices is essential. In addition, carefully designed pre-assessments should be used to more accurately quantify the foundational footing of the students with regards to discrete concepts. Learning opportunities for teachers in the use of curriculum mapping of concepts and cognitive demand should be provided in order to ensure the validity and quality of pre-assessments, delivered curriculum, formative assessments and summative assessments. Finally, inquiry discussion techniques can be used to further define the students’ preconceptions and real world examples of conceptual ideas.

The acquisition of factual knowledge embedded in an accurate conceptual framework is no small order. The too often employed style of procedures and facts presented in a grocery listing, rote memorization method is bound for failure as there is no conceptual framework in which to place the facts and procedures. The previously mentioned content mapping procedures are an effective method of assessing the delivered curriculum in order to ensure that the full range of cognitive demands are correctly sequenced and scaffolded for a given content topic. In addition, the use of inquiry-based learning methods is more conducive to the inclusion and use of both factual knowledge and the corollary contextual framework. The deliberate and conscious use of quantitative and qualitative methods is another important component in tying factual knowledge to the contextual net. Well designed units integrating across the content areas can also enable the students to construct their knowledge with an eye on the larger conceptual ideas and way in

which the disciplines interact. An emphasis on modeling in science and math, as well as the requirement of multiple representations both in instruction delivery and in student product has been shown to greatly enhance not only the integrity of the content knowledge, but also the student's understanding of scientific inquiry and critical thinking. The implementation of senior year capstone projects which require the understanding and use of critical thinking skills, effective writing skills, technological proficiency as well as rich content knowledge would address the common problem of senior slump, provide a bridging activity toward higher education and demonstrate the acquisition of the necessary knowledge and skills to succeed in higher education.

Finally, the sustained practice of metacognitive assessment and intervention has been shown to greatly increase the achievement of students with significant fungibility. The use of reflection and attribution should be implemented and reinforced at the onset of middle school. Reflecting being defined as the students' discovery of the strategies, learning tools, effort and time management which are personally effective in achieving learning outcomes. Attributing is defined as a students' assigning their learning outcomes to particular causes (6). The assessment of students' learning style preferences and the coaching of the students' in effective study strategies associated with particular learning style preferences has also been shown to increase student metacognition as well as student achievement. This tool can also be used to reinforce the acquisition of conceptual knowledge well grounded in the contextual framework.

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