"Fundamentals of Middle School Mathematics".

In Section 1 of this course you will cover these topics:

- Mathematics For The 21st Century
- The Challenge Of Middle School Learners
- The Practice Of Effective Instruction

Topic : Mathematics For The 21st Century

Topic Objective:

At the end of this topic student would be able to:

- learn about National Council of Teachers of Mathematics
- Understand Math Education

Definition/Overview:

National Council of Teachers of Mathematics: The National Council of Teachers of Mathematics (NCTM) was founded in 1920. It has grown to be the world's largest organization concerned with mathematics education, having close to 100,000 members across the USA and Canada, and internationally.

NCTM Standards: NCTM has published a series of math Standards outlining a vision for school mathematics in the USA and Canada.

Key Points:

1. National Council of Teachers of Mathematics

The National Council of Teachers of Mathematics (NCTM) was founded in 1920. It has grown to be the world's largest organization concerned with mathematics education, having close to 100,000 members across the USA and Canada, and internationally.

NCTM holds annual national and regional conferences for American teachers and publishes four print journals and one on-line journal. Its published standards have been highly influential in the direction of mathematics education in the United States and Canada.

1.2 NCTM Standards

NCTM has published a series of math Standards outlining a vision for school mathematics in the USA and Canada. In 1989 NCTM developed the Curriculum and Evaluation Standards for School Mathematics followed by the Professional Standards for Teaching Mathematics (1991), and the Assessment Standards for School Mathematics (1995). These math standards were widely lauded by education officials, and the National Science Foundation funded a number of projects to develop curricula consistent with recommendations of the standards. Several of these programs were cited by the Department of Education as "exemplary". On the other hand, implementation of the reform has run into strong criticism and opposition, including parental revolts and the creation of anti-reform organizations such as Mathematically Correct and HOLD. These organizations object especially to reform curricula that greatly decrease attention to the practice and memorization of basic skills and facts.

Critics of the reform include a contingent of vocal mathematicians and many other mathematicians have expressed at least some serious criticism of the reformers in the past. Given the strong support for the reform among math educators, the conflict over the reform has created tensions between them and mathematicians.

In 2000 NCTM released the updated Principles and Standards for School Mathematics. PSSM is widely considered to be a more balanced and less controversial vision of reform than its predecessor.

1.3 1989 Curriculum and Evaluation Standards for School Mathematics

The controversial 1989 NCTM standards called for more emphasis on conceptual understanding and problem solving informed by a constructivist understanding of how children learn. The increased emphasis on concepts required decreased emphasis on direct instruction of facts and algorithms. This decrease of traditional rote learning was sometimes understood by both critics and proponents of the standards to mean elimination of basic skills and precise answers, but the NCTM has refuted this interpretation.

The standards recommended teaching elements of algebra as early as grade 5, and elements of calculus as early as grade 9, though this was rarely adopted even as late as the 2000s. In standards based education reform, all students, not only the college bound must take advanced mathematics. In some large school districts, this means requiring algebra of all students by the end of junior high school, compared to the tradition of tracking only college bound and the most advanced junior high school students to take algebra.

The standards soon became the basis for many new federally funded curricula such as the Core-Plus Mathematics Project and became the foundation of many local and state curriculum frameworks. Although the standards were the consensus of those teaching mathematics in the context of real life, they also became a lightning rod of criticism as math wars erupted in some communities that were opposed to some of the more radical changes to mathematics instruction such as Mathland's Fantasy Lunch and what some dubbed "rainforest algebra". Some students complained that their new math courses placed them into remedial math in college.

The standards set forth a democratic vision that for the first time set out to promote equity and mathematical power as a goal for all students, including women and underrepresented minorities. The use of calculators and manipulatives is encouraged, but standard

algorithms and rote memorization are deemphasized. The standards encourage writing about mathematics as well as computation. Some controversial math curricula such as Investigations in Numbers, Data, and Space were based on research papers such as those by Constance Kamii which assert that teaching of traditional arithmetic methods such as borrowing "not only are not helpful in learning arithmetic, but also hinder childrens development of numerical reasoning". All students are expected to master enough mathematics to succeed in college, and rather than defining success by rank order, uniform, high standards are set for all students. Explicit goals of standards based education reform are to require all students to pass high standards of performance, to improve international competitiveness, eliminate the achievement gap and produce a productive labor force. Such beliefs, which are congruent with the democratic vision of outcome-based education and standards based education reform that all students will meet standards, refute past research which shows an achievement gap in scores between groups of different education development on every test and assessment, even those aligned with reformed mathematics standards and instruction. The U.S. Department of Education would name several standards based curricula as "exemplary", though academics would respond in protest with an ad taken out the in the Washington Post, and they would note selection was made largely on which curricula implemented the standards most extensively rather than on demonstrated improvements in test scores. The reform standards, while widely accepted as a consensus by education agencies from local to federal levels, were met with intense criticism from groups such as Mathematically Correct; the controversy was widely characterized by newspapers such as the Wall Street Journal as "math wars".

In the era of standards based education reform, a curriculum framework is often set at a state level. For example, the California State Board of Education was one of the first to embrace the 1989 standards, and also among the first to move towards traditional standards. In a standards based system, the curriculum is aligned with the standards. The final step in the system is that by 2006, nearly two-thirds of students in the USA would have to pass high school graduation examination set to World class standards of what every student must know and be able to do to succeed in the 21st century. However in states such as Washington, the success of mathematics reform was in question as half of sophomores and four-fifths of minorities were still struggling to pass the math standard needed to make the promise made in the 1993 education reform bill a reality that most or

all would graduate two years later with a diploma. While some officials blamed this on incomplete adoption of the 1989 standards, other districts which had already embraced the 1989 standards were deciding instead to replace or supplement standards-based curricula with more traditional instruction such as Saxon math or Singapore Math in face of poor standardized test results.

The style of instruction can also vary from traditional direct instruction of multi-digit multiplication in books such as Singapore Math to standards-based instruction such as Investigations in Numbers, Time, and Space which may omit instruction or even discourage use of any standard calculation algorithm or method in favor of guiding students to invent their own mathematical algorithms. Some education officials have stated that achieving a numerically correct result is secondary to the process of obtaining that answer.

In standards-based curriculum frameworks developed in the 1990s, math topics and goals might include the history and legacy of diverse multicultural groups in mathematics, mathematical communication, number sense, mathematical power, and equity. Real life examples integrated contemporary issues such as the rain forests, environment, careers, and other topics which integrate other fields of knowledge. Critics including US senators would dub one such text as "rainforest algebra" with 812 pages of seemingly anything but algebra content.

Related to issues of equity in mathematics, where some groups are under-represented in math and science fields, and others tend to dominate mathematics research, the field of Mathematical Relationships concerns how persons form relationships with mathematics, how they identify with the subject and how they disidentify with it, around social class, gender, race/ethnicity, dis/ability, nationality, and sexuality. Some critics such as David Klein of California State University Northridge believe such issues belong in social studies, not mathematics, and that mathematics should be taught in a classical method to all students without regard to a student's group affinities.

In a February 9, 1994 article in Education Week on the Web, Steven Leinwand wrote: "It's time to recognize that, for many students, real mathematical power, on the one hand, and facility with multidigit, pencil-and-paper computational algorithms, on the other, are mutually exclusive. In fact, it's time to acknowledge that continuing to teach these skills

to our students is not only unnecessary, but counterproductive and downright dangerous." Leinwand was part of the expert panel that in early October of 1999 directed the United States Department of Education to endorse ten K-12 mathematics as "exemplary" or "promising." The "exemplary" programs announced by the Department of Education were:

- Cognitive Tutor Algebra
- College Preparatory Mathematics (CPM)
- Connected Mathematics Program (CMP)
- Core-Plus Mathematics Project
- Interactive Mathematics Program (IMP)

The "promising" programs were:

- Everyday Mathematics
- MathLand
- Middle-school Mathematics through Applications Project (MMAP)
- Number Power
- The University of Chicago School Mathematics Project (UCSMP)

Some mathematicians such as David Klein of California State University Northridge challenged the emphasis given to gender and race "equity" in the mathematics reform movement. One of the themes of the mathematics reform movement is that traditional mathematics fails because women and members of ethnic minority groups are treated differently than white males. Objections to mathematics curricula which introduced multicultural writing while often omitting traditional arithmetic methods recognizable to parents came largely from mathematicians rather than educators whose "real life" applications might be to use linear algebra to compute bake sale proceeds.

A few states such as California which were early adopters of the 1989 standards would later revise their math standards and assessments, leading a new movement to reject the assumptions of the original 1989 standards as fatally flawed in favor of traditional skills and memorization of math facts. Some public schools in recent years have started to supplement or replace their standards-based mathematics curricula with texts which emphasized direct instruction of traditional mathematics such as Saxon math, popularized

by homeschoolers who often rejected standards-based curricula, and Singapore Math because of poor performance on standardized tests compared to other nations and frustration over standards-based approaches which de-emphasized traditional instruction..

1.4 2006 Curriculum Focal Points

In September 2006, NCTM released Curriculum Focal Points for Prekindergarten through Grade 8 Mathematics: A Quest for Coherence. In the Focal Points, NCTM identifies what it believes to be the most important mathematical topics for each grade level, including the related ideas, concepts, skills, and procedures that form the foundation for understanding and lasting learning.

Mathematics curricula in the United States are often described as a mile wide and an inch deep when compared with curricula from other countries. State content expectations per grade level range anywhere between 26 and 89 topics. At just three per grade (plus a few additional "connection" topics), the focal points offer more than headings for long lists, providing instead descriptions of the most significant mathematical concepts and skills at each grade level and identifying important connections to other topics. NCTM believes that organizing a curriculum around these described focal points, with a clear emphasis on the processes that Principles and Standards addresses in the Process Standardscommunication, reasoning, representation, connections, and, particularly, problem solvingcan provide students with a connected, coherent, ever expanding body of mathematical knowledge and ways of thinking.

2. Math Education

The field of math education, both the teaching of mathematics and the preparation of math teachers, remained constant during much of the twentieth century. Yet, since the 1960s, reforms in math education have raised questions and caused debate about best practices in the teaching of mathematics and the preparation of math educators. These questions and debates have sparked a series of changes in the nature of the public school and college curricula and the focus of research on the teaching and learning of mathematics. The rise of technology for

instruction, the standards and accountability movement, and new national and international measures of comparative assessment have further fueled the debates and continue to shape the evolution of the field of math education.

Prior to the twentieth century, math educators were primarily viewed as drillmasters charged with the utilitarian responsibility of teaching for the memorization of basic arithmetic skills, computation, and problem solving in mathematics. During the early part of the twentieth century, most math teachers were prepared with 1 or 2 additional years of schooling at a specialized high school called a normal school. After 1900, when the concept of a universal high school curriculum took hold, math educators majored in mathematics in a teacher's college and were prepared to serve as secondary content specialists. Inherent in this program design was the assumption that math teachers for the elementary and primary grades learned all the mathematics they needed during their postsecondary schooling, and because of such thinking, most elementary and middle grade math teachers received only mathematics required of an elementary education major. After World War II, however, the curriculum emphasis shifted to more modern, sophisticated levels in public schools and colleges, including the inclusion of elements of geometry and algebra in elementary curriculum, greater emphasis on functions and less emphasis on trigonometry in high school, and the introduction of calculus into the curriculum of the first year of college. This shift caused subsequent rethinking of the math curriculum in colleges and schools of education for the preparation of math educators.

Today, the downplaying of basic memorization and computational skills during the twentieth century has surfaced as a serious problem in the P16 curriculum evidenced by international comparisons of student performance on standardized tests. Students in the United States consistently perform below that of their counterparts in highly developed countries. Since the mid-1980s, international comparison studies, such as the Third International Mathematics and Sciences Study (TIMSS), show that mathematics instruction in many developed nations, particularly Eastern Asia, is definitely richer in comparison to math instruction in American classrooms. The TIMSS study, the largest cross-national, multiyear research study conducted in the history of math education, included 41 countries across five continents and compared over 500,000 students' scores in mathematics and science.

Other comparative assessments, such as the National Assessment of Educational Progress (NAEP), show equally alarming data. Positive press that was provided early during the

release of main NAEP data occurred primarily because of the fact that fourth graders and eight graders increased overall from 1999 to 2003 by a range of 15 to 22 scale points respectively. However, a closer look at the comparisons of student performance over time as revealed on the specialized long-term-trend NAEP show that the gains portrayed by the main NAEP are 10 times larger than on the trend NAEP. In fact, in 1999 only 56% of 17-year-olds scored correctly on basic computation skills. Trend analysts blame hidden differences such as this one on differing curriculum frameworks. Test items for the main NAEP tests are developed from the National Assessment Governing Board (NAGB) and closely approximate changes within math instruction in the field, while the trend NAEP utilizes the same testing instruments in order to be able to make comparisons over time. Regardless of the reason, the dismal performance of American students on national measures of standardized assessment and in comparison to other developed nations has called the math curriculum and the preparation of math teachers into question. As the United States neared the end of the twentieth century, it was apparent that we would not achieve the federally legislated goal of *Academics 2000* for American students to place first in math and science achievement in the world.

Comparisons between textbook and curriculum guide content performed by researchers in the TIMMS study show a similar magnitude of difference across various countries in the TIMMS study. Textbooks produced for math instruction in the United States are on the average 25% larger and outweigh the average international length. For example, a fourth-grade mathematics textbook contains an average of 530 pages, while the international length for a fourth-grade math textbook is 170 pages. The reason for the difference in length is the breadth of coverage. U.S. textbooks contain a far greater number of topics than most other countries participating in the TIMSS. This broad coverage is typically presented at the expense of thorough in-depth treatment of the content.

These findings of this and other TIMMS studies show that the math curriculum in America is highly repetitive, revolving around a definition of basics that are largely repeated from the fourth grade and upward, while the view of what constitutes a focused curriculum in other countries involves a tightly regimented introduction of new content throughout the upper grades. For example, in the U.S. math curriculum, American textbooks introduce most of the core content by fourth grade, with only one topic introduced in depth in each grade between fourth and eighth grades. Yet, in most TIMMS countries, textbooks and curriculum guides

between fourth and eighth grade introduce roughly 75% of new material each year from fourth grade and beyond, approximately 15 new topics in depth per year. As identified in the TIMMS study, the lack of focus and coherence in the American curriculum and other factors contributing to the mediocre performance of American schoolchildren in mathematics suggest that the schooling itselfin other words, inadequate preparation of math teachersmay be responsible.

Following the initial release of the TIMMS data in the 1980s, heightened interest and intense debate about strengthening math curriculum and instruction began among the various math societies and professional associations, and in response, the National Council of Teachers of Mathematics (NCTM) published the first academic standards for subject matter instruction in mathematics, the Curriculum and Evaluation Standards. First released in 1989 and updated in 2000, the standards address issues of making math more engaging and demanding to meet the needs of a changing America in a global economy. However, the lack of guidance in the implementation of the standards and competition from state standards with accompanying subject matter test frameworks have diffused the results that were anticipated initially.

Some of the criticism of the NCTM standards and state standards stem from issues of racial equality as the achievement gap that persists among White, Black, and Hispanic subgroups on standardized tests widened in mathematics computation during the 1990s. Numerous research studies attest to the importance of arithmetic, in particular that computation skills are necessary for advancement in careers in math and science. Research studies also show that computation skills are a valuable predictor of adult earnings. Yet, reducing inequity in mathematics instruction by enforcing high standards for all, by raising teacher expectations, and by appropriating resources does not appear to be a priority of local school systems within the United States. Poor teacher preparation, the extensive reliance on calculators in early- and middle-level instruction in mathematics, and the reformist standards of the 1990s are recognized as contemporary issues in math education in the twenty-first century. Changing expectations for math knowledge, coupled with increased uses of technology applications for school mathematics instruction, has directed the rethinking of the current curriculum and preparation that is needed in the math education of prospective teachers.

In response to the criticism and in order to undertake such a massive curriculum reworking, the American Mathematical Society and the Mathematical Association of America joined and formed the Conference Board of the Mathematical Sciences. During the latter part of the

1990s, the board designed a series of federally funded research and development projects commonly called the Mathematics Education of Teachers Project (METP). Stemming from the ongoing debate over student performance, curriculum, and teacher education, METP was designed to examine two general themes: (1) the intellectual substance in school mathematics and (2) the special nature of the mathematical knowledge needed for teaching. The final report of the METP was published in 2000 as a resource for math faculty, administrators in schools and colleges, and others involved in the education of math teachers. While the report itself was not aligned with any particular mathematics curriculum for schools, its findings are consistent with the NCTM's *Principles and Standards for School Mathematics* and other recent national reports on school mathematics. Recognized as a synthesis of contemporary thinking on policy and issues affecting math educators, the METP report is being explored widely by the mathematical sciences community and educational sector to design new preparation programs for prospective math teachers, such as fostering math specialists for middlelevel math instruction, and to redesign new professional development opportunities to implement national initiatives in public schools.

The METP report provides the 11 general recommendations to mathematics departments and the larger educational community to guide contemporary discourse and the direction of practice for math education stated below.

- Prospective teachers need mathematics courses that develop a deep understanding of the mathematics they will teach.
- Although the quality of mathematical preparation is more important than the quantity, the following amount of mathematics coursework for prospective teachers is recommended:
    - Prospective elementary teachers should be required to take at least nine semester hours on fundamental ideas of elementary school mathematics.
    - Prospective middle grades math teachers should be required to take at least 21 semester hours of mathematics, which include at least 12 hours of fundamental ideas of school mathematics appropriate for middle grades teachers.

  - Prospective high school teachers of mathematics should be required to complete the equivalent of an undergraduate major in mathematics, which includes a 6-hour capstone course connecting their college mathematics courses with high school mathematics.

- Courses on fundamental ideas of school mathematics should focus on a thorough development of basic mathematical ideas. All courses are designed for prospective teachers, who should develop careful reasoning and mathematical common sense in analyzing relationships and in solving problems.
- Along with building mathematical knowledge, mathematics courses for prospective teachers should develop the habits of mind of a mathematical thinker and demonstrate flexible, interactive styles of teaching.
- Teacher education must be recognized as an important part of mathematics department missions at institutions that educate teachers. More mathematicians should consider becoming deeply involved in K12 mathematics education.
- The mathematical education of teachers should be seen as a partnership between mathematics faculty and mathematics education faculty.
- There needs to be greater cooperation between 2-year and 4-year colleges in the mathematical education of teachers.
- There needs to be more collaboration between mathematics faculty and school mathematics teachers.
- Efforts to improve standards for school mathematics instruction, as well as for teacher preparation accreditation and teacher certification, will be strengthened by the full-fledged participation of the academic mathematics community.
- Teachers need the opportunity to develop their understanding of mathematics and its teaching throughout their careers, through both self-directed and collegial study, and through formal coursework.
- Mathematics in the middle grades (five through eight) should be taught by mathematics specialists.

The recommendations of the METP report are highly specific and differ widely from earlier recommendations found in reports such as Mathematics Association of America's 1983 *Recommendations on the Mathematical Preparation of Teachers*. The METP recommendations are organized around three common grade clusterselementary, middle, and

high schooland address the need for teachers to study within one of these three specialized clusters. The recommendations further contend that teachers need a deeper and broader understanding of the curriculum, in particular where their grade-level content is situated within the larger context of mathematical knowledge in the total curriculum. A number of statements in the recommendations express the need for prospective teachers to acquire a deep understanding of mathematics with the emphasis on nurturing the teacher's ability to be able to assess student work, to understand the nature of student errors in relation to student understanding, and to be able to foster high levels of engagement among students, thereby promoting interest in the study of mathematics.

The METP report acknowledges that the P12 mathematics content is qualitatively different across the curriculum, and thus teachers need to be prepared to make connections that exist among math concepts as they are sequenced along the curriculum. One assumption of the METP report is that with this deeper understanding, math teachers across the various grade levels and clusters will be able to build on students' earlier mathematics knowledge. While the recommendations seem lofty for prospective teachers, the METP report allows that preservice teacher education is essential to a true understanding of school mathematics.

The expectations for high school math teachers in the METP report calls for teacher preparation programs to enable prospective teachers to develop awareness of the mathematics their students are likely to face after high school, either in college, technical studies, or employment, and to foster a mature attitude that will encourage continued growth in the teaching and learning of mathematics. In order to support the METP recommendations, mathematics departments are charged with redesigning their core courses to help secondary teachers make connections across the curriculum content and to offer a capstone course collaboratively taught by faculty in math education and secondary pedagogy for advanced exploration of conceptually challenging points in the teaching and learning of high school mathematics.

As the study of math education evolves to meet the needs of a diverse and changing student population in the United States, the direction of research in the twenty-first century continues to expand to address the complex issues of advancing the study of mathematics in our public schools and society. Instructional leadership for advanced mathematics, the role of technology in math instruction, and the inclusion of special needs students in mathematics programs are pressing topics being explored through research and development in math

education. Together with the NCTM, the Mathematical Society of America, and other professional associations of math educators, the mathematical sciences community seeks ways to improve the preparation and professional development through national research and international comparative studies with other countries whose mathematics programs offer insight into best practices for understanding and improving the field of mathematics education in the United States

Topic : The Challenge Of Middle School Learners

Topic Objective:

At the end of this topic student would be able to:

- Understand Challenge of Middle School International Learners
- Overcoming the challenge
- Accommodations for Students with Special Needs
- Instructional Materials:
- Culturally Responsive Teaching
- Introduction to CRT

Definition/Overview:

Culturally Responsive Teaching: Culturally responsive teaching (CRT) is an educational reform that strives to increase the engagement and motivation of students of color who historically have been both unsuccessful academically and socially alienated from their public schools.

Key Points:

1. Challenge of Middle School International Learners

For many students immigrating from Foreign countries, prior schooling may not only have been intermittent as described in the above vignette, but may have also taken place in low-resource environments both in Foreign countries and in the U.S. While living in Foreign countries, many students may have resided in rural areas where schools were understaffed and limited in teaching and learning materials. [2] After moving to the U.S., Foreign countries immigrant students are more likely to attend overcrowded, limited-resource urban schools with fewer certified teachers.[3] In North Carolina, migration lines have been traced from rural Foreign countries to specific North Carolina destinations. Not only do students come largely from rural schools in Foreign countries, but they often hail from families whose home language is an indigenous language rather than Spanish. Upon arrival in U.S. schools, these students are assumed to be native Spanish speakers, but may in fact be minimally proficient in Spanish. In addition, these students may have had no previous exposure to English upon entry into U.S. schools.[4]

Gaining literacy in English may become an increasing challenge for these incoming students. In addition to education and language gaps, students may also face social and cultural barriers to learning English. Immigration patterns show that incoming families move into relational and geographic enclaves due to social and economic forces.[5] This may add to the social and linguistic segregation experienced by Latinos and make the task of learning English through day-to-day interactions with English speakers difficult. In addition, Jim Cummins has underlined a delay between the acquisition of oral language and academic language pertinent to the experience of English language learners (ELLs).[6] Students need an estimated five additional years of schooling to become proficient in academic reading and writing, such as reading science or social studies textbooks, after reaching oral English proficiency.

Teachers in the U.S. may assume an ELL has sufficient proficiency to read and understand academic tasks at the middle school level when they hear a student speak basic English, which leads to a lack of support and increasing rates of academic failure among ELLs. Without additional tutoring, the student may simply lose interest, run out of energy to surmount the ever-growing language and content hurdles, and eventually drop out. Indeed,

the dropout rate from eighth to ninth grades sharply increases in North Carolina from around 3% in eighth grade to about 32% of all dropouts occurring in ninth grade.[7] Students may make it through middle school with difficulty, then decide to drop out when high school starts and academic pressures increase. In North Carolina, Latinos show disproportionately high rates of dropout at over 7%.[8]

2. Overcoming the challenge

Social and cultural capital (a network of people and resources from which the student gains support) are often discussed in research and writing on Latino students. *Academic instrumental knowledge* as a subset of social and cultural capital refers to school-specific knowledge as a type of cultural capital.[9] Many children of immigrants are at a disadvantage when it comes to understanding how U.S. schools function. In 1990, the average Foreign countries immigrant in the U.S. had 7.6 years of schooling. In 2002, 20% of the population in Foreign countries had no schooling compared to 0.6% of the population in the U.S.[10] Schooling experiences, thus, are less prevalent on the whole for parents of current incoming Foreign countries students, so access to the academic instrumental knowledge needed to help their children succeed is limited.

How can teachers and schools help students overcome the middle school challenge? Teachers and schools must work hand in hand with students, but also with the students parents to enlist support and build solutions.

Rueda, Monzo, and Arzubiaga outline an intervention process that works with parents and students using an additive approach.[11] For example, schools and teachers find links between parents knowledge and practices about literacy and the schools literacy approach. Then, schools promote a negotiation of these in relation to the students literacy.

The ALAS project (Achievement for Latinos through Academic Success) in Los Angeles brought improvement in school retention for a group of seventh graders. The intervention included monitoring school attendance period by period and notifying parents daily of their childs attendance or truancy, training for the students on problem-solving skills, weekly or daily feedback to students and parents from teachers on behavior and schoolwork, training for

parents on how to participate in schools and how to manage their childrens behavior, recognition and bonding activities for students, and connecting students and families with community services.[12]

Research on culturally relevant curriculum has also pointed out the increase in engagement among middle school students when Meso-american culture, language, and history is taught.[13] Tapping into families cultural capital and knowledge are critical to engaging the student and the parents in the educational process. Curricular choices such as these can help teachers understand the students background and skills, as well as open the door to a connection with the students parents.

3. Accommodations for Students with Special Needs

Rarely are there specific lesson plans for special education. Teachers take existing lesson plans and provide either accommodations or modifications to enable the student with special education to have optimum success. This tip sheet will focus on four areas where one can make special accomodations to support students with special needs students in the inclusive classroom. Those four areas include:

1.) Instructional Materials

2.) Vocabulary

2.) Lesson Content

4.) Assessment

4. Instructional Materials:

- Are the materials you select for the instruction conducive to meeting the child(ren) with special needs?
- Can they see, hear or touch the materials to maximize learning?
- Are the instructional materials selected with all of the students in mind?
- What are your visuals and are they appropriate for all?
- What will you use to demonstrate or simulate the learning concept?

- What other hands on materials can you use to ensure that the students with needs will understand learning concepts?
- If you are using overheads, are there extra copies for students who need to see it closer or have it repeated?
- Does the student have a peer that will help?

5. Vocabulary

- Do the students understand the vocabulary necessary for the specific concept you are going to teach?
- Is there a need to focus first on the vocabulary prior to starting the lesson?
- How will you introduce the new vocabulary to the students?
- What will your overview look like?
- How will your overview engage the students?

6. Lesson Content

- Does your lesson focus completely on the content, does what the students do extend or lead them to **new** learning? (Wordsearch activities rarely lead to any learning)
- What will ensure that the students are engaged?
- What type of review will be necessary?
- How will you ensure that students are understanding?
- Have you built in time for a breakout or change in activity?
- Many children have difficulty sustaining attention for lenghty periods of time. Have you maximized assistive technology where appropriate for specific students?
- Do the students have a element in choice for the learning activities?
- Have you addressed the multiple learning styles?
- Do you need to teach the student specific learning skills for the lesson? (How to stay on task, how to keep organized, how to get help when stuck etc).
- What strategies are in place to help re-focus the child, continue to build self-esteem and prevent the child from being overwhelmed?

7. **Assessment**

- Do you have alternate means of assessment for students with special needs (word processors, oral or taped feedback)?
- Do they have a longer time lines?
- Have you provided checklists, graphic organizers, or/and outlines?
- Does the child have reduced quantities?

Overall, this may seem like a lot of questions to ask yourself to ensure that all students have maximized learning opportunities. However, once you get into the habit of this type of reflection as you plan each learning experience, you will soon be a pro at ensuring the inclusional classroom works as best as it can to meet your diverse group of students which are found in most classrooms today. Always remember, that no 2 students learn the same, be patient and continue to differentiate both instruction and assessment as much as possible.

8. Culturally Responsive Teaching

Culturally responsive teaching (CRT) is an educational reform that strives to increase the engagement and motivation of students of color who historically have been both unsuccessful academically and socially alienated from their public schools. Specifically, culturally responsive teaching acknowledges and infuses the culture of such students into the school curriculum and makes meaningful connections with community cultures. Culturally responsive teaching is designed to help empower children and youth by using meaningful cultural connections to convey academic and social knowledge and attitudes.

This chapter presents an introductory overview of CRT, also commonly referred to as *culturally relevant* or *culturally congruent* teaching. Historical and theoretical roots of CRT are discussed. Specific knowledge, skills, and professional dispositions are examined, followed by a discussion of generic applications of CRT and future directions for CRT. The chapter concludes with bibliographic references and suggestions for further readings.

9. Introduction to CRT

CRT is a direct response to concern over an academic achievement differential and high school dropout rates based on race, socioeconomic class, and level of English-language ability. Demographically, this academic achievement gap is generally evidenced between (1) White economically advantaged students and (2) students of color, immigrant children, and students from lower socio-economic families. Examined from a school reform perspective, CRT is a concept that signals a need to expand the customary professional knowledge base for teachers in order to close this achievement gap.

CRT is best understood as a response to traditional curricular and instructional methods that have often been ineffective for students of color, immigrant children, and students from lower socioeconomic families. CRT calls attention to schooling norms where White middle-class values and expectations are privileged while other cultural, racial, and economic histories and community backgrounds are overlooked or degenerated. In contrast to assimilationist teaching, CRT values and incorporates as appropriate a student's culture into instruction. In this regard, CRT is not only interested in providing mainstream knowledge through different techniques, but it also involves transforming the actual perspectives, knowledge base, and approaches of a conventional classroom's curriculum and instruction.

As the nation's student body continues to grow more culturally and racially diverse, the demographic composition of teachers remains extremely homogenous racially with nearly 90% of all teachers identifying themselves as White. CRT recognizes that the cultural identity of most teachers is significantly different than their increasingly diverse student populations. The educator and philosopher Paulo Freire (19211997) reminds educators that public education is a form of cultural expression, which left unexamined by classroom teachers, can create a disconnect for historically marginalized students. Hence, CRT provides support to the cultural identities of struggling students while striving simultaneously to raise academic achievement.

CRT works to build an inclusive and welcoming classroom and school environments that can create culturally appropriate approaches to raising academic expectations for all students. This involves teachers proactively using cultural knowledge and experiences of diverse students to establish a caring school climate. The purpose is to make learning more culturally relevant and effective for this particular population of students. In this way, CRT holds the

potential to validate and affirm the cultural frames of references of all students as a means to help students attain their academic goals.

CRT is a student-centered strategy that embraces a learning community model for the organization of a classroom. CRT incorporates into classroom teaching and school policies and practices the cultural knowledge and assets of historically marginalized students and their communities and families. This approach rests on an equity pedagogy designed to rectify educational conditions that have fallen short of facilitating the learning of many students from racially, culturally, and economically diverse groups. As an educational reform, CRT represents a growing shift away from equating student seat time in a classroom with learning and to evaluating teacher performance on the basis of student engagement and gains in academic learning.

A CRT goal is to actively engage all students in learning, a fundamental element of effective teaching. CRT recognizes that teacher effectiveness decreases when instruction is primarily teacher centered with an absence of student and community voices. CRT conceptualizes pedagogy as a two-way communicative process designed to decrease student passivity by placing student involvement at the center of teaching and learning. Rather than teachers defining their roles as just the transmitters of information, CRT calls on teachers to help students be active participants in the production and acquisition of knowledge. This requires teachers to acknowledge the conceptual and cultural resources or assets that culturally different students bring to their schools and then to affirm the backgrounds of all students. Without this acknowledgment and affirmation, teachers may be unable to utilize the background knowledge and experiences that students bring to their learning environments.

The National Research Council's Commission on Behavioral and Social Sciences and Education notes that teachers who are aware of the relationship between student learning and cultural variations in communications are apt to enhance necessary supports for the development of children and youth. Learning stems from a complex relationship among social, biological, and emotional elements in which intersections with an individual's cultural orientation must be taken into consideration. CRT helps in this developmen-tally appropriate learning process by making connections for students between schooling norms and the familiarity of home and cultural background. To reach this objective, CRT works to transform traditional educational norms of practice so that disparity is reduced between the cultural lives of students and their experiences with public schooling. Ultimately, it is the

interaction between a teacher and a student that becomes a key learning site that can determine the degree of success for culturally diverse children and youth in public schools. For CRT, this involves purposefully incorporating aspects of the cultural perspectives of this targeted population into the everyday practices and instructional activities of the classroom. In this way a school can use multicultural frames of reference to help determine its policies and practices.

For effective CRT, teachers would need to expand and apply their multicultural knowledge, skills, and dispositions so that opportunities for student gains in academic achievement and a willingness to complete public school are improved. Preservice and inservice teaching education is the primary avenue by which teachers can learn how to create conditions of cultural expression that are more congruent with the backgrounds of their culturally diverse students and their families. Through CRT preparation, educators can better grasp how student cultural backgrounds affect learning and student development. This can lead to a multicultural commitment on behalf of educators, a professional disposition that is widely recognized as a foundational attitudinal component for the successful development of CRT.

10. Historical and Theoretical Foundations

CRT developed out of tensions within a society that aspires to unified democratic ideals and goals while being demo-graphically composed of a culturally and linguistically diverse multicultural population. The following section addresses CRT in a historical and democratic context specific to the United States. The emerging recognition of the costs of marginalizing students of color in the educational process is examined. CRT is further discussed in relation to multicultural education and critical pedagogy. The final section concludes with a presentation of the tensions around the concept of culture and its subsequent implications for CRT.

11. Historical Foundations

Amidst the U.S. Supreme Court ruling in the 1954 case *Brown v. Board of Education*, which declared separate schools for Black and White students unconstitutional, and President

Lyndon Johnson's signing into law the 1964 Civil Rights Act, which ended legalized Jim Crow racial segregation in public facilities and housing, public awareness was growing about the cultural discontinuity for African American children and other students of color with mainstream public schools. Whereas some educators and policy makers described these differences as cultural deficits or disadvantages on the part of students of color and their families, educational reformers influenced by the aims of the civil rights movement turned their attention to what they identified as deficiencies in the structure and curriculum of public schools. These civil rights activists contended that public schooling skewed advantage toward White middle-class students and ignored or punished the cultural orientations of students of color.

The civil rights movement helped to usher in the concepts and approaches of the modern reform movement of multicultural education. During the past 35 years, the multicultural education reform movement has advocated for a deeper understanding of the prospects to transform traditional schools into ones with a more democratic, inclusive, and civic face. Multicultural educators have consistently stressed the need for teachers to expand their cultural competence in relation to their own dispositions, knowledge base, and performance skills. Imbedded within this expectation is a desire to have a teaching force with a deeper understanding of the relationship of the school curriculum to a pluralistic society with particular attention to the needs of students of color. The legacy of the civil rights movement highlighted the need for a teaching force that can understand and interact effectively with diverse cultural groups outside the standard school boundaries and is able to provide curricular opportunities reflective of this diversity within schools.

CRT developed out of both the social cauldron of the civil rights movement and multicultural education reform efforts to expand democratic opportunities for all students and their families. Emerging conceptually in the 1980s, CRT came of age during the 1990s in an effort to meet the multicultural goal to have teachers who hold the knowledge, skills, and professional dispositions that are sensitive and responsive to the conditions of people historically placed on the margins of society's political and economic activities. Nevertheless, by the end of the first decade of the 21st century, students of color continued to constitute disproportionately high percentages among the estimated 1.2 million students who drop out of high school every year. Currently in the United States, approximately 68% of those who begin ninth grade graduate at the end of what would be their twelfth grade. Furthermore, for

African American, Native American Indians, and Latino students, graduation rates hover around 50%, whereas for males in those groups the figure ranges from 43 to 48%. Researchers have found that by the age of 8, disparities between the cultural values and patterns of communication of the home and the school can diminish the desire of young people to learn and to believe in their own capacity to learn. Some students come to see schooling as detrimental to their own language, culture, and identity. In this historical and contemporary context CRT is looked to as a potential solution to this seemingly entrenched racialized differential.

11. Democratic Foundations

Recent court decisions point to the expectation that an adequate education should include the preparation of economically productive citizens who can actively participate in a democratic society. These decisions find that an adequate education is constitutionally defined in relation to access and opportunity for learning. Like these court cases, the preeminent educational philosopher and practitioner John Dewey (18591952) had located the purpose of schooling in the larger context of a democratic society. He conceived of a democratic community founded upon goodwill that can result when individuals empathetically see across their self-interests and biasesbe they cultural or racialand work toward common learnings and understandings. In this context, Dewey warned against one group acting under the guise of benevolence by dictating to others what was in their best interest. Similar to Dewey, CRT literature promotes honoring and incorporating multiple cultural perspectives rather than defaulting to dominant monocultura! schooling norms of Euro-Americanism.

CRT is representative of both Dewey's democratic ideal and a manifestation of the schooling goal to educate young people to be informed and active democratic citizens. CRT strives to enact the Deweyian concept of democratic goodwill by teaching across and to significant cultural differences. Like contemporary CRT theorists and practitioners, Dewey chastised traditional schooling arrangements that dismiss the importance of an individual's relationship to the conditions of teaching and learning. To create a learning experience, Dewey contended that educators should account for how learning environments positively interact with the needs, abilities, and aspirations of individual students. Because he saw education as fundamentally a social process, Dewey recognized that personal experiences of students must

be incorporated into the curriculum for learning to have a lasting effect. From a Deweyian standpoint, CRT as a learner-centered pedagogy acknowledges the importance of student's prior and current experiences for the long-range goal of the development of citizenship competencies.

Low-Status Students

A democratic goal of CRT is to close the disparity of academic and social opportunities observed primarily between students of color and White students. Prominent educational researcher Linda Darling-Hammond observes that structures of inequality in public education as evidenced in the distribution of funding, qualified teachers, courses, and instructional materials have been a part of U.S. history since the founding era. Research indicates that teachers need to recognize this condition of inequities in order to begin closing the achievement gap for those students habitually assigned low status and inferior academic competence. The Learning First Alliance finds that when schools support the academic progress of students, their engagement with school increases. Low-status students, according to researchers, are among those who lack opportunities to receive the equitable benefits of pedagogical approaches designed to help students acquire meaningful and engaging academic content that can help them meet school district and state learning standards, stay in school through graduation, and develop into active democratic citizens.

Low-status students include individuals whose academic rights have been historically marginalized by institutions and people in privileged positions. This discrimination continues to be experienced by many students of color, immigrant children, and students from low-income families. Based on her extensive research, Elizabeth Cohen found that from a democratic perspective, low-status students working, for example, in small learning groups often are limited in their participation and have their ideas disregarded by other students. When low-status/ historically marginalized students become disengaged in learning, teachers often see this as a discipline problem rather than a status problem that needs teacher intervention and support in order that such students can demonstrate academic competence. It is within this democratic context to help all students that CRT is situated.

12. Multicultural Education Foundations

CRT is an expression of multicultural education. Through multicultural educational approaches a culturally responsive teacher is theorized as contributing to the elimination of models of cultural deficiency by attending to the learning needs of low-status students with the expressed purpose to educate citizen-students who work to the ideals of a democracy. To varying degrees, CRT is viewed as an enactment of the reform goals and dimensions of multicultural education as articulated by James Banks.

Banks theorized a multidimensional concept of equity and schooling with five interactive dimensions of multicultural education. For Banks, each enacted multicultural dimension by culturally responsive teachers holds the theoretical potential to meet the broad goal to develop an educated democratic citizenry. He conceptualized the multicultural dimension *content integration* as an instructional approach where a culturally responsive teacher presents subject matter content from a variety of cultural perspectives. The dimension *knowledge construction* is when culturally responsive teachers can reveal to students how subject matter is constructed from particular racial and social class perspectives in contrast to dominant models that privilege Euro-American knowledge bases over those from culturally different groups. *Prejudicial discrimination reduction* entails for the culturally responsive teacher creating school and classroom opportunities for students to learn to develop more democratic attitudes and behaviors. The *equity pedagogy* dimension finds a culturally responsive teacher focusing not only on equality of learning opportunities but also consciously implementing strategies that assist those culturally diverse students who struggle academically. The final dimension, an *empowering school culture and social structure*, calls on the culturally responsive teacher to support efforts to restructure schools organizationally and culturally in order to increase for all students educational equity and cultural affirmations.

13. Critical Pedagogy Foundations

The concept of pedagogy in its contemporary usage is a perspective that envisions effective teaching as a process rather than a set of discrete techniques. Congruent with CRT, pedagogy as currently defined situates effective teaching more as two-way communication between

teachers and students in contrast to the direct transmission of information to students by teachers. A teacher, then, practices approaches to teaching and learning that build relationships with and among students and focuses ultimately on how and to what extent students are learning. This definition of pedagogy mirrors research that finds achievement improves through active student participation in the learning process.

More specifically for CRT, *critical pedagogy* offers ways to look at teaching and learning that can bring to the forefront such concepts as ideology, hegemony, resistance, power, knowledge construction, class, cultural politics, and emancipatory actions. The underlying concepts of critical pedagogy are theorized as necessary for teachers and their students to understand seemingly intractable conditions of social and educational inequities. CRT uses a critical pedagogy philosophical orientation to differing degrees when conceiving and implementing curriculum and instruction.

Identifying Dominant Practices

Unraveling issues of political dominance and oppression is a task that critical pedagogy attempts to undertake. Such work necessitates a knowledge base that analyzes how and why a dominant ideology supports a particular kind of political and economic arrangement that directly affects public school goals, policies, and practices in ways that can undermine the academic achievement of students of color. CRT theorists and practitioners find critical pedagogy as an approach where culturally responsive teachers can acquire a knowledge base that helps explain the existence of inequalities that can negatively affect the academic achievement of culturally diverse students. Freire noted that when inexperienced teachers from mainstream cultures find themselves working with culturally different students, students' language, values, and behaviors may be so different from their teachers' that the culture of those students may be deemed by teachers as strange and dangerous. Advocates for CRT contend that culturally responsive teachers must not retreat from such differences but should become themselves students of these differences as a means to know and help each of their students socially and academically.

Praxis

The concept of praxis has direct theoretical relevance to critical pedagogy and CRT. Freire (1970) explained that the discovery of oppressive conditions cannot be purely intellectual but

must involve *action;* nor can it be limited to mere activism, but must include *serious reflection:* only then will it be a praxis (p. 52, emphasis added). When applied to teaching, praxis requires teachers to alter traditional norms of teaching and learning. Freire postulated that it is necessary to reduce the perceived distance and contradictions between students and teachers in order that both groups can share collaboratively in the teaching and learning process. Hence, praxis requires culturally responsive teachers to become a learner along with their students. At a minimum, this can involve culturally responsive teachers learning with and from their students about various cultural communities and backgrounds from which students come. Thus, the idea of praxis reminds culturally responsive teachers that it is not enough to only identify unequal, racist, and undemocratic situations. By means of a pedagogy that is critical and imbedded with the concept of praxis, culturally responsive teachers are theoretically expected to work with their culturally diverse students and communities to help overcome inequities that may exist under mainstream arrangements of schooling.

14. Cultural Complexities

The concept of culture is complex, and efforts to narrow its meaning can have negative implications for student learning under CRT. Multicultural educator Sonia Nieto (2000) defines culture as the values, traditions, social and political relationships, and worldview created, shared, and transformed by a group of people bound together by a common history, geographic location, language, social class, and/or religion (p. 138). Culture defined as such is not a static entity that a culturally responsive teacher can easily identify because culture is interactive, affects a person's life, and is continually changing.

Cultural tensions underlie the emergence of CRT. Debates exist among scholars and practitioners who approach the racialized achievement gap as a function of cultural deficiencies. Others contend that the academic achievement differential is based on a lack of acknowledgment of the cultural assets held by culturally different students. This debate has led to an examination of the theoretical concept of learning styles as a means to better understand the learning needs of all students. The following sections describe these varying perspectives and their relationship to CRT.

Cultural Deficits/Differences/Assets

At various points throughout U.S. history, population groups who were not of Anglo- or Western European origins have been considered to be culturally deficient, disadvantaged, or deprived. The cultural deficiency model that was articulated in the 1960s and cyclically reemerges over time has led, CRT scholars contend, to discriminatory schooling conditions for students of color and those from low-income families. The cultural deficiency perspective assumes that children and youth who are culturally different from mainstream society need an education that assimilates them into dominant norms and behaviors and away from the cultures of their families and communities. From this point of view, minority students are constructed as culturally disadvantaged by presumed deficits located within their cultural histories, beliefs, and conduct. Theorists who support a cultural deficiency standard tend to blame culturally different groups for their lack of economic and political gains and believe that a democracy must have a unified culture that is built on Anglo-European values.

Theorists countered the monoculturalist's cultural deficiency model by emphasizing cultural and ethnic differences. CRT emerged from this debate about an apparent lack of cultural congruence between the public school and the home life of students of color. Culturally responsive teachers who practice under a cultural difference model have been encouraged to learn about the various cultures of their students as assets rather than deficits and to incorporate those cultures into curriculum and instruction. A challenge for culturally responsive teachers, however, is avoiding a common tendency to stereotype students of color according to their ethnic or racial identification. This essentialized labeling can lead to narrow and simplistic understandings of the complexities of culture and what it means to students of color in the myriad settings in which they live and attend school. Additionally, some multicultural scholars question whether it is possible to attain culture congruence between the public school and the lives of culturally diverse students. To overcome these issues, researchers Luis Moll and Norma Gonzalez call for application of funds-of-knowledge approach that documents cultural knowledge from home visits. The funds-of-knowledge strategy can help culturally responsive teachers learn more about their students, apply this new cultural knowledge to the curriculum, and discover the heterogeneity within cultural groups.

Learning Styles

Although a popular construct, learning styles is a somewhat indeterminate concept in order to grasp the social-psychological dynamics of subject-specific learning. Approached from a

CRT perspective, learning styles research indicates that teachers should know how to (1) incorporate the cultural context of teaching and learning into the curriculum by using the prior learning of students and including students' own personal cultural perceptions, (2) utilize affect in building interpersonal relationships with students, and (3) adjust teaching approaches that conflict with student learning styles. Nevertheless,

research on learning styles using culturally diverse students fails to support the premise that members of a given group exhibit a distinctive style. Clearly, learning-styles research is a useful beginning in designing appropriate instruction for culturally diverse students, and not an end in itself. (Irvine & York, 1995, p. 494)

Yet, when learning styles are conceived in the context of instruction being culturally congruent, learning gains may accrue to marginalized students of color. The theoretical tension here is to recognize that individual students may have preferred learning styles that may or may not be attached to their cultural backgrounds.

Learning styles used simplistically can stereotype children of color and further stigmatize non-Western cultures. Research suggests that developmental learning needs of students from outside the dominant culture cannot necessarily be comprehended by teachers without analyzing students' experiences with the curriculum and how they locate themselves with a classroom's specific learning environment. Learning styles approaches that either negate or abridge cultural orientations and differences can be counterproductive to the achievement of children and youth living in subordinated cultures. Hence, the challenge for CRT is to identify those situation-specific cultural variables that may contribute or detract from student learning and to build a teaching and learning program around such knowledge.

15. Knowledge, Skills, and Professional Dispositions

CRT requires teachers to acquire particular knowledge, skills, and professional dispositions in order to effectively meet the social and academic needs of culturally diverse students. The following three sections focus on these competencies.

16. Knowledge Base

Culturally responsive teachers hold a knowledge base that emerges out of historical and theoretical foundations similar to what has been discussed above. This includes a grounding in a multicultural perspective of U.S. history and a comparative grasp of the difference between expressed democratic ideals and actual institutional practices. Specifically, culturally responsive teachers need to be aware how the concepts of White privilege and property rights can be manifested in contemporary political, economic, and educational systems through various forms of biases and racism, including color blindness. Underlying this foundation is an understanding that citizenship rights have not always been able to be exercised equally by all groups of people and the subsequent economic effect that this has had on schooling, housing, and employment opportunities for populations of color. These studies also include the historic opposition and resistance by people of color to acts of oppression, especially as pertains to access to educational opportunities such as rigorous academic courses taught by qualified teachers.

Teacher inservice and preservice education for CRT includes in-depth multicultural education in combination with contemporary research on effective teaching. A knowledge base steeped in constructionist theory and practice is vital to counter a transmission approach that is problematic for implementing a student-centered pedagogy like CRT. CRT necessitates a background in learning theory and human development that is based in social psychology and analyzes individual students within cultural and social contexts. Important is an understanding of the rationale behind democratic classroom management approaches that are welcoming, participatory, and inclusive of cultural diversity. Critical is a research background on heterogeneous cooperative learning and its value in regular application for students who come from population groups who have been historically marginalized in public schools and are likely candidates to exit school before twelfth grade.

Ideally culturally responsive teachers will have had a preservice field experience that can provide them with the experiential knowledge of a working in a culturally diverse setting. This kind of field experience is most effective before a student teaching internship when combined with critical reflection that is connected to issues of equity and effective teaching research. Providing preservice teachers with well-designed experiences with culturally diverse populations in communities and K-12 schools continues to offer the possibility of

expanding multicultural understandings that appear necessary for culturally responsive teachers.

Culturally responsive teachers are well informed about their subject matter and are regularly investigating sources that can increase the multicultural perspective of their teaching disciplines. Teachers also learn about the communities and cultures from which their students originate and try to incorporate those orientations and resources into daily instruction. Culturally responsive teachers are lifelong learners of culture and its implications for teaching and learning in their particular settings. Therefore, CRT is enhanced by foundational academic knowledge in the study of culture.

Culturally responsive teachers have not only a knowledge base conducive to investigate local cultures, but they also need to have explored their own personal knowledge about their cultural and racial identity formation. With an understanding that their teacher identities are not fixed but subject to socialization, culturally responsive teachers can learn how their own socially constructed histories can potentially both enhance and impede learning in a culturally diverse classroom. This knowledge can be effectively gained through autobiographical or autoethnographical research based on appropriately structured multicultural writing prompts.

Building on their knowledge base, culturally responsive teachers need specific skills to create interactive group curricular experiences from an antiracist orientation that works toward prejudice reduction among students. Culturally responsive teachers demonstrate a proficiency to create a welcoming and inclusive classroom. This positive learning community environment permeates all classroom interactions under CRT and is conducive for student discussions on subject matter topics that allow for multiple viewpoints.

Culturally responsive teachers have the ability to implement a constructionist orientation to teaching and learning that allows students to have their voices and cultural backgrounds incorporated into curriculum and instruction. Effective CRT regularly uses cooperative learning, especially with well-designed heterogeneous group work. Culturally responsive teachers consider frequent use of heterogeneous cooperative learning central to the maintenance of an engaged classroom learning community. In this context, culturally responsive teachers know how to create assignments that permit small groups of students to collaborate on academic projects that are based on problem-solving skills. Paramount under a constructionist approach to CRT is the ability to design detailed lesson and unit plans that

make visible links among target learning goals, student/community cultures and interests, learning activities, and assessment.

CRT emphasizes high academic expectations in a curriculum that makes meaningful connections for students between academic knowledge and application. Culturally responsive teachers have the ability to effectively communicate these expectations regularly and compassionately to individual students who have historically struggled academically and/or experienced social alienation from their schools. The skill of active listening is imperative for culturally responsive teachers' effectiveness in conversations with individual students from culturally diverse backgrounds. Within their schools, skilled culturally responsive teachers advocate for their students of color by making a concerted effort to challenge negative attitudes and help ensure that all students are honored in the school, particularly those traditionally underserved.

The skill of critical reflection is practiced regularly by culturally responsive teachers. Through critical reflection, teachers' social definitions about the parameters of their professional work can be reexamined in the context of multicultural education reform goals. This skill constantly demands the willingness of teachers to reexamine the degree of their own cultural encapsulation and to use personal and public insights of cultural encapsulation to make culturally responsive contributions to student learning and school improvement activities.

17. Dispositions

Culturally responsive teachers exhibit their culturally responsive dispositions by classroom behaviors that create thoughtful and supportive learning environments and encourage self-directed learning by all students. Therefore, CRT values demographic diversity as an enriching social context and supports a just and caring society for children and youth. Culturally responsive teachers embrace diversity as an asset to a school, affirm the cultural backgrounds of students, and believe in high achievement goals for all students regardless of their race, ethnicity, or class.

High consensus exists among CRT scholars and practitioners that in order for teachers to be culturally responsive, they must develop and hold a multicultural commitment to the values of equity and cultural diversity. This involves a sociocultural disposition based in a critical consciousness about the world around them. Such teachers hold a transformative attitude toward educational inequities when conceiving and implementing curriculum. They are able to articulate an antibias/antiracist multicultural philosophy of education that informs their work. Importantly, culturally responsive teachers recognize when their own professional dispositions may need to be adjusted and are able to develop plans to do so.

18. Applications

Current research indicates that CRT is used across all disciplines. In its application CRT uses a transformational approach to teaching and learning. This involves changing the structure of the curriculum to enable students to view concepts, issues, events, and themes from the perspective of diverse racial and cultural groups.

Common elements exist when culturally responsive teachers have transformed the traditional curriculum. This transformative process includes helping students recognize strengths and significance of their cultures, families, and communities, and to see their own lives and perspectives as subjects worthy of study; studying subject matter concepts from the point of view of students' cultures in comparison to the way concepts are presented in textbooks; and providing opportunities for community members to witness the accomplishments of students through meetings, presentations, and exhibitions and, therefore, potentially increasing community support for the school.

Case study research suggests that culturally responsive teachers hold (1) a positive image of themselves and their students, (2) democratic and inclusive culturally sensitive social relations with their students and their students' communities, and (3) a conception of knowledge as socially constructed and capable of transformation. Culturally responsive teachers act to transform their classroom curriculum in traditional school settings so that they can more thoroughly provide students access to academic knowledge connections relevant to their own lives, a primary goal of CRT. Case study research also highlights and reflects other common characteristics of culturally responsive teachers: regards students as competent;

provides students challenging content built on students' prior knowledge; uses students' cultures to understand themselves, others, and the curriculum; and develops a positive student-centered learning community

Topic Objective:

At the end of this topic student would be able to:

- Understand Challenge of Middle School International Learners
- Overcoming the challenge
- Accommodations for Students with Special Needs
- Instructional Materials:
- Culturally Responsive Teaching
- Introduction to CRT

Definition/Overview:

Culturally Responsive Teaching: Culturally responsive teaching (CRT) is an educational reform that strives to increase the engagement and motivation of students of color who historically have been both unsuccessful academically and socially alienated from their public schools.

Key Points:

1. Challenge of Middle School International Learners

For many students immigrating from Foreign countries, prior schooling may not only have been intermittent as described in the above vignette, but may have also taken place in low-resource environments both in Foreign countries and in the U.S. While living in Foreign countries, many students may have resided in rural areas where schools were understaffed and limited in teaching and learning materials. [2] After moving to the U.S., Foreign countries

immigrant students are more likely to attend overcrowded, limited-resource urban schools with fewer certified teachers.[3] In North Carolina, migration lines have been traced from rural Foreign countries to specific North Carolina destinations. Not only do students come largely from rural schools in Foreign countries, but they often hail from families whose home language is an indigenous language rather than Spanish. Upon arrival in U.S. schools, these students are assumed to be native Spanish speakers, but may in fact be minimally proficient in Spanish. In addition, these students may have had no previous exposure to English upon entry into U.S. schools.[4]

Gaining literacy in English may become an increasing challenge for these incoming students. In addition to education and language gaps, students may also face social and cultural barriers to learning English. Immigration patterns show that incoming families move into relational and geographic enclaves due to social and economic forces.[5] This may add to the social and linguistic segregation experienced by Latinos and make the task of learning English through day-to-day interactions with English speakers difficult. In addition, Jim Cummins has underlined a delay between the acquisition of oral language and academic language pertinent to the experience of English language learners (ELLs).[6] Students need an estimated five additional years of schooling to become proficient in academic reading and writing, such as reading science or social studies textbooks, after reaching oral English proficiency.

Teachers in the U.S. may assume an ELL has sufficient proficiency to read and understand academic tasks at the middle school level when they hear a student speak basic English, which leads to a lack of support and increasing rates of academic failure among ELLs. Without additional tutoring, the student may simply lose interest, run out of energy to surmount the ever-growing language and content hurdles, and eventually drop out. Indeed, the dropout rate from eighth to ninth grades sharply increases in North Carolina from around 3% in eighth grade to about 32% of all dropouts occurring in ninth grade.[7] Students may make it through middle school with difficulty, then decide to drop out when high school starts and academic pressures increase. In North Carolina, Latinos show disproportionately high rates of dropout at over 7%.[8]

2. Overcoming the challenge

Social and cultural capital (a network of people and resources from which the student gains support) are often discussed in research and writing on Latino students. *Academic instrumental knowledge* as a subset of social and cultural capital refers to school-specific knowledge as a type of cultural capital.[9] Many children of immigrants are at a disadvantage when it comes to understanding how U.S. schools function. In 1990, the average Foreign countries immigrant in the U.S. had 7.6 years of schooling. In 2002, 20% of the population in Foreign countries had no schooling compared to 0.6% of the population in the U.S.[10] Schooling experiences, thus, are less prevalent on the whole for parents of current incoming Foreign countries students, so access to the academic instrumental knowledge needed to help their children succeed is limited.

How can teachers and schools help students overcome the middle school challenge? Teachers and schools must work hand in hand with students, but also with the students parents to enlist support and build solutions.

Rueda, Monzo, and Arzubiaga outline an intervention process that works with parents and students using an additive approach.[11] For example, schools and teachers find links between parents knowledge and practices about literacy and the schools literacy approach. Then, schools promote a negotiation of these in relation to the students literacy.

The ALAS project (Achievement for Latinos through Academic Success) in Los Angeles brought improvement in school retention for a group of seventh graders. The intervention included monitoring school attendance period by period and notifying parents daily of their childs attendance or truancy, training for the students on problem-solving skills, weekly or daily feedback to students and parents from teachers on behavior and schoolwork, training for parents on how to participate in schools and how to manage their childrens behavior, recognition and bonding activities for students, and connecting students and families with community services.[12]

Research on culturally relevant curriculum has also pointed out the increase in engagement among middle school students when Meso-american culture, language, and history is taught.[13] Tapping into families cultural capital and knowledge are critical to engaging the student and the parents in the educational process. Curricular choices such as these can help

teachers understand the students background and skills, as well as open the door to a connection with the students parents.

3. Accommodations for Students with Special Needs

Rarely are there specific lesson plans for special education. Teachers take existing lesson plans and provide either accommodations or modifications to enable the student with special education to have optimum success. This tip sheet will focus on four areas where one can make special accomodations to support students with special needs students in the inclusive classroom. Those four areas include:

1.) Instructional Materials

2.) Vocabulary

2.) Lesson Content

4.) Assessment

4. Instructional Materials:

- Are the materials you select for the instruction conducive to meeting the child(ren) with special needs?
- Can they see, hear or touch the materials to maximize learning?
- Are the instructional materials selected with all of the students in mind?
- What are your visuals and are they appropriate for all?
- What will you use to demonstrate or simulate the learning concept?
- What other hands on materials can you use to ensure that the students with needs will understand learning concepts?
- If you are using overheads, are there extra copies for students who need to see it closer or have it repeated?
- Does the student have a peer that will help?

5. Vocabulary

- Do the students understand the vocabulary necessary for the specific concept you are going to teach?
- Is there a need to focus first on the vocabulary prior to starting the lesson?
- How will you introduce the new vocabulary to the students?
- What will your overview look like?
- How will your overview engage the students?

6. Lesson Content

- Does your lesson focus completely on the content, does what the students do extend or lead them to **new** learning? (Wordsearch activities rarely lead to any learning)
- What will ensure that the students are engaged?
- What type of review will be necessary?
- How will you ensure that students are understanding?
- Have you built in time for a breakout or change in activity?
- Many children have difficulty sustaining attention for lenghty periods of time. Have you maximized assistive technology where appropriate for specific students?
- Do the students have a element in choice for the learning activities?
- Have you addressed the multiple learning styles?
- Do you need to teach the student specific learning skills for the lesson? (How to stay on task, how to keep organized, how to get help when stuck etc).
- What strategies are in place to help re-focus the child, continue to build self-esteem and prevent the child from being overwhelmed?

7. **Assessment**

- Do you have alternate means of assessment for students with special needs (word processors, oral or taped feedback)?
- Do they have a longer time lines?
- Have you provided checklists, graphic organizers, or/and outlines?
- Does the child have reduced quantities?

Overall, this may seem like a lot of questions to ask yourself to ensure that all students have maximized learning opportunities. However, once you get into the habit of this type of reflection as you plan each learning experience, you will soon be a pro at ensuring the inclusional classroom works as best as it can to meet your diverse group of students which are found in most classrooms today. Always remember, that no 2 students learn the same, be patient and continue to differentiate both instruction and assessment as much as possible.

8. Culturally Responsive Teaching

Culturally responsive teaching (CRT) is an educational reform that strives to increase the engagement and motivation of students of color who historically have been both unsuccessful academically and socially alienated from their public schools. Specifically, culturally responsive teaching acknowledges and infuses the culture of such students into the school curriculum and makes meaningful connections with community cultures. Culturally responsive teaching is designed to help empower children and youth by using meaningful cultural connections to convey academic and social knowledge and attitudes.

This chapter presents an introductory overview of CRT, also commonly referred to as *culturally relevant* or *culturally congruent* teaching. Historical and theoretical roots of CRT are discussed. Specific knowledge, skills, and professional dispositions are examined, followed by a discussion of generic applications of CRT and future directions for CRT. The chapter concludes with bibliographic references and suggestions for further readings.

9. Introduction to CRT

CRT is a direct response to concern over an academic achievement differential and high school dropout rates based on race, socioeconomic class, and level of English-language ability. Demographically, this academic achievement gap is generally evidenced between (1) White economically advantaged students and (2) students of color, immigrant children, and students from lower socio-economic families. Examined from a school reform perspective,

CRT is a concept that signals a need to expand the customary professional knowledge base for teachers in order to close this achievement gap.

CRT is best understood as a response to traditional curricular and instructional methods that have often been ineffective for students of color, immigrant children, and students from lower socioeconomic families. CRT calls attention to schooling norms where White middle-class values and expectations are privileged while other cultural, racial, and economic histories and community backgrounds are overlooked or degenerated. In contrast to assimilationist teaching, CRT values and incorporates as appropriate a student's culture into instruction. In this regard, CRT is not only interested in providing mainstream knowledge through different techniques, but it also involves transforming the actual perspectives, knowledge base, and approaches of a conventional classroom's curriculum and instruction.

As the nation's student body continues to grow more culturally and racially diverse, the demographic composition of teachers remains extremely homogenous racially with nearly 90% of all teachers identifying themselves as White. CRT recognizes that the cultural identity of most teachers is significantly different than their increasingly diverse student populations. The educator and philosopher Paulo Freire (19211997) reminds educators that public education is a form of cultural expression, which left unexamined by classroom teachers, can create a disconnect for historically marginalized students. Hence, CRT provides support to the cultural identities of struggling students while striving simultaneously to raise academic achievement.

CRT works to build an inclusive and welcoming classroom and school environments that can create culturally appropriate approaches to raising academic expectations for all students. This involves teachers proactively using cultural knowledge and experiences of diverse students to establish a caring school climate. The purpose is to make learning more culturally relevant and effective for this particular population of students. In this way, CRT holds the potential to validate and affirm the cultural frames of references of all students as a means to help students attain their academic goals.

CRT is a student-centered strategy that embraces a learning community model for the organization of a classroom. CRT incorporates into classroom teaching and school policies and practices the cultural knowledge and assets of historically marginalized students and their communities and families. This approach rests on an equity pedagogy designed to rectify

educational conditions that have fallen short of facilitating the learning of many students from racially, culturally, and economically diverse groups. As an educational reform, CRT represents a growing shift away from equating student seat time in a classroom with learning and to evaluating teacher performance on the basis of student engagement and gains in academic learning.

A CRT goal is to actively engage all students in learning, a fundamental element of effective teaching. CRT recognizes that teacher effectiveness decreases when instruction is primarily teacher centered with an absence of student and community voices. CRT conceptualizes pedagogy as a two-way communicative process designed to decrease student passivity by placing student involvement at the center of teaching and learning. Rather than teachers defining their roles as just the transmitters of information, CRT calls on teachers to help students be active participants in the production and acquisition of knowledge. This requires teachers to acknowledge the conceptual and cultural resources or assets that culturally different students bring to their schools and then to affirm the backgrounds of all students. Without this acknowledgment and affirmation, teachers may be unable to utilize the background knowledge and experiences that students bring to their learning environments.

The National Research Council's Commission on Behavioral and Social Sciences and Education notes that teachers who are aware of the relationship between student learning and cultural variations in communications are apt to enhance necessary supports for the development of children and youth. Learning stems from a complex relationship among social, biological, and emotional elements in which intersections with an individual's cultural orientation must be taken into consideration. CRT helps in this developmen-tally appropriate learning process by making connections for students between schooling norms and the familiarity of home and cultural background. To reach this objective, CRT works to transform traditional educational norms of practice so that disparity is reduced between the cultural lives of students and their experiences with public schooling. Ultimately, it is the interaction between a teacher and a student that becomes a key learning site that can determine the degree of success for culturally diverse children and youth in public schools. For CRT, this involves purposefully incorporating aspects of the cultural perspectives of this targeted population into the everyday practices and instructional activities of the classroom. In this way a school can use multicultural frames of reference to help determine its policies and practices.

For effective CRT, teachers would need to expand and apply their multicultural knowledge, skills, and dispositions so that opportunities for student gains in academic achievement and a willingness to complete public school are improved. Preservice and inservice teaching education is the primary avenue by which teachers can learn how to create conditions of cultural expression that are more congruent with the backgrounds of their culturally diverse students and their families. Through CRT preparation, educators can better grasp how student cultural backgrounds affect learning and student development. This can lead to a multicultural commitment on behalf of educators, a professional disposition that is widely recognized as a foundational attitudinal component for the successful development of CRT.

10. Historical and Theoretical Foundations

CRT developed out of tensions within a society that aspires to unified democratic ideals and goals while being demo-graphically composed of a culturally and linguistically diverse multicultural population. The following section addresses CRT in a historical and democratic context specific to the United States. The emerging recognition of the costs of marginalizing students of color in the educational process is examined. CRT is further discussed in relation to multicultural education and critical pedagogy. The final section concludes with a presentation of the tensions around the concept of culture and its subsequent implications for CRT.

11. Historical Foundations

Amidst the U.S. Supreme Court ruling in the 1954 case *Brown v. Board of Education*, which declared separate schools for Black and White students unconstitutional, and President Lyndon Johnson's signing into law the 1964 Civil Rights Act, which ended legalized Jim Crow racial segregation in public facilities and housing, public awareness was growing about the cultural discontinuity for African American children and other students of color with mainstream public schools. Whereas some educators and policy makers described these differences as cultural deficits or disadvantages on the part of students of color and their families, educational reformers influenced by the aims of the civil rights movement turned

their attention to what they identified as deficiencies in the structure and curriculum of public schools. These civil rights activists contended that public schooling skewed advantage toward White middle-class students and ignored or punished the cultural orientations of students of color.

The civil rights movement helped to usher in the concepts and approaches of the modern reform movement of multicultural education. During the past 35 years, the multicultural education reform movement has advocated for a deeper understanding of the prospects to transform traditional schools into ones with a more democratic, inclusive, and civic face. Multicultural educators have consistently stressed the need for teachers to expand their cultural competence in relation to their own dispositions, knowledge base, and performance skills. Imbedded within this expectation is a desire to have a teaching force with a deeper understanding of the relationship of the school curriculum to a pluralistic society with particular attention to the needs of students of color. The legacy of the civil rights movement highlighted the need for a teaching force that can understand and interact effectively with diverse cultural groups outside the standard school boundaries and is able to provide curricular opportunities reflective of this diversity within schools.

CRT developed out of both the social cauldron of the civil rights movement and multicultural education reform efforts to expand democratic opportunities for all students and their families. Emerging conceptually in the 1980s, CRT came of age during the 1990s in an effort to meet the multicultural goal to have teachers who hold the knowledge, skills, and professional dispositions that are sensitive and responsive to the conditions of people historically placed on the margins of society's political and economic activities. Nevertheless, by the end of the first decade of the 21st century, students of color continued to constitute disproportionately high percentages among the estimated 1.2 million students who drop out of high school every year. Currently in the United States, approximately 68% of those who begin ninth grade graduate at the end of what would be their twelfth grade. Furthermore, for African American, Native American Indians, and Latino students, graduation rates hover around 50%, whereas for males in those groups the figure ranges from 43 to 48%. Researchers have found that by the age of 8, disparities between the cultural values and patterns of communication of the home and the school can diminish the desire of young people to learn and to believe in their own capacity to learn. Some students come to see schooling as detrimental to their own language, culture, and identity. In this historical and

contemporary context CRT is looked to as a potential solution to this seemingly entrenched racialized differential.

11. Democratic Foundations

Recent court decisions point to the expectation that an adequate education should include the preparation of economically productive citizens who can actively participate in a democratic society. These decisions find that an adequate education is constitutionally defined in relation to access and opportunity for learning. Like these court cases, the preeminent educational philosopher and practitioner John Dewey (18591952) had located the purpose of schooling in the larger context of a democratic society. He conceived of a democratic community founded upon goodwill that can result when individuals empathetically see across their self-interests and biasesbe they cultural or racialand work toward common learnings and understandings. In this context, Dewey warned against one group acting under the guise of benevolence by dictating to others what was in their best interest. Similar to Dewey, CRT literature promotes honoring and incorporating multiple cultural perspectives rather than defaulting to dominant monocultura! schooling norms of Euro-Americanism.

CRT is representative of both Dewey's democratic ideal and a manifestation of the schooling goal to educate young people to be informed and active democratic citizens. CRT strives to enact the Deweyian concept of democratic goodwill by teaching across and to significant cultural differences. Like contemporary CRT theorists and practitioners, Dewey chastised traditional schooling arrangements that dismiss the importance of an individual's relationship to the conditions of teaching and learning. To create a learning experience, Dewey contended that educators should account for how learning environments positively interact with the needs, abilities, and aspirations of individual students. Because he saw education as fundamentally a social process, Dewey recognized that personal experiences of students must be incorporated into the curriculum for learning to have a lasting effect. From a Deweyian standpoint, CRT as a learner-centered pedagogy acknowledges the importance of student's prior and current experiences for the long-range goal of the development of citizenship competencies.

Low-Status Students

A democratic goal of CRT is to close the disparity of academic and social opportunities observed primarily between students of color and White students. Prominent educational researcher Linda Darling-Hammond observes that structures of inequality in public education as evidenced in the distribution of funding, qualified teachers, courses, and instructional materials have been a part of U.S. history since the founding era. Research indicates that teachers need to recognize this condition of inequities in order to begin closing the achievement gap for those students habitually assigned low status and inferior academic competence. The Learning First Alliance finds that when schools support the academic progress of students, their engagement with school increases. Low-status students, according to researchers, are among those who lack opportunities to receive the equitable benefits of pedagogical approaches designed to help students acquire meaningful and engaging academic content that can help them meet school district and state learning standards, stay in school through graduation, and develop into active democratic citizens.

Low-status students include individuals whose academic rights have been historically marginalized by institutions and people in privileged positions. This discrimination continues to be experienced by many students of color, immigrant children, and students from low-income families. Based on her extensive research, Elizabeth Cohen found that from a democratic perspective, low-status students working, for example, in small learning groups often are limited in their participation and have their ideas disregarded by other students. When low-status/ historically marginalized students become disengaged in learning, teachers often see this as a discipline problem rather than a status problem that needs teacher intervention and support in order that such students can demonstrate academic competence. It is within this democratic context to help all students that CRT is situated.

12. Multicultural Education Foundations

CRT is an expression of multicultural education. Through multicultural educational approaches a culturally responsive teacher is theorized as contributing to the elimination of models of cultural deficiency by attending to the learning needs of low-status students with the expressed purpose to educate citizen-students who work to the ideals of a democracy. To varying degrees, CRT is viewed as an enactment of the reform goals and dimensions of multicultural education as articulated by James Banks.

Banks theorized a multidimensional concept of equity and schooling with five interactive dimensions of multicultural education. For Banks, each enacted multicultural dimension by culturally responsive teachers holds the theoretical potential to meet the broad goal to develop an educated democratic citizenry. He conceptualized the multicultural dimension *content integration* as an instructional approach where a culturally responsive teacher presents subject matter content from a variety of cultural perspectives. The dimension *knowledge construction* is when culturally responsive teachers can reveal to students how subject matter is constructed from particular racial and social class perspectives in contrast to dominant models that privilege Euro-American knowledge bases over those from culturally different groups. *Prejudicial discrimination reduction* entails for the culturally responsive teacher creating school and classroom opportunities for students to learn to develop more democratic attitudes and behaviors. The *equity pedagogy* dimension finds a culturally responsive teacher focusing not only on equality of learning opportunities but also consciously implementing strategies that assist those culturally diverse students who struggle academically. The final dimension, an *empowering school culture and social structure*, calls on the culturally responsive teacher to support efforts to restructure schools organizationally and culturally in order to increase for all students educational equity and cultural affirmations.

13. Critical Pedagogy Foundations

The concept of pedagogy in its contemporary usage is a perspective that envisions effective teaching as a process rather than a set of discrete techniques. Congruent with CRT, pedagogy as currently defined situates effective teaching more as two-way communication between teachers and students in contrast to the direct transmission of information to students by teachers. A teacher, then, practices approaches to teaching and learning that build relationships with and among students and focuses ultimately on how and to what extent students are learning. This definition of pedagogy mirrors research that finds achievement improves through active student participation in the learning process.

More specifically for CRT, *critical pedagogy* offers ways to look at teaching and learning that can bring to the forefront such concepts as ideology, hegemony, resistance, power, knowledge construction, class, cultural politics, and emancipatory actions. The underlying

concepts of critical pedagogy are theorized as necessary for teachers and their students to understand seemingly intractable conditions of social and educational inequities. CRT uses a critical pedagogy philosophical orientation to differing degrees when conceiving and implementing curriculum and instruction.

Identifying Dominant Practices

Unraveling issues of political dominance and oppression is a task that critical pedagogy attempts to undertake. Such work necessitates a knowledge base that analyzes how and why a dominant ideology supports a particular kind of political and economic arrangement that directly affects public school goals, policies, and practices in ways that can undermine the academic achievement of students of color. CRT theorists and practitioners find critical pedagogy as an approach where culturally responsive teachers can acquire a knowledge base that helps explain the existence of inequalities that can negatively affect the academic achievement of culturally diverse students. Freire noted that when inexperienced teachers from mainstream cultures find themselves working with culturally different students, students' language, values, and behaviors may be so different from their teachers' that the culture of those students may be deemed by teachers as strange and dangerous. Advocates for CRT contend that culturally responsive teachers must not retreat from such differences but should become themselves students of these differences as a means to know and help each of their students socially and academically.

Praxis

The concept of praxis has direct theoretical relevance to critical pedagogy and CRT. Freire (1970) explained that the discovery of oppressive conditions cannot be purely intellectual but must involve *action;* nor can it be limited to mere activism, but must include *serious reflection:* only then will it be a praxis (p. 52, emphasis added). When applied to teaching, praxis requires teachers to alter traditional norms of teaching and learning. Freire postulated that it is necessary to reduce the perceived distance and contradictions between students and teachers in order that both groups can share collaboratively in the teaching and learning process. Hence, praxis requires culturally responsive teachers to become a learner along with their students. At a minimum, this can involve culturally responsive teachers learning with and from their students about various cultural communities and backgrounds from which students come. Thus, the idea of praxis reminds culturally responsive teachers that it is not

enough to only identify unequal, racist, and undemocratic situations. By means of a pedagogy that is critical and imbedded with the concept of praxis, culturally responsive teachers are theoretically expected to work with their culturally diverse students and communities to help overcome inequities that may exist under mainstream arrangements of schooling.

14. Cultural Complexities

The concept of culture is complex, and efforts to narrow its meaning can have negative implications for student learning under CRT. Multicultural educator Sonia Nieto (2000) defines culture as the values, traditions, social and political relationships, and worldview created, shared, and transformed by a group of people bound together by a common history, geographic location, language, social class, and/or religion (p. 138). Culture defined as such is not a static entity that a culturally responsive teacher can easily identify because culture is interactive, affects a person's life, and is continually changing.

Cultural tensions underlie the emergence of CRT. Debates exist among scholars and practitioners who approach the racialized achievement gap as a function of cultural deficiencies. Others contend that the academic achievement differential is based on a lack of acknowledgment of the cultural assets held by culturally different students. This debate has led to an examination of the theoretical concept of learning styles as a means to better understand the learning needs of all students. The following sections describe these varying perspectives and their relationship to CRT.

Cultural Deficits/Differences/Assets

At various points throughout U.S. history, population groups who were not of Anglo- or Western European origins have been considered to be culturally deficient, disadvantaged, or deprived. The cultural deficiency model that was articulated in the 1960s and cyclically reemerges over time has led, CRT scholars contend, to discriminatory schooling conditions for students of color and those from low-income families. The cultural deficiency perspective assumes that children and youth who are culturally different from mainstream society need an education that assimilates them into dominant norms and behaviors and away from the cultures of their families and communities. From this point of view, minority students are

constructed as culturally disadvantaged by presumed deficits located within their cultural histories, beliefs, and conduct. Theorists who support a cultural deficiency standard tend to blame culturally different groups for their lack of economic and political gains and believe that a democracy must have a unified culture that is built on Anglo-European values.

Theorists countered the monoculturalist's cultural deficiency model by emphasizing cultural and ethnic differences. CRT emerged from this debate about an apparent lack of cultural congruence between the public school and the home life of students of color. Culturally responsive teachers who practice under a cultural difference model have been encouraged to learn about the various cultures of their students as assets rather than deficits and to incorporate those cultures into curriculum and instruction. A challenge for culturally responsive teachers, however, is avoiding a common tendency to stereotype students of color according to their ethnic or racial identification. This essentialized labeling can lead to narrow and simplistic understandings of the complexities of culture and what it means to students of color in the myriad settings in which they live and attend school. Additionally, some multicultural scholars question whether it is possible to attain culture congruence between the public school and the lives of culturally diverse students. To overcome these issues, researchers Luis Moll and Norma Gonzalez call for application of funds-of-knowledge approach that documents cultural knowledge from home visits. The funds-of-knowledge strategy can help culturally responsive teachers learn more about their students, apply this new cultural knowledge to the curriculum, and discover the heterogeneity within cultural groups.

Learning Styles

Although a popular construct, learning styles is a somewhat indeterminate concept in order to grasp the social-psychological dynamics of subject-specific learning. Approached from a CRT perspective, learning styles research indicates that teachers should know how to (1) incorporate the cultural context of teaching and learning into the curriculum by using the prior learning of students and including students' own personal cultural perceptions, (2) utilize affect in building interpersonal relationships with students, and (3) adjust teaching approaches that conflict with student learning styles. Nevertheless,

research on learning styles using culturally diverse students fails to support the premise that members of a given group exhibit a distinctive style. Clearly, learning-styles research is a

useful beginning in designing appropriate instruction for culturally diverse students, and not an end in itself. (Irvine & York, 1995, p. 494)

Yet, when learning styles are conceived in the context of instruction being culturally congruent, learning gains may accrue to marginalized students of color. The theoretical tension here is to recognize that individual students may have preferred learning styles that may or may not be attached to their cultural backgrounds.

Learning styles used simplistically can stereotype children of color and further stigmatize non-Western cultures. Research suggests that developmental learning needs of students from outside the dominant culture cannot necessarily be comprehended by teachers without analyzing students' experiences with the curriculum and how they locate themselves with a classroom's specific learning environment. Learning styles approaches that either negate or abridge cultural orientations and differences can be counterproductive to the achievement of children and youth living in subordinated cultures. Hence, the challenge for CRT is to identify those situation-specific cultural variables that may contribute or detract from student learning and to build a teaching and learning program around such knowledge.

15. Knowledge, Skills, and Professional Dispositions

CRT requires teachers to acquire particular knowledge, skills, and professional dispositions in order to effectively meet the social and academic needs of culturally diverse students. The following three sections focus on these competencies.

16. Knowledge Base

Culturally responsive teachers hold a knowledge base that emerges out of historical and theoretical foundations similar to what has been discussed above. This includes a grounding in a multicultural perspective of U.S. history and a comparative grasp of the difference between expressed democratic ideals and actual institutional practices. Specifically, culturally responsive teachers need to be aware how the concepts of White privilege and property rights can be manifested in contemporary political, economic, and educational systems through

various forms of biases and racism, including color blindness. Underlying this foundation is an understanding that citizenship rights have not always been able to be exercised equally by all groups of people and the subsequent economic effect that this has had on schooling, housing, and employment opportunities for populations of color. These studies also include the historic opposition and resistance by people of color to acts of oppression, especially as pertains to access to educational opportunities such as rigorous academic courses taught by qualified teachers.

Teacher inservice and preservice education for CRT includes in-depth multicultural education in combination with contemporary research on effective teaching. A knowledge base steeped in constructionist theory and practice is vital to counter a transmission approach that is problematic for implementing a student-centered pedagogy like CRT. CRT necessitates a background in learning theory and human development that is based in social psychology and analyzes individual students within cultural and social contexts. Important is an understanding of the rationale behind democratic classroom management approaches that are welcoming, participatory, and inclusive of cultural diversity. Critical is a research background on heterogeneous cooperative learning and its value in regular application for students who come from population groups who have been historically marginalized in public schools and are likely candidates to exit school before twelfth grade.

Ideally culturally responsive teachers will have had a preservice field experience that can provide them with the experiential knowledge of a working in a culturally diverse setting. This kind of field experience is most effective before a student teaching internship when combined with critical reflection that is connected to issues of equity and effective teaching research. Providing preservice teachers with well-designed experiences with culturally diverse populations in communities and K-12 schools continues to offer the possibility of expanding multicultural understandings that appear necessary for culturally responsive teachers.

Culturally responsive teachers are well informed about their subject matter and are regularly investigating sources that can increase the multicultural perspective of their teaching disciplines. Teachers also learn about the communities and cultures from which their students originate and try to incorporate those orientations and resources into daily instruction. Culturally responsive teachers are lifelong learners of culture and its implications for teaching

and learning in their particular settings. Therefore, CRT is enhanced by foundational academic knowledge in the study of culture.

Culturally responsive teachers have not only a knowledge base conducive to investigate local cultures, but they also need to have explored their own personal knowledge about their cultural and racial identity formation. With an understanding that their teacher identities are not fixed but subject to socialization, culturally responsive teachers can learn how their own socially constructed histories can potentially both enhance and impede learning in a culturally diverse classroom. This knowledge can be effectively gained through autobiographical or autoethnographical research based on appropriately structured multicultural writing prompts.

Building on their knowledge base, culturally responsive teachers need specific skills to create interactive group curricular experiences from an antiracist orientation that works toward prejudice reduction among students. Culturally responsive teachers demonstrate a proficiency to create a welcoming and inclusive classroom. This positive learning community environment permeates all classroom interactions under CRT and is conducive for student discussions on subject matter topics that allow for multiple viewpoints.

Culturally responsive teachers have the ability to implement a constructionist orientation to teaching and learning that allows students to have their voices and cultural backgrounds incorporated into curriculum and instruction. Effective CRT regularly uses cooperative learning, especially with well-designed heterogeneous group work. Culturally responsive teachers consider frequent use of heterogeneous cooperative learning central to the maintenance of an engaged classroom learning community. In this context, culturally responsive teachers know how to create assignments that permit small groups of students to collaborate on academic projects that are based on problem-solving skills. Paramount under a constructionist approach to CRT is the ability to design detailed lesson and unit plans that make visible links among target learning goals, student/community cultures and interests, learning activities, and assessment.

CRT emphasizes high academic expectations in a curriculum that makes meaningful connections for students between academic knowledge and application. Culturally responsive teachers have the ability to effectively communicate these expectations regularly and compassionately to individual students who have historically struggled academically and/or experienced social alienation from their schools. The skill of active listening is imperative for

culturally responsive teachers' effectiveness in conversations with individual students from culturally diverse backgrounds. Within their schools, skilled culturally responsive teachers advocate for their students of color by making a concerted effort to challenge negative attitudes and help ensure that all students are honored in the school, particularly those traditionally underserved.

The skill of critical reflection is practiced regularly by culturally responsive teachers. Through critical reflection, teachers' social definitions about the parameters of their professional work can be reexamined in the context of multicultural education reform goals. This skill constantly demands the willingness of teachers to reexamine the degree of their own cultural encapsulation and to use personal and public insights of cultural encapsulation to make culturally responsive contributions to student learning and school improvement activities.

17. Dispositions

Culturally responsive teachers exhibit their culturally responsive dispositions by classroom behaviors that create thoughtful and supportive learning environments and encourage self-directed learning by all students. Therefore, CRT values demographic diversity as an enriching social context and supports a just and caring society for children and youth. Culturally responsive teachers embrace diversity as an asset to a school, affirm the cultural backgrounds of students, and believe in high achievement goals for all students regardless of their race, ethnicity, or class.

High consensus exists among CRT scholars and practitioners that in order for teachers to be culturally responsive, they must develop and hold a multicultural commitment to the values of equity and cultural diversity. This involves a sociocultural disposition based in a critical consciousness about the world around them. Such teachers hold a transformative attitude toward educational inequities when conceiving and implementing curriculum. They are able to articulate an antibias/antiracist multicultural philosophy of education that informs their work. Importantly, culturally responsive teachers recognize when their own professional dispositions may need to be adjusted and are able to develop plans to do so.

18. Applications

Current research indicates that CRT is used across all disciplines. In its application CRT uses a transformational approach to teaching and learning. This involves changing the structure of the curriculum to enable students to view concepts, issues, events, and themes from the perspective of diverse racial and cultural groups.

Common elements exist when culturally responsive teachers have transformed the traditional curriculum. This transformative process includes helping students recognize strengths and significance of their cultures, families, and communities, and to see their own lives and perspectives as subjects worthy of study; studying subject matter concepts from the point of view of students' cultures in comparison to the way concepts are presented in textbooks; and providing opportunities for community members to witness the accomplishments of students through meetings, presentations, and exhibitions and, therefore, potentially increasing community support for the school.

Case study research suggests that culturally responsive teachers hold (1) a positive image of themselves and their students, (2) democratic and inclusive culturally sensitive social relations with their students and their students' communities, and (3) a conception of knowledge as socially constructed and capable of transformation. Culturally responsive teachers act to transform their classroom curriculum in traditional school settings so that they can more thoroughly provide students access to academic knowledge connections relevant to their own lives, a primary goal of CRT. Case study research also highlights and reflects other common characteristics of culturally responsive teachers: regards students as competent; provides students challenging content built on students' prior knowledge; uses students' cultures to understand themselves, others, and the curriculum; and develops a positive student-centered learning community

Topic : The Practice Of Effective Instruction

Topic Objective:

At the end of this topic students will be able:

- Acknowledge that teaching styles can lie at either of two extremes, teachercentered and student-centered, or someplace in between.
- Understand that Constructivism is a theory of learning that suggests students learn mathematics best when they can build or construct their own personal understanding of concepts and relationships.
- Recall that two key components of cooperative learning groups are individual accountability and positive interdependence.
- Recognize manipulatives as a key means of helping students move from concrete understandings to abstract understandings.
- Understand teaching exclusively to high-stakes test can be destructive to an effective mathematics curriculum.
- Appreciate the critical role small groups play in effective mathematics instruction.

Definition/Overview:

Classical or Traditional Methods of teaching: Examples of classical education include that of the Egyptian school, the rhetorical school during the last period of the Roman Empire, and the Confucius school. In Egypt, education and writing (hieroglyphs) were interdependent as the aim of societal literacy was the preservation of religious texts by the scribes (priests).

Key Points:

1. Teaching Styles

From the educational practices of Mesopotamia to current interest in technology infusion, a variety of ways to teach have been developed over the centuries. Models and methods often reflect the society's goals for education and its other values. Whether the student is an active partner in the process also varies over time. This entry summarizes the history of teaching methods and examines more closely two primary strands: traditional teaching and progressive teaching.

2. Historical Record

Models and methods of teaching, or different educational practices, date to the prehterate societies in ancient Mesopotamia (present-day Iraq). As city-states flourished (c. 3000-500 BCE), three major civilizationsthe Sumerians, Akkadians, and Babyloniansdeveloped the framework for the teaching of literature, writing, mathematics, and astronomy. Indeed, it was in the ancient Babylonian city of Ur that the tenets for the traditional or didactic model of teaching and learning are evident. Clearly, the Babylonian school curriculum centered on the memorization of literary works, emphasis on cuneiform script, and the focus on mathematical achievement; the teaching methodology was one of drill and practice reflecting the basic levels of what modern-day educators will identify as Bloom's Taxonomyknowledge, comprehension, and application.

Around the sixth century BCE, the Greeks established questioning and experimentation as educational practices in their quest for the foundations of a democratic system of government. In China (c. the fifth century BCE), Confucius focused his teaching methods on ritual and discipline toward formulation of ethical conduct and a cohesive social structure. Socrates, the Greek philosopher, affirmed the art of questioning as the essence of intellectual reasoning or *logos* (Greek for logic). The Socratic model became the catalyst for two eminent building blocks in the history of teaching and learningempiricism and critical thinking. These constructs were to constitute the higher-order thinking skills in the Western mind and, thus,

align with Bloom's higher-order thinking skillsanalysis, synthesis, and evaluation. Aristotle emphasized empiricism and critical thinking in his Lyceum (school), and his legacy transcended through the Middle Ages, the Renaissance, and the Enlightenment to the present day.

The methods of teaching in the twenty-first century are grounded in the classical or traditional practices of the ancient world and the modern-day progressive theories of Bloom, Dewey, Freir, and Perry, to name a few.

3. Classical or Traditional Methods

Examples of classical education include that of the Egyptian school, the rhetorical school during the last period of the Roman Empire, and the Confucius school. In Egypt, education and writing (hieroglyphs) were interdependent as the aim of societal literacy was the preservation of religious texts by the scribes (priests). In this context, teaching was focused on the writing of moral essays in preparation for the development of a disciplined mind. In Roman education, participatory citizenship was the main objective of a teaching methodology where students learned the art of rhetoric through speech exercises that focused on the recitation of poetry and the characterization of historical figures such as Ulysses. In China, Confucius focused his teachings on the symbiotic relationship between ethical conduct toward an acceptable social order and political philosophy and the individual's existence. Confucius promoted the idea of relying on classical works and influenced the development of comprehensive assessment that was to transcend through centuries.

In essence, the classical or traditional methods of teaching, then, focused on an integrative framework, where a didactic in lieu of a critical theory prevailed, through a teacher-centered learning environment in an effort to produce good citizens. In this context of teaching practices in the ancient world, it is worthy to note that these societies were homogeneous within themselves, notwithstanding the salient dichotomy between an upper and lower class structure and, thus, the absence of an egalitarian system of education.

4. A Progressive Pedagogy

In the *Yale Report of 1828,* Jeremiah Day, president of Yale University, launched the campaign to uphold the classical curriculum as an imperative for the discipline and furniture of the mind. Albeit the content of the Canongreat works of literature throughout the agesserves as the knowledge base for the understanding of the human experience, the context of how and not necessarily what to teach is the topic of debate among all educatorsfrom K-12 to post-secondary levels. Terminology such as a constructivist approach to teaching, critical literacy, experiential learning, service learning, and student-centered learning (to name a few) is commonplace as educators work to identify those methods of teaching that will develop critical thinking skills in all students in spite of a diversified student population across schools, colleges, and universities.

Whereas the didactic model of education tends to place the teacher at the center of the learning process, teaching that is critical focuses on the construction of a learning environment where students are active members through stimulation of intellectual curiosity, while respecting each other's cultures as well as learning styles. Within this context, the teacher's or professor's repertoire of methodology or practices should be one where there is a balance between memorization of facts, as necessary, and the evaluation of constructs.

Some examples of critical theory teaching methodology include active learning, technology infusion, and experiential learning.

Active Learning. As in the schooling of ancient Roman times, poetry may be a powerful teaching tool toward conveying the relationship between the human experience and/or culture and a democratic society. In a critical theory or critical literacy platformone where the teacher takes into account the diversity of learnersselected works (poems or prose) may be identified that allow students to connect their personal experiences to the work. In this context, students can work in small groups and analyze the issues behind the literary work, given a specific period in history. Such a methodology is reflective of John Dewey's philosophy of progressive education, rooted in hands-on learning, as well as Paulo Freire's pedagogy, which stresses dialogue.

Case study analysis calls for a collaborative, action-learning environment whereby the balance between knowledge base (content) and its application through discussions, vis--vis

analytical writing, become essential for the ultimate evaluation of a problem or situation. Within this scenario, students must consistently practice Socratic questioning as they engage in individual as well as group reflection. Indeed, case study analysis can take the place of a formative-type assessment or continuous learning experience, while emphasizing student engagement, oral and written communication skills, and higher-level thinking.

Technology Infusion. Modern-day technology may be used effectively at the K-12 and postsecondary levels toward maintaining the balance between the what and the how to think. In the elementary grades, for example, visual images serve to stimulate intellectual curiosity about different ethnic groups, forms of artwork, and so on. These images may provide the introduction to cultural awareness, which will later translate to questioning and reflecting about students' own communities and, ultimately, the world around them.

At the university level, the use of discussion forums, where students must post questions in response to others within a synchronous (limited time-frame) context, will provide opportunities for prompt analysis, synthesis of information, and evaluation of an issue or problem. Such an exercise will require all students, in spite of the diversity in learning styles, to become active learners and think holistically about the role of technology as one of several interdependent factors that frame today's global arena.

Experiential Learning. Perry's theory of contextual relativismthe connection between an individual's experience and the intellectual realmis evident in experiential learning opportunities. The portfolio development approach used by some colleges and universities enables students to reflect on prior learning or work experience through comprehensive journal writing. This exercise calls for students' self-reflection as they analyze, synthesize, and evaluate information.

5. Learning Style

Learning style is a term used to portray individual differences in the way that people prefer to learn. Learning styles are typical patterns individuals use to process information or approach learning situations. These learning style preferences are thought to occur naturally. According to learning style theory, when an individual's learning preferences are met, the individual

learns more easily and effectively. There are more than 70 theories and models of learning styles. Each model describes how particular kinds of individual differences influence learning. However, the kinds of individual differences and the ways that these differences influence learning vary considerably among theories. Although it is not possible or useful to summarize all theories, a few models that are frequently cited and described in the learning style literature are overviewed here and used as examples. Cautions and guidelines for using learning style information will also be discussed.

6. Importance

An underlying assumption of learning style theories is that individual differences in learning preferences are positive and useful and that both learners and teachers will benefit from becoming aware of, and understanding, learning style information about themselves and others. Also implicit in these theories is the idea that it is important to acknowledge learner diversity and to customize and individualize learning so the needs of all learners are met. When learners understand how they prefer to learn, they can seek preferred learning settings and learn to cope with settings that do not align to their learning preferences. Teachers, administrators, and program planners can use learning style information when planning teaching strategies and learning activities, evaluating learning, and developing programs and curricula. Teacher education about learning styles will help teachers recognize their preferred learning and teaching styles and provide alternative ideas and strategies to help teachers incorporate multiple teaching strategies to facilitate the needs of individuals with different learning styles.

Many models assert that the process of self-awareness of how one learns may be the most useful part of learning style information. In many models learning style information is seen as a key component in learning to learn. When learners understand how they prefer to learn and find ways to incorporate their learning preferences into a variety of learning settings, they can become more effective learners. Thus, the purpose of learning style information is to increase learner awareness about how they prefer to learn, so that they can learn more effectively. Learners who understand their own learning styles can also recognize and seek learning situations that match their preferences and learn to develop skills and strategies for success in conditions that do not match their learning preferences.

7. Are Learning Styles Modifiable?

Individual differences in learning style can be seen as preferences or as stable traits. In most learning style models, a learning preference is not thought to be the same as a trait or ability. However, in some theories, learning styles are thought to be relatively fixed characteristics or traits inherent within individuals. When learning styles are seen as relatively stable or unchanging, the theory's emphasis is on the need for teachers and trainers to adapt learning strategies and settings to accommodate the needs of learners with different learning styles. Within these models, it is often proposed that it is essential for teachers to be aware of all learning styles and to be able to accommodate them. Teachers are encouraged to present the same information in multiple formats and to provide optional learning assignments and options.

However, matching learning to the learner's style is not always possible. Most theories tend to see learning style as somewhat adaptable and assert learners can succeed in a variety of learning tasks, settings, and situations. In these models, learners are encouraged to identify their learning preferences and utilize strategies aligned to their learning style to maximize their learning. Learners are also encouraged to identify learning situations that are challenging and then develop learning skills and strategies to manage their learning in these situations. In models that conceptualize learning style as modifiable, often the focus is on becoming aware of preferences while, at the same time, recognizing and learning to adapt to learning tasks and situations that do not align with an individual's learning style.

Some models place learning styles within steps or stages of a learning process. In these models, learning is usually conceptualized as a multistep process. Learning style is seen as a preference for a particular step within the learning process. Because learning requires all steps in these models, learners are encouraged to expand and develop learning skills and strategies to complete the nonpreferred parts of the learning process.

Consensus indicates that learning style describes natural and innate preferences for learning. However, the literature also makes it clear that learning style preferences are not to be seen as limiting or defining. Everyone can learn to thrive in nonpreferred learning situations, as

necessary. However, when natural learning preferences are identified and supported, learning is easiest and most comfortable.

8. Learning Style Models

There have been various attempts made to organize learning style models into groupings. Some classification systems organize models on the basis of how stable or flexible learning styles are thought to be. Other classifications are made based on the various influences on learning, such as learning modality preferences, personality preferences, social or emotional aspects, and preferences for particular cognitive processes. Still other models focus on the process of learning and individual preferences for engaging in parts of the learning process.

To simplify a complex topic, three general kinds of learning style theories will be overviewed: those focusing on input of information, which will cover preferences for sensory input and learning environments; those focused on the cognitive processing and organization of information; and those developed around a learning process. Although there are more than 70 different models, only a few of the most often-cited and well-established models will be discussed.

9. Perceptually and Environmentally Based Learning Style Theories

Some theories propose that sensory input or environmental preferences are key aspects of learning style. These theories focus on preferences such as the sensory modality in which information is provided, preferred activity level of the learner, and specific characteristics of the physical learning environment that may impede or enhance learning.

One popular way of looking at learning style is by preference for visual, auditory, tactile, or kinesthetic sensory modes. Seeing, hearing, touching, and doing may be more or less preferred by an individual learner. It is assumed that individuals will learn more easily and remember better if information is presented in one or two of these modes. Visual learners will prefer written or visual instructions and will observe and remember visual resources. Auditory learners will prefer verbal instructions, find discussion helpful, and remember what

is said. Tactile learners will want to touch and manipulate learning materials and will remember best when they can handle materials. Kinesthetic learners will prefer hands-on active experiences and will remember best when they can move around or become physically involved with learning materials.

A learning style model by Rita Dunn and Kenneth Dunn builds on this basic sensory preference model and suggests there are at least 18 basic elements that influence how well an individual will take in and retain information. These elements are linked to four modalities: environmental, emotional, sociological, and physical. The physical modality includes the four sensory modality preferences (auditory, visual, tactile, and kinesthetic) as elements. Their model also includes three other physical modality elements: preferences for intake of food or drink, time of day, and mobility. Environmental elements include noise, temperature, and design of learning space. Sociological elements include preferences for learning with others, presence of authority, routines, and need for approval of others. Emotional elements include motivation, responsibility, persistence, and need for structure. In this model, all of these elements combine to form an individual's learning style. When these elements are in place, learning will be enhanced.

Some learning style models explore other kinds of perceptual differences among learners. Herman Witkin explored how an individual's perception was influenced by the context or field the information is contained in. He found two kinds of perception: field-dependent and field-independent. Field-dependent perception learners are influenced by the visual field in which visual information is presented, whereas field-independent learners are not. He then asserted field-dependent learners will perceive information globally and will have a social orientation to the learning. Field-dependent learners will thrive in more personal learning settings and when learning information that is personally relevant. Field-independent learners will perceive information analytically and will have an impersonal orientation to learning. They will thrive in learning settings that provide opportunities to ask questions, solve problems, and work independently.

10. Cognitive Processing Models

Many learning style models describe differences in the way a learner prefers to process information. Sometimes these models refer to cognitive processing styles rather than learning styles. The term *cognitive style* is used in various ways in the learning style literature. Cognitive styles are sometimes conceptualized as a part of an overall learning style; when thought of this way, it describes how individuals approach cognitive tasks rather than how they approach learning overall. However, in many models the terms *cognitive style* and *learning style* are used interchangeably. Similarly, in different models, the terms *thinking styles* and *intellectual styles* are also sometimes used to describe learning style preferences, as well as alternatively proposed as a component of learning styles.

In general, cognitive processing models of learning styles propose dichotomies of individual differences. These models usually acknowledge that both sides of a processing dichotomy are important parts of the learning process. They assert that individual learners will prefer one side of each dichotomy and will find it easier to learn when this preference is accommodated in the learning situation. These differences are given a variety of names and are described in different ways, depending on the specific model; generally, however, they fit into three dichotomies: abstract versus concrete, sequential versus simultaneous, and action versus reflection. Models that incorporate social aspects of learning include an additional dichotomy: logical versus personal.

Learners with a concrete learning style prefer to learn about relevant, practical, and useful information. They are drawn to learning that can be immediately applied in their current situation. Learners with an abstract learning style prefer learning about ideas and concepts. They are drawn to theory and enjoy linking and connecting ideas. Sequential learners prefer a step-by-step approach to learning, whereas simultaneous learners prefer to process information in a nonordered, more random way. Simultaneous learners tend to focus on more than one fact or concept at a time, whereas sequential learners tend to take on one piece of information at a time. In some theories, simultaneous processing is also referred to as *random processing*.

Action-oriented learners prefer to interact with others and with materials when they are learning; they are stimulated by discussions and other opportunities to share ideas and information with others. Reflective learners, on the other hand, prefer to have time to think

about material. They process information most effectively when they are alone. Learners who prefer a logical approach to learning are described as objective and tend to prefer frank, corrective feedback from a competent expert. Individuals with a values-based approach prefer cooperative and collaborative learning settings and like to receive positive feedback and support from an approachable, personable teacher.

Anthony Gregorc, in his mind styles model, proposes combinations of two processing preferences to delineate four learning styles. Gregorc uses the concrete versus abstract dichotomy to describe how learners perceive and understand information. He then adds a second dichotomysequential versus randomto describe how learners organize and order information. When these processing preferences are combined, his model results in four distinct learning styles: concrete sequential, abstract sequential, abstract random, and concrete random. An emotional and logical dichotomy is also incorporated into the model. For example, an abstract sequential learning style is characterized as logical and analytical, whereas an abstract random learning style is characterized as sensitive and emotional. An individual may have one strongly preferred learning style or may learn best with a combination of two or more styles.

Theories built on the personality type theory of Carl Jung link abstract and simultaneous processing. In personality type models, this preference is referred to as Intuition: a preference for taking in abstract information about ideas, theories, and concepts. This theory also links preferences for concrete and sequential learning. In the personality type model, this preference is referred to as Sensing: a preference for taking in information gained through the senses that is related to real-world experiences and applications. Personality type theory also proposes dichotomies between action and reflection (Extraversion and Introversion) as preferred orientation to the world, between logical and personal information processing (Thinking and Feeling), and between a structured and flexible approach to the environment (Judging and Perceiving). Because this model uses four dichotomies, the various combinations of preferences lead to 16 distinct learning styles with individualized learning preferences. Some learning style models simplify personality type theory and use differences in two of the four dichotomies to describe four learning styles.

Left- and right-brain models provide another way of looking at cognitive processing. In these models, the processing differences are verbal versus visual-spatial, sequential versus holistic, and logical versus emotional. Building on the idea that there are biological differences in the

way the different sides of the brain process information, these models assert that the left side of the brain prefers to process information verbally, sequentially, and logically, whereas the right side of the brain processes information in a visual-spatial, holistic, and emotional manner.

Ned Herrmann created a learning styles model based on mental preferences or thinking styles from right- and left-brain models. In his model, there are four styles: the Theorists (rational), Organizers (safe keeping), Innovators (experimental), and Humanitarians (feeling). The Theorist learning style is characterized by preferences for logical analysis. Sequencing and structuring information characterizes the Organizer learning style. The Innovator learning style is characterized by preferences for exploration and self-discovery, and the Humanitarian learning style is linked to emotional involvement and harmony. In his model, Herrmann asserts that it is difficult for learners to accommodate information presented in opposing styles. For example, a learner who prefers an Organizer learning style may have difficulty accommodating Innovator styles, or a learner with a Humanitarian learning style may find it difficult to accommodate a Theoretical style.

11. Learning Process Models

Some models, such as the one by David Kolb, propose that learning occurs in a process or cycle. Each part of the learning cycle requires the use of different combinations of processing preferences. In his model, the processing dichotomies (abstract vs. concrete and action vs. reflection) are not only linked to individuals' learning preferences but also incorporated into a defined learning cycle. In his model, the learning process begins with a concrete experience. Then reflective observation occurs, followed by abstract conceptualization and active experimentation. Learners tend to prefer one part of the learning process to the other. As a result of these preferences, four learning styles are proposed: abstract conceptualization combined with active experimentation (converging learning style), concrete experience combined with reflective observation (diverging learning style), abstract conceptualization combined with reflective observation (assimilating learning style), and concrete experience combined with active experimentation (accommodating learning style).

Peter Honey and Alan Mumford built on Kolb's work to identify four different learning styles. They proposed that learning comprises four steps: experiencing, reflecting, concluding, and planning next steps. Individuals tend to prefer one or two steps in the process over the others, so the four steps in the learning cycle link to four learning styles. The four styles include activists, who prefer to actively engage in experiences when learning; reflectors, who prefer to review or ponder experiences; theorists, who analyze and make conclusions; and pragmatists, who plan next steps. Similarly, Bernice McCarthy elaborated on Kolb's model. She linked the abstract versus concrete and action versus reflection processes to left- and right-brain functions. McCarthy proposed four learning styles within these new dimensions. In these process-based learning style models, learning styles are thought to be modifiable. Effective learners need to utilize all four steps. Learning style information helps them understand what steps they prefer and provides insights into how to develop underutilized steps.

12. Measuring Learning Styles

From the various theoretical models, there are at least a hundred inventories developed to measure learning styles. Many of these instruments have not been subjected to stringent test construction, and because of this, some practitioners and researchers question the use of learning style inventories.

Many of these inventories do not have demonstrated repeatability or accuracy, so it is important for practitioners to assess the reliability and validity evidence provided with a learning style measure to determine if it is based on sound psychometric principles. Even when a reliable and valid instrument is used, most instruments have not yet demonstrated a clear link between learning style and an individual's ability to learn certain kinds of information or thrive in specific learning environments. For example, if a learner does succeed in an environment that is not aligned to his or her learning style, it is difficult to know if this success indicates that learning styles are not important. Such a finding may alternatively indicate the learner has been able to adapt to that setting. Researchers cannot easily know if learning was more difficult or uncomfortable in that situation than it would have been in another environment.

The plethora of terminology and the large number of models and inventories contribute to the difficulty of surveying and assessing learning style inventories. As with many kinds of applied research, multiple interest groups in various settings, including academics, schools, and businesses, are developing learning style measures. These various interest groups have different aims and approaches, and there is little integration of the information gathered about the instruments used in each sector. There is also a large interest in the commercial applications of learning style inventories. A commercial focus can lead to research and promotional material that is focused on marketing a product rather than demonstrating the reliability of the inventory or the validity of a model.

Many learning style inventories use a self-report format. Self-report instruments are subject to error if learners are unaware of, or unable to, accurately report their preferences. If learning style measures are to be a tool for self-awareness, those taking them must be able to use metacognitive skills to accurately evaluate themselves. When using these kinds of measures, it is always important to use the results only as a guide and explore possible reasons for inaccurate results. Some administration instructions for using learning style inventories do include a self-validating process whereby learners think about, and can override, results on an inventory. However, it is possible that not all learners have the skill to engage in this kind of reflective, self-awareness process.

It is also important to ensure the results of learning style indicators do not limit or stereotype learners so as to discourage them or have them dismiss certain ways of learning. For example, some information is more abstract than concrete. If a learner believes he or she cannot learn abstract information because he or she has a concrete learning style, then the learning style information has limited rather than benefited the learner. It would be more useful to show the learner how to ground the abstract information in a concrete way or to teach other similar learning strategies for thriving in this situation.

It is possible to use observational data and meta-cognitive questioning as well as inventories to help students become aware of their learning preferences. For example, Barbara Given has created a methodology for assessing learning styles that incorporates information from many models within an observational and self-report format. This model considers emotional, social, cognitive, physical, and metacognitive aspects of learning preferences.

13. Validity of Learning Styles

With all of the different theories, models, and inventories of learning styles, it is difficult to know which ones are valid. Likely there are a number of individual differences and preferences in the way a learner absorbs and retains information and interacts with others in a specific learning situation that affects the ease of learning and comfort the learner experiences. Reviews of learning style models and instruments conclude that there is a lack of definitive evidence that would demonstrate the adequacy and validity of any one approach to learning styles. Reviewers often mention the importance of considering the context and purposes for learning style information when assessing and choosing to use a particular model or instrument.

When critiquing the learning style literature, it is important to understand the connotation of the labels and terminology used. For example, the word *abstract* is used in several learning style models. However, what is meant by *abstract* and the characteristics of learners who prefer abstract learning can vary greatly. To use learning style information, practitioners need to be able to sort through the multiple models, terminology, and concepts associated with learning styles to find a model that works in their situation. This can be accomplished by critically assessing the strengths and limitations of specific models. For example, if the purpose of learning style information is to help individuals understand how they prefer to learn, models with defined support resources and applications will be more useful than those that do not provide this link.

It also is important to ensure learning style models are not too limiting. This can be the case when learning styles are conceptualized as either/or. For example, it may be unwise to characterize a learner as experiential if this infers they are not reflective. This kind of characterization might indicate an experiential learner cannot reflect or will struggle in situations that require reflection. Such categorization has not been demonstrated and may provide a mind-set in which learners unnecessarily avoid or feel inadequate in certain learning situations.

Some researchers propose it would be most effective to take an integrated approach to defining and describing learning styles by including a number of models and dimensions for learners to consider as they are thinking about and identifying their learning preferences. Such models would include sensory preferences, environmental preferences, instructional

preferences, social and emotional learning aspects, and thinking or cognitive style preferences. Ultimately, learning style information is a tool to be utilized carefully by teachers, educational planners, and learners, with an emphasis on an increased awareness of learning and teaching preferences, on learning how to adapt to and manage all learning situations, and on enhancing learning and teaching effectiveness. Perhaps it is the process of helping students and educators to think about and determine their learning preferences that is more important than any specific model used to carry this activity out.

14. Cultural Combination of Teaching and Learning Styles

The unique ways in which students learn and teachers teach, or learning and teaching styles, are closely related to cultural values and personality types. Matching preferred styles can prevent school failure, enhance success, and motivate students to stay in school and develop talents to their fullest. Matching students' preferred styles can also make the teaching experience more satisfying for educators and can increase the effectiveness of educational programs. However, as American society becomes more complex and diverse, schools and teachers are finding it more difficult to identify and match the preferred cultural and cognitive styles of students.

Cultural styles reflect virtues and philosophies of life that are emphasized by families, communities, and cultures. As one component of learning styles, they serve as guideposts or markers that children use as they move through life in search of the careers and the life goals they find meaningful and fulfilling.

A second major component of students' unique learning styles and teachers' instructional styles is cognitive styles. These are styles of personality that determine how students like to learn, the ways in which they prefer to relate, the types of rewards that make success in school meaningful, the preferred manner of communication, and leadership style. Cognitive styles are related to cultural styles through the process of socialization and instruction by parents, other authority figures, and cultural experiences in the home and community.

By the time children attend school, they have developed specific cultural and cognitive styles that are related to how they like to learn and how they process and retain information. These

cultural and cognitive styles may or may not be compatible with their instructors' teaching styles and the cognitive and cultural styles emphasized by the schools they attend. Some cultures and families emphasize emotional IQ, or the importance of understanding people and relationships, and emphasize being a helpful and spiritual person who is a contributing member of a family and society. Instruction by adults is largely done by modeling and demonstration while simultaneously discouraging deviation from set practices and procedures. Other families and cultures tend to emphasize the value of traditional educational skills such as reading and math, and the importance of the individual is emphasized over that of the group. Instruction in these families is largely transmitted through trial-and-error learning where the child is encouraged to learn and to work independently of adults.

This entry focuses on how teachers, schools, colleges, and universities can become more sensitive to the preferred cultural and cognitive styles of students regardless of familial and cultural background. It is argued that the ultimate goal of education should be to identify the uniqueness of learners, and to individualize instruction in order to match the individuality of expression in learning environments. Specifically, the goal should be to match preferred student styles and worldviews in order to ensure enthusiasm for learning and success, thereby enhancing the adaptability and flexibility necessary to live happily and meaningfully in a diverse society and a global world.

15. Encouraging Development of Cultural and Cognitive Style Flexibility

The cultural and cognitive flex model applies the philosophy of cultural and individual democracy to educational environments. Horace Kallen introduced cultural democracy in response to the concern expressed by some segments of American society that some immigrants were slow at becoming Americanized. Observing a continuing persistence of languages, values, and lifestyles associated with nations and cultures of origin, Kallen suggested that it was necessary to adopt a cultural democracy perspective rather than a melting pot ideal for American society. That is, rather than insisting on forced enculturation to the American way of life, cultural democracy, derived from the idea of political democracy, would allow development of flexibility of beliefs and ways of life. It would give citizens the option to remain identified with their culture of origin while they adopt

mainstream American culture. What Kallen proposed was an alternative to the melting pot; an opportunity for the development of bicultural or multicultural orientations to life.

Ramirez and Castaneda proposed that if cultural democracy were applied to education, it would facilitate the development of cultural and cognitive style flexibility in students regardless of ethnic origins. Specifically, cultural democracy was perceived as a philosophical precept that recognizes that the way a student communicates, relates to others, seeks support and recognition from his or her environment, and thinks and learns is a product of the value system of his or her home and community. When students are allowed to use their preferred cultural and cognitive styles, they achieve success and can proceed to learn their nonpreferred learning style. Through this process, students become bicultural and bicognitive. They become Americanized, but they also retain their identities with their original cultures. Individual democracy in the context of education, introduced by John Dewey, concluded that a society that constricted individuality would lose sight of democratic principles. He emphasized that public policy should respect whatever is unique and distinctive in each individual.

Research by Ramirez and Castaneda and also Barbara Cox and Ramirez found that most students have personality types that are bicognitive to differing degrees. Most learners, however, have a preference for one or the other style. By observing children in classrooms and college students in different learning environments and social and work settings, results showed that the degree of success in education and in life in general depends on their degree of bicognitive functioning. The researchers concluded that the ultimate goal of education was the promotion of flexibility in cultural and cognitive styles resulting in development of the total person.

To promote flexibility in cultural and cognitive styles, it is necessary to individualize instruction by encouraging flexibility in teachers and educational environments. Changes were suggested in four major components of instruction:

- Teacher training to enhance understanding of diverse cultural styles in American society. Specifically, teacher training programs need to present the sociological, psychological, and anthropological characteristics of the different ethnic groups in this country. The information

needs to be presented in an educational perspective. For example, cultures that are more traditional tend to teach by modeling and direct instruction, whereas more modern cultures generally teach by trial and error using a less directive approach. Teachers could be trained to use culture-matching teaching strategies and could learn how to assess the preferred cultural and cognitive styles of students. Teachers also need to perform self-assessment to become aware of their own preferred cultural styles and their relation to teaching styles.

- Development and selection of different kinds of curricula to facilitate learning among children with different cultural styles. The principal focus of curriculum development should be on how new material is introduced and presented such that it incorporates cultural and cognitive styles. For example, if the lesson plan calls for teaching about rainbows, allowing children to tell stories about their experiences with rainbows is likely to be meaningful to those from traditional cultures. On the other hand, children from modern cultures might prefer experimenting with a bowl of water and a small mirror inside the bowl to capture sunlight to show how rainbows are formed. Both teaching strategies will benefit field sensitive/ traditional as well as field independent/modern learners because they offer a diversity of teaching approaches that serves to match the preferred styles of each group while simultaneously providing the opportunity to add the nonpreferred skills to existing learning repertoires.
- Training teachers to use learning experiences and environments to teach respect for cultural differences and cross-ethnic cooperation. This is particularly applicable in social studies curricula where the objective is to encourage students to understand familial, cultural, individual, and gender differences. For example, teaching about holidays celebrated by different cultures and discussing the lives of prominent women in society as well as the achievements of historical figures of different ethnic, religious, racial, gender, and socioeconomic backgrounds should be a part of social studies curricula. Teachers should also be taught to discourage use of ethnic and racial slurs and language that tends to disparage any group or person. Teachers should engage in proactive behavior to discourage ethnic isolation and should emphasize children of different genders and groups working together as a team to prevent isolationism and clique formation.
- Training for use of tests and other procedures for assessment of academic progress and intellectual ability to match the cultural styles of learners. For example, children from traditional cultures are more likely to prefer essay-type questions or tasks that tap creative writing skills, whereas children from modern environments usually prefer multiple choice-type tests and assignment of projects that apply concepts to problems. The negative

consequences of mismatch can have dire consequences for both learners and teachers because inaccurate conclusions can be drawn about the capabilities of students and the effectiveness of teachers.

- Once instruction and curriculum content have been addressed, the students can then begin the match-mismatch process. The cultural and cognitive flex model of education follows three instructional steps: match of preferred cultural and cognitive styles, initiation of mismatch through match, and continued match and mismatch to promote flexibility and adaptability.

The first step acknowledges and respects the child's cultural and familial experiences in learning by matching the student's preferred cultural and cognitive styles. Assessment of the preferred styles of children when they first come to school is essential. Identification of the preferred cultural and cognitive styles of each child is done through classroom observation of behavior in an environment that allows for freedom of individual expression of cultural and cognitive styles. Once assessment is completed, the child is placed in one of three groups where instruction will be matched to preferred styles. This is the initial match.

The second stage is to gradually introduce mismatch of styles once the child achieves mastery in his or her preferred style. This is done by introduction to a bicognitive-bicultural group in which the nonpreferred styles are presented through use of the dominant styles; for example, introducing individual competition through group competition by asking group members to focus on which member achieved the most points during the exercise. This approach benefits the field sensitive and traditional learner who is in the process of becoming more bicognitive and bicultural.

Upon mastery in this environment, children are then introduced to the third stage in the flexibility development process, which is placement in a group where the child is introduced to new instructional strategies. These strategies include exposure to learning and testing materials that are written and presented in the previously unfamiliar styles. For example, a teacher introducing the nonpreferred style who uses the discovery approach might proceed in this manner: Yesterday, I showed you how to find out if two triangles are equal. I have also showed you how to find out if two squares are equal. Now you know the shortcut I use in finding out the area of something. I have some rectangles for you to look at, and I want you to find out if they are the same, but I want you to do it in the way you think I would, using the shortcut I used with the triangles and the squares. After becoming familiar with the mixture

of cognitive and cultural styles, the child is ready for the transfer to the group in which teaching and curriculum are based almost exclusively in the unfamiliar style.

The fourth and final stage is progression into an advanced mixed-styles group in which both styles are used to reinforce maximum flexibility and adaptability. An example of a lesson plan that would be presented in this group is as follows: In a field independent math lesson, a child whose preferred cognitive style is field independent and cultural style is modern feels familiar with an abstract, impersonal curriculum. This student enjoys individual competition and learns most advantageously when the teacher emphasizes individual effort. In a field sensitive and traditional curriculum (based on the child's unfamiliar styles), the child easily makes the transition from a math lesson that emphasizes inductive reasoning and abstract concepts to one that emphasizes deductive reasoning and personalized/ humanized concepts. This student can work just as well cooperating with classmates as competing with them in the field independent-modern math lesson.

The flexibility and adaptability that students develop can transfer to areas of life outside educational environments. They are likely to become more receptive to other languages and other cultures, giving them the opportunity to achieve linguistic and cultural flexibility.

To succeed in preparing students for success and good psychological adjustment in a complex and technological society, we must get away from the one-size-fits-all mentality that is presently so much a part of the American educational system. A focus on individualizing instruction and utilizing technology can make this possible. For example, a computer program can determine a child's preferred cultural and cognitive styles by assessing the preferred styles at the start of the school year. The program would teach a new concept by asking simple questions regarding preferences for content and strategies for learning. The program could also monitor the progress of the student through the steps of cognitive and cultural flex achievement. Each individual student's record can become a part of his or her educational history and used to plan his or her advancement through each grade. In addition, it could serve as a useful record for different teachers when students change schools or move from elementary through middle and high school.

The work by Ramirez and Castaneda and that of their colleagues focused primarily on Mexican American children, showing how the traditional cultural styles of Latino children were being mismatched by the predominantly modern styles of the American public school

system. Mismatch between preferred cultural and cognitive styles and the teaching styles, curriculum, and educational procedures of schools can result in mismatch shock, defined as exhibiting stress and feelings of failure and alienation. To this day, mismatch is the major reason why Mexican Americans continue to have the highest dropout rate of any ethnic group in American society. The mismatch factor is also important for the high failure rate in other ethnic/racial cultural groups in the United States who are being mismatched by educational institutions, teachers, and professors. As reported by the *New York Times* in February 2007, even when some schools make the effort to introduce diversity in curriculum offerings, school boards may stifle the effort. In fact, all school-aged children and college students, regardless of race, ethnicity, or socioeconomic class, are likely to be mismatched and to become discouraged and frustrated. A recent study by the Education Testing Service found that high school graduation rates and achievement gaps in reading and math skills have not changed very much in the past 20 years

Instructions

Section 2 of this course you will cover these topics:

- Effective Assessment
- Problem Solving: An Approach To Teaching And Learning Mathematics
- Making Sense Of Number And Operations

Topic : Effective Assessment

Topic Objective:

At the end of this topic student would be able to learn:

Assessment

Formative and summative

Objective and subjective

Definition/Overview:

Assessment: It is the process of documenting, usually in measurable terms, knowledge, skills, attitudes and beliefs. This article covers educational assessment including the work of institutional researchers, but the term applies to other fields as well including health and finance.

Key Points:

1. Assessment

Assessment is the process of documenting, usually in measurable terms, knowledge, skills, attitudes and beliefs. This article covers educational assessment including the work of institutional researchers, but the term applies to other fields as well including health and finance. Performance assessment is the formal and informal judgments of how well people complete observable tasks. The two most common uses of the term *performance assessment* in education relate to student achievement and employees, such as teachers, completing the functions of their jobs.

The first use the assessment serves is what has been called the American meritocracy, which is a way of determining who gets America's material rewards. Intelligence tests, and also education itself, can't be counted on to find every form of merit. They don't find wisdom, originality, humor, toughness, empathy, common sense, independence, or determinationlet alone moral value. Student performance assessment is not presently able to provide opportunity on the basis of the various forms of merit that a true meritocracy should have, but it can measure some preestablished academic criteria. One important caution that has been noted by some is that we need to be aware of the impact and limitations of what criteria are used. In this regard, no amount of subsequent manipulation can eliminate all the initial biases that are imposed upon policy and program decisions in the selection of a specific model as a guide to analyze performance.

There have been some improvements in measuring certain identified academic standards,

which some argue have a relationship with future potential to succeed within the present university system and at some jobs. This is criterionrather than norm-referencedassessment, which measures how well individuals perform in relation to a group of individuals. It should be noted that there is a difference between norms and standards. That is, norms change, standards do notstandards are fixed. Standards promote mixed ability grouping. Norms tend to promote segregation of students by ability.

It is believed that good classroom assessment can improve student achievement. Alan Glatthorn indicated that assessment-driven instruction entirely focused upon performance assessment, from planning to execution. However, he cautioned that performance assessments can have problems. It is important to identify the tasks to be assessednamely, the standards that are established before teaching begins.

The second use of the term *performance assessment* deals with employee evaluation, most often teachers. Teacher evaluation takes many forms.

The system used to assess teaching performance is important. One confusing aspect of employee performance appraisal is the distinction that is made between formative evaluation and summative evaluation. Formative evaluation occurs when the main purpose is to help an individual improve performanceput another way, it forms a better employee. Summative evaluation, on the other hand, results in a summation or final report as its main purpose and is used to make a personnel decision (such as the nonrenewal of an employee's contract or a promotion).

The distinction is blurred at least in part by the requirement in most states that in order to nonrenew a teacher's contract, the summative evaluation must include at least documentation of formative evaluation. Employees enjoy certain types of legislative protection within the performance appraisal process. These legal issues are one of several reasons that can be offered for paying more attention to the psychometric properties of performance assessments (such as reliability and validity).

Most personnel texts recognize the importance of reliability and validity. While reliability deals with the various types of consistency that may or may not be in a process, the various types of validity deal with how well the performance appraisal process performs relative to the intended purpose of the procedure. The two most salient types of validity are content and

construct. Content validity, which is analytically determined, basically examines the process to see whether it evaluates all that it purports to and only that which it purports to evaluate. In other words, content validity evaluates whether there is anything deficient, or is being missed (e.g., if creativity was important, is that part of what is being assessed?), or whether there is anything contaminating the assessment (e.g., if classroom order were one aspect of the process, that should not influence other aspects of the assessment), or whether there is anything extra being assessed that should not be (e.g., if personal appearance was not important to a particular school, then that would not need to be part of the assessment). Construct validity, on the other hand, is more complex and involves multiple approaches attempting to support the process in terms of whether constructs (such as leadership or empathy) are accurately measured.

Assessments can be classified in many different ways. The most important distinctions are: (1) formative and summative; (2) objective and subjective; (3) referencing (criterion-referenced, norm-referenced, and ipsative); and (4) informal and formal.

2. Formative and summative

There are two main types of assessment:

Summative assessment - Summative assessment is generally carried out at the end of a course or project. In an educational setting, summative assessments are typically used to assign students a course grade.

Formative assessment - Formative assessment is generally carried out throughout a course or project. Formative assessment, also referred to as **educative assessment**, is used to aid learning. In an educational setting, formative assessment might be a teacher (or peer) or the learner, providing feedback on a student's work, and would not necessarily be used for grading purposes.

Summative and formative assessment are referred to in a learning context as "**assessment of learning**" and "**assessment for learning**" respectively.

A common form of formative assessment is **diagnostic assessment**. Diagnostic assessment

measures a student's current knowledge and skills for the purpose of identifying a suitable program of learning. **Self-assessment** is a form of diagnostic assessment which involves students assessing themselves. **Forward-looking assessment** asks those being assessed to consider themselves in hypothetical future situations. Assessments can also be done on pieces of legislation.

Performance-based assessment is similar to formative assessment, as it focuses on achievement. It is often aligned with the standards-based education reform and outcomes-based education movement. Though ideally they are significantly different from a traditional multiple choice test, they are most commonly associated with standards-based assessment which use free-form responses to standard questions scored by human scorers on a standards-based scale, meeting, falling below, or exceeding a performance standard rather than being ranked on a curve.

A well-defined task is identified and students are asked to create, produce, or do something, often in settings that involve real-world application of knowledge and skills. Proficiency is demonstrated by providing an extended response. Performance formats are further differentiated into products and performances. The performance may result in a product, such as a painting, portfolio, paper, or exhibition, or it may consist of a performance, such as a speech, athletic skill, musical recital, or reading.

3. Objective and subjective

Assessment (either summative or formative) can be subjective. Objective assessment is a form of questioning which has a single correct answer. Subjective assessment is a form of questioning which may have more than one correct answer (or more than one way of expressing the correct answer). There are various types of objective and subjective questions. Objective question types include true/false answers, multiple choice, multiple-response and matching questions. Subjective questions include extended-response questions and essays. Objective assessment is becoming more popular due to the increased use of online assessment (e-assessment) since this form of questioning is well-suited to computerisation.

Topic : Problem Solving: An Approach To Teaching And Learning Mathematics

Topic Objective:

Definition/Overview:

Problem Solving: Problem solving is a multiple-step process that purposefully analyzes an issue, generates alternatives, evaluates and implements selected choices, and monitors progress.

Key Points:

1. Problem Solving

Problem solving is a multiple-step process that purposefully analyzes an issue, generates alternatives, evaluates and implements selected choices, and monitors progress. For the purposes of this entry, it will be assumed that a team approach to problem solving will be used. At an early point, the importance of the problem should be evaluated in comparison to the values of a possible solution. The following types of questions need to be addressed: Is this problem important for the school or the district, or what will happen if the problem is unresolved? Is it best that the problem remain unsolved? Some problems can remain unresolved without significant impact on the mission and strategic plan. At a basic level, the steps include the following: identify the problem, generate solutions, evaluate the alternatives, implement the selected alternative, and evaluate progress.

At the first stage, identification and clarification of the problem are essential; describe the problem but avoid potential solutionssolutions will come later. The following types of

questions will help the team keep on task: What is the problem, and is the problem relevant to the mission and strategic plan of the organization? What are the symptoms associated with the problem? It must be understood that symptoms, root causes, and the problem are confused but must be kept separate. Do not assume that these differences are understood by the person who presented them or that you totally understand the problem. Collect data that describe the problem and define the impact the problem has had or will have on the organization. In some cases, restating the problem in general terms or providing illustrative examples can clarify the issues.

During the definition of the problem, ambiguous issues should be clarified. To illustrate, reading scores are too low is unclear and is an ill-defined statement of a problem. Does this mean all students or selected students? What type of assessment was used to determine reading level? What is an acceptable reading level? When will assessments occur? When will the problem be judged as resolved? The criteria for success should be clearly stated as a part of the definition of the problem; this information is needed at all steps in the problem-solving process.

After the problem is defined and understood, the next step is to generate as many alternative solutions as possible. Because educators are very intent on developing solutions to immediate problems, and complex educational problems have multiple root causes, the team should be encouraged to consider all possible alternatives without judging the value of the alternatives. The generation of multiple possible solutions is time consuming and can produce many false starts, but the process is necessary to identify potential solutions with merit. Often, when complex problems are discussed, assumptions, symptoms, solutions, and subjective data are intermixed and confused.

Teamwork and brainstorming are beneficial skills that can be used to generate alternative approaches to the problem. Alternatives should not be evaluated and assessed; however, avoid blame for the problem, because blame is unproductive and destructive to the process. The goal is to generate a wide variety of solutions: some realistic, some analytical, and some very creative. Traditional rules for brainstorming should guide the brainstorming process. Open discussion that is not personalized encourages communication and supports team building.

Next, the various alternatives must be evaluated and an approach selected to resolve the

problem. The possible alternatives should be considered in relationship to the vision, mission, and strategic plan of the organization. Numerous questions should be considered. What are costs, time restraints, and personnel requirements? The strengths and weaknesses of each approach should be considered in relationship to both short-term and long-term impact. In addition, existing policies and procedures should be reviewed in reference to each alternative. During this phase of problem solving, the team should be objective, record data, collect feedback, make pertinent notes, and listen for root causes. The potential results, causes, and impacts of the problem are valuable information.

The bottom line is that an alternative must be selected. The chosen alternative must address the root causes identified, and it must be implemented completely. An action plan should be developed to provide a road map for the implementation process. In schools, most meaningful changes will require a significant adjustment in budget, program adjustments, and staff changes; therefore, the plan will need to address personnel, timelines, facilities, and external issues. Roles and responsibilities related to implementation need to be clarified. Who is responsible for implementation, communication, and evaluation? Each member of the team must commit to making the improvement happen.

At this point, problem solving will become a project management process; the plan must be implemented, managed, and monitored. Formative evaluation of the implementation process can provide feedback on budget, timelines, personnel, and policies. The process of implementation must be monitored to ensure that the plan was implemented. If changes were made during the implementation process, then information must be recorded for consideration during the evaluation component.

Because the criteria for success were identified in early stages, the evaluation of the progress is easier. Evaluation of the success of a selected solution should be a formative process, and many issues related to monitoring progress need to be clarified. Was the plan implemented? Are other measures available as indicators that the problem has been resolved? Do not assume a single problem existsapply systems thinking. Was the problem resolved, and was the alternative responsible for the improvement? Did the plan result in a systemic change, or is it likely that the problem will reoccur? The evaluation of progress enables the organization to determine the extent of success and level of implementation.

Finally, communication with stakeholders is essential at each step of the problem-solving

process. A clear communication plan that openly discusses the alternative will eliminate guessing, develop a broader base of support, and reduce some potential problems if the plan is unsuccessful.

Feedback at each step will support the process of teamwork and group involvement in problem solving. Effective group problem solving requires that a group be creative, systematic, and thorough in its problemsolving approach.

The leader's role helps determine whether group problem solving is effective or not. Although the members also are responsible for the group's ultimate output, the leader can facilitate effective problem solving by making sure that the important problem-solving functions are met. The leader needs to be highly skilled to keep the problem-solving process on track.

2. Problem Solving in Maths

2.1 What Are Problem Solving Strategies?

Strategies are things that Plya would have us choose in his second stage of problem solving and use in his third stage (What is Problem Solving?). In actual fact he called them **heuristics**. To Plya they were things to try that he couldnt guarantee would solve the problem but, of course, he sincerely hoped they would. So they are some sort of general ideas that might work for a number of problems. And then again they might not.

As speaking in riddles isnt likely to be of much assistance to you, lets get down to some examples. There are a number of common strategies that children of primary age can use to help them solve problems. We discuss below several that will be of value for problems on this web-site and in books on problem solving. In this site we have linked the problem solving lessons to the following groupings of problem solving strategies. As the site develops we may add some more but we have tried to keep things simple for now.

Common Problem Solving Strategies

Guess (this includes guess and check, guess and improve)
Act It Out (act it out and use equipment)

Draw (this includes drawing pictures and diagrams)
Make a List (this includes making a table)
Think (this includes using skills you know already)

We have provided black line masters for these strategies so that you can make posters and display them in your classroom. There are two kinds of these. The first is just a list of strategies (Strategy List BLM). You might find this useful for you and your children to refer to from time to time. The second consists of a page per strategy with space provided to insert the name of any problem that you come across that uses that particular strategy (Act it out, Draw, Guess, Make a List). We have found that this kind of poster provides good revision for children. It also establishes links across curriculum areas. Through these links, children can see that mathematics is not only connected by skills but also by processes.

3. An In-Depth Look At Strategies

We now look at each of the following strategies and discuss them in some depth. You will see that each strategy we have in our list is really only a summary of two or more others.

Guess Act It Out Draw Make a List Think

3.1 Guess

This stands for two strategies, guess and check and guess and improve.

Guess and check is one of the simplest strategies. Anyone can guess an answer. If they can also check that the guess fits the conditions of the problem, then they have mastered guess and check. This is a strategy that would certainly work on the Farmyard problem but it could take a lot of time and a lot of computation.

Because it is such a simple strategy to use, you may have difficulty weaning some children away from guess and check. If you are not careful, they may try to use it all the time. As problems get more difficult, other strategies become more important and more

effective. However, sometimes when children are completely stuck, guessing and checking will provide a useful way to start and explore a problem. Hopefully that exploration will lead to a more efficient strategy and then to a solution.

Guess and improve is slightly more sophisticated than guess and check. The idea is that you use your first incorrect guess to make an improved next guess. You can see it in action in the Farmyard problem. In relatively straightforward problems like that, it is often fairly easy to see how to improve the last guess. In some problems though, where there are more variables, it may not be clear at first which way to change the guessing.

3.2 Act It Out

We put two strategies together here because they are closely related. These are Act it Out and Use Equipment.

Young children especially, enjoy using Act it Out. Children themselves take the role of things in the problem. In the Farmyard problem, the children might take the role of the animals though it is unlikely that you would have 87 children in your class! But if there are not enough children you might be able to press gang the odd teddy or two.

There are pros and cons for this strategy. It is an effective strategy for demonstration purposes in front of the whole class. On the other hand, it can also be cumbersome when used by groups, especially if a largish number of students is involved. We have, however, found it a useful strategy when students have had trouble coming to grips with a problem.

The on-looking children may be more interested in acting it out because other children are involved. Sometimes, though, the children acting out the problem may get less out of the exercise than the children watching. This is because the participants are so engrossed in the mechanics of what they are doing that they dont see through to the underlying mathematics. However, because these children are concentrating on what they are doing, they may in fact get more out of it and remember it longer than the others, so there are pros and cons here.

Use Equipment is a strategy related to Act it Out. Generally speaking, any object that can be used in some way to represent the situation the children are trying to solve, is

equipment. This includes children themselves, hence the link between Act it Out and Use Equipment.

One of the difficulties with using equipment is keeping track of the solution. Actually the same thing is true for acting it out. The children need to be encouraged to keep track of their working as they manipulate the equipment.

In our experience, children need to be encouraged and helped to use equipment. Many children seem to prefer to draw. This may be because it gives them a better representation of the problem in hand. Also, if theyre a little older, they may feel that using equipment is only 'for babies'. Since there are problems where using equipment **is** a better strategy than drawing, you should encourage childrens use of equipment by modelling its use yourself from time to time.

3.3 Draw

It is fairly clear that a picture has to be used in the strategy **Draw a Picture**. But the picture need not be too elaborate. It should only contain enough detail to solve the problem. Hence a rough circle with two marks is quite sufficient for chickens and a blob plus four marks will do for pigs. There is no need for elaborate drawings showing beak, feathers, curly tails, etc., in full colour. Some children will need to be encouraged not to over-elaborate their drawings (and so have time to attempt the problem). But all children should be encouraged to use this strategy at some point because it helps children see the problem and it can develop into quite a sophisticated strategy later.

Its hard to know where Drawing a Picture ends and Drawing a Diagram begins. You might think of a diagram as anything that you can draw which isnt a picture. But where do you draw the line between a picture and a diagram? As you can see with the chickens and pigs, discussed above, regular picture drawing develops into drawing a diagram.

Venn diagrams and tree diagrams are particular types of diagrams that we use so often they have been given names in their own right.

Its probably worth saying at this point that acting it out, drawing a picture, drawing a diagram, and using equipment, may just be disguises for guessing and checking or even

guessing and improving. Just watch children use these strategies and see if this is indeed the case.

3.4 Make a List

Making **Organised Lists and Tables** are two aspects of working systematically. Most children start off recording their problem solving efforts in a very haphazard way. Often there is a little calculation or whatever in this corner, and another one over there, and another one just here. It helps children to bring a logical and systematic development to their mathematics if they begin to organise things systematically as they go. This even applies to their explorations.

There are a number of ways of using **Make a Table**. These range from tables of numbers to help solve problems like the Farmyard, to the sort of tables with ticks and crosses that are often used in logic problems. Tables can also be an efficient way of finding number patterns.

When an **Organised List** is being used, it should be arranged in such a way that there is some natural order implicit in its construction. For example, shopping lists are generally not organised. They usually grow haphazardly as you think of each item. A little thought might make them organised. Putting all the meat together, all the vegetables together, and all the drinks together, could do this for you. Even more organisation could be forced by putting all the meat items in alphabetical order, and so on. Someone we know lists the items on her list in the order that they appear on her route through the supermarket.

3.5 Think

In many ways we are using this strategy category as a catch-all. This is partly because these strategies are not usually used on their own but in combination with other strategies. The strategies that we want to mention here are Being Systematic, Keeping Track, Looking For Patterns, Use Symmetry and Working Backwards and Use Known Skills.

Being Systematic, Keeping Track, Looking For Patterns and Using Symmetry are different from the strategies we have talked about above in that they are over-arching strategies. In all problem solving, and indeed in all mathematics, you need to keep these strategies in mind.

Being systematic may mean making a table or an organised list but it can also mean keeping your working in some order so that it is easy to follow when you have to go over it. It means that you should work logically as you go along and make sure you dont miss any steps in an argument. And it also means following an idea for a while to see where it leads, rather than jumping about all over the place chasing lots of possible ideas.

It is very important to **keep track** of your work. We have seen several groups of children acting out a problem and having trouble at the end simply because they had not kept track of what they were doing. So keeping track is particularly important with Act it Out and Using Equipment. But it is important in many other situations too. Children have to know where they have been and where they are going or they will get hopelessly muddled. This begins to be more significant as the problems get more difficult and involve more and more steps.

In many ways **looking for patterns** is what mathematics is all about. We want to know how things are connected and how things work and this is made easier if we can find patterns. Patterns make things easier because they tell us how a group of objects acts in the same way. Once we see a pattern we have much more control over what we are doing.

Using symmetry helps us to reduce the difficulty level of a problem. Playing Noughts and crosses, for instance, you will have realised that there are three and not nine ways to put the first symbol down. This immediately reduces the number of possibilities for the game and makes it easier to analyse. This sort of argument comes up all the time and should be grabbed with glee when you see it.

Finally **working backwards** is a standard strategy that only seems to have restricted use. However, its a powerful tool when it can be used. In the kind of problems we will be using in this web-site, it will be most often of value when we are looking at games. It frequently turns out to be worth looking at what happens at the end of a game and then work backward to the beginning, in order to see what moves are best.

Then we come to **use known skills**. This isn't usually listed in most lists of problem solving strategies but as we have gone through the problems in this web site, we have found it to be quite common. The trick here is to see which skills that you know can be applied to the problem in hand.

One example of this type is Fertiliser (Measurement, level 4). In this problem, the problem solver has to know the formula for the area of a rectangle to be able to use the data of the problem.

This strategy is related to the first step of problem solving when the problem solver thinks 'have I seen a problem like this before?' Being able to relate a word problem to some previously acquired skill is not easy but it is extremely important.

Topic : Making Sense Of Number And Operations

Topic Objective:

At the end of this topic student would be able to learn:

Algorithm
Why algorithms are necessary: an informal definition
Interpretations of Rational Number Concepts
The cause for concern

Definition/Overview:

Numeral system (or **system of numeration**): it is a mathematical notation for representing numbers of a given set by symbols in a consistent manner. It can be seen as the *context* that allows the numeral "11" to be interpreted as the binary numeral for *three*, the decimal numeral for *eleven*, or other numbers in different bases.

Key Points:

1. Algorithm

In mathematics, computing, linguistics and related subjects, an **algorithm** is a sequence of finite instructions, often used for calculation and data processing. It is formally a type of effective method in which a list of well-defined instructions for completing a task will, when given an initial state, proceed through a well-defined series of successive states, eventually terminating in an end-state. The transition from one state to the next is not necessarily deterministic; some algorithms, known as probabilistic algorithms, incorporate randomness.

A partial formalization of the concept began with attempts to solve the Entscheidungsproblem (the "decision problem") posed by David Hilbert in 1928. Subsequent formalizations were framed as attempts to define "effective calculability" (Kleene 1943:274) or "effective method" (Rosser 1939:225); those formalizations included the Gdel-Herbrand-Kleene recursive functions of 1930, 1934 and 1935, Alonzo Church's lambda calculus of 1936, Emil Post's "Formulation 1" of 1936, and Alan Turing's Turing machines of 19367 and 1939.

2. Why algorithms are necessary: an informal definition

While there is no generally accepted *formal* definition of "algorithm", an informal definition could be "an algorithm is a process that performs some sequence of operations." For some people, a program is only an algorithm if it stops eventually. For others, a program is only an algorithm if it stops before a given number of calculation steps.

A prototypical example of an "algorithm" is Euclid's algorithm to determine the maximum common divisor of two integers greater than one: "subtract the smaller number from the larger one; repeat until you get a zero or a one." This procedure is known to stop always and the number of subtractions needed is always smaller than the larger of the two numbers.

We can derive clues to the issues involved and an informal meaning of the word from the

following quotation from Boolos & Jeffrey (1974, 1999) (boldface added):

No human being can write fast enough or long enough or small enough to list all members of an enumerably infinite set by writing out their names, one after another, in some notation. But humans can do something equally useful, in the case of certain enumerably infinite sets: They can give explicit instructions for determining the nth member of the set, for arbitrary finite n. Such instructions are to be given quite explicitly, in a form in which they could be followed by a computing machine, or by a human who is capable of carrying out only very elementary operations on symbols.

The words "enumerably infinite" mean "countable using integers perhaps extending to infinity." Thus Boolos and Jeffrey are saying that an algorithm *implies* instructions for a process that "creates" output integers from an *arbitrary* "input" integer or integers that, in theory, can be chosen from 0 to infinity. Thus we might expect an algorithm to be an algebraic equation such as y = m + n two arbitrary "input variables" m and n that produce an output y. As we see in Algorithm characterizations the word algorithm implies much more than this, something on the order of (for our addition example):

Precise instructions (in language understood by "the computer") for a "fast, efficient, good" *process* that specifies the "moves" of "the computer" (machine or human, equipped with the necessary internally-contained information and capabilities) to find, decode, and then munch arbitrary input integers/symbols m and n, symbols + and = ... and (reliably, correctly, "effectively") produce, in a "reasonable" time, output-integer y at a specified place and in a specified format.

The concept of *algorithm* is also used to define the notion of decidability. That notion is central for explaining how formal systems come into being starting from a small set of axioms and rules. In logic, the time that an algorithm requires to complete cannot be measured, as it is not apparently related with our customary physical dimension. From such uncertainties, that characterize ongoing work, stems the unavailability of a definition of *algorithm* that suits both concrete (in some sense) and abstract usage of the term.

3. Interpretations of Rational Number Concepts

For a variety of reasons rational number concepts are among the most important concepts children will experience during their presecondary years. From a practical perspective, the ability to deal effectively with rational numbers vastly improves one's ability to understand and deal with situations and problems in the real world. From a psychological perspective, an understanding of rational number provides a rich ground from which children can develop and expand the mental structures necessary for continued intellectual development. From a mathematical point of view, rational number understandings are the foundation on which basic algebraic operations will later be based. Students have consistently experienced significant difficulty dealing with and applying these concepts. Perhaps one reason is that for the most part school programs tend to emphasize procedural skills and computational aspects rather than the development of important foundational understandings. Recent developments in the mathematical, psychological, and instructional realms have revealed important insights into the problems involved in teaching rational number concepts to children.

4. The cause for concern

The mathematics assessment of the National Assessment of Educational Progress (NAEP) was conducted in 1972-73 and again in 1977-78. It assessed outcomes on mathematics items related to objectives at four cognitive levels: knowledge, skills, understandings, and applications. Commenting on the results of the second assessment, Carpenter and his colleagues made the following generalizations:

In general, both of the younger age groups [9- and 13-year-olds] performed at an acceptable level on knowledge and skill exercises. . . . Students appear to be learning many mathematical skills at a rote manipulation level and do not understand the concepts underlying the computation. . . In general, respondents demonstrated a lack of even the most basic problem-solving skills.

What conditions led to this rather disappointing state of affairs? We suspect the reasons are many; including much premature abstraction of mathematical ideas and a general lack of attention to higher-order thinking skills. A recent examination of three widely used 1978 mathematics text series revealed that by far the greatest emphasis in time spent on rational number concepts (as inferred by the number of pages) is on developing skills with

algorithms. This practice continues despite repeated assertions that premature emphasis of algorithmic learning will result in an inability to internalize, operationalize, and apply this concept in an appropriate manner (Carpenter et al. 1978, 1980; Freudenthal1973; Payne 1976).

Another probable reason relates to the level of abstraction at which much instruction is focused. Children are expected to operate at the abstract symbolic level too often and too soon. Piaget has suggested that children pass through qualitatively different stages of intellectual development in a predictable order but at varying rates. The stages have been referred to as sensory-motor, preoperational, concrete operational, and formal operational. Children at the age where fractions are normally introduced and developed in the school program will generally be at the concrete operational level. Their ability to synthesize, make deductions, and follow *if/then* arguments very much depends on their personal experience and firsthand interactions with the environment.

In Section 3 of this course you will cover these topics:

- Algebra: The Gateway
- Geometry: Moving Beyond Formulas

Topic : Algebra: The Gateway

Topic Objective:

At the end of this topic student would be able to:

Understand Algebra
Learn about lassification
Understand Abstract algebra

Definition/Overview:

Algebra

Algebra is a branch of mathematics concerning the study of structure, relation, and quantity.

Key Points:

1. Algebra

Algebra is a branch of mathematics concerning the study of structure, relation, and quantity. The name is derived from the treatise written by the Persian mathematician, astronomer, astrologer and geographer, Muhammad bin Mūsā al-Khwārizmī (born in Uzbekistan) titled Kitab al-Jabr wa-l-Muqabala (meaning "The Compendious Book on Calculation by Completion and Balancing"), which provided symbolic operations for the systematic solution of linear and quadratic equations, and recognized algebra as an independent discipline. Al-Khwarizimi's book made its way to Europe and was translated into Latin as Liber algebrae et almucabala.Together with geometry, analysis, combinatorics, and number theory, algebra is one of the main branches of mathematics. Elementary algebra is often part of the curriculum in secondary education and provides an introduction to the basic ideas of algebra, including effects of adding and multiplying numbers, the concept of variables, definition of polynomials, along with factorization and determining their roots.Algebra is much broader than elementary algebra and can be generalized. In addition to working directly with numbers, algebra covers working with symbols, variables, and set elements. Addition and multiplication are viewed as general operations, and their precise definitions lead to structures such as groups, rings and fields.

The development of algebraic reasoning begins even before students start theirformal education. Young children enjoy patterns in the sounds of language, for example.In the very early grades, students make patterns with blocks, enjoy rhythmic clapping andinvestigate how sizes and shapes compare. In the early grades, students explore patternson the number chart as they skip count. Students look at change over time in a variety ofcontexts such as weather, their own growth and the amount of food consumed by theclass pet during the week.In the elementary grades, students work with geometric and numerical patterns.They explore how these patterns grow or change. They might predict what the next threeshapes might look like or determine the tenth number in the series. Students also exploreproperties such as the commutative, associative, and distributive.

2. Classification

Algebra may be divided roughly into the following categories:

Elementary algebra, in which the properties of operations on the real number system are recorded using symbols as "place holders" to denote constants and variables, and the rules governing mathematical expressions and equations involving these symbols are studied (note that this usually includes the subject matter of courses called intermediate algebra and college algebra), also called second year and third year algebra;
Abstract algebra, sometimes also called modern algebra, in which algebraic structures such as groups, rings and fields are axiomatically defined and investigated.
Linear algebra, in which the specific properties of vector spaces are studied (including matrices);
Universal algebra, in which properties common to all algebraic structures are studied.
Algebraic number theory, in which the properties of numbers are studied through algebraic systems. Number theory inspired much of the original abstraction in algebra.
Algebraic geometry in its algebraic aspect.
Algebraic combinatorics, in which abstract algebraic methods are used to study combinatorial questions.

In some directions of advanced study, axiomatic algebraic systems such as groups, rings, fields, and algebras over a field are investigated in the presence of a geometric structure (a metric or a topology) which is compatible with the algebraic structure.

3. Abstract algebra

Abstract algebra extends the familiar concepts found in elementary algebra and arithmetic of numbers to more general concepts.

Sets: Rather than just considering the different types of numbers, abstract algebra deals with the more general concept of *sets*: a collection of all objects (called elements) selected by property, specific for the set. All collections of the familiar types of numbers are sets. Other examples of sets include the set of all two-by-two matrices, the set of all second-degree polynomials ($ax^2 + bx + c$), the set of all two dimensional vectors in the plane, and the

various finite groups such as the cyclic groups which are the group of integers modulo *n*. Set theory is a branch of logic and not technically a branch of algebra.

Binary operations: The notion of addition (+) is abstracted to give a *binary operation*, $*$ say. The notion of binary operation is meaningless without the set on which the operation is defined. For two elements *a* and *b* in a set *S*, $a * b$ is another element in the set; this condition is called closure. Addition (+), subtraction (-), multiplication (), and division () can be binary operations when defined on different sets, as is addition and multiplication of matrices, vectors, and polynomials.

Identity elements: The numbers zero and one are abstracted to give the notion of an *identity element* for an operation. Zero is the identity element for addition and one is the identity element for multiplication. For a general binary operator $*$ the identity element *e* must satisfy $a * e = a$ and $e * a = a$. This holds for addition as $a + 0 = a$ and $0 + a = a$ and multiplication $a\ 1 = a$ and $1\ a = a$. However, if we take the positive natural numbers and addition, there is no identity element.

Inverse elements: The negative numbers give rise to the concept of *inverse elements*. For addition, the inverse of *a* is $-a$, and for multiplication the inverse is $1/a$. A general inverse element a^{-1} must satisfy the property that $a * a^{-1} = e$ and $a^{-1} * a = e$.

Associativity: Addition of integers has a property called associativity. That is, the grouping of the numbers to be added does not affect the sum. For example: $(2 + 3) + 4 = 2 + (3 + 4)$. In general, this becomes $(a * b) * c = a * (b * c)$. This property is shared by most binary operations, but not subtraction or division or octonion multiplication.

Commutativity: Addition of integers also has a property called commutativity. That is, the order of the numbers to be added does not affect the sum. For example: 2+3=3+2. In general, this becomes $a * b = b * a$. Only some binary operations have this property. It holds for the integers with addition and multiplication, but it does not hold for matrix multiplication or quaternion multiplication

Topic : Geometry: Moving Beyond Formulas

Topic Objective:

At the end of this topic student would be able to:

Expand own spatial sense and realize the importance of developing middle school students' spatial sense.

Understand how the van Hiele levels of Geometry Thinking should affect the selection of materials and activities in the classroom.

Appreciate the need to employ manipulatives in the classroom to explore and develop mathematics relationships.

Recognize the need for middle grade students to do more than memorize geometric relationships

Be conscious of the benefit of multiple representations of geometric relationships.

Definition/Overview:

Key Points:

1. Geometry

Geometry is a part of mathematics concerned with questions of size, shape, and relative position of figures and with properties of space. Geometry is one of the oldest sciences. Initially a body of practical knowledge concerning lengths, areas, and volumes, in the third century BC geometry was put into an axiomatic form by Euclid, whose treatmentEuclidean

geometryset a standard for many centuries to follow. The field of astronomy, especially mapping the positions of the stars and planets on the celestial sphere, served as an important source of geometric problems during the next one and a half millennia. A mathematician who works in the field of geometry is called a geometer.

Introduction of coordinates by Ren Descartes and the concurrent development of algebra marked a new stage for geometry, since geometric figures, such as plane curves, could now be represented analytically, i.e., with functions and equations. This played a key role in the emergence of calculus in the seventeenth century. Furthermore, the theory of perspective showed that there is more to geometry than just the metric properties of figures. The subject of geometry was further enriched by the study of intrinsic structure of geometric objects that originated with Euler and Gauss and led to the creation of topology and differential geometry.

Since the nineteenth century discovery of non-Euclidean geometry, the concept of space has undergone a radical transformation. Contemporary geometry considers manifolds, spaces that are considerably more abstract than the familiar Euclidean space, which they only approximately resemble at small scales. These spaces may be endowed with additional structure, allowing one to speak about length. Modern geometry has multiple strong bonds with physics, exemplified by the ties between Riemannian geometry and general relativity. One of the youngest physical theories, string theory, is also very geometric in flavour.

The visual nature of geometry makes it initially more accessible than other parts of mathematics, such as algebra or number theory. However, the geometric language is also used in contexts that are far removed from its traditional, Euclidean provenance, for example, in fractal geometry, and especially in algebraic geometry.

2. Spatial sense

Spatial sense is a critical ability for any student who studies geometry. Generally,little attention is paid to spatial sense in mathematics classrooms, and students must usewhat spatial sense they have developed on their own by playing with Lego Blocks, building sand castles and solving jigsaw puzzles. Some students will enter middle schoolwith a finely developed spatial sense, while others have a poorly developed sense. It isimportant to

develop students' spatial sense and also instill in them the importance ofdeveloping their students' spatial sense. We suggest selecting at least one spatial senseactivity for your class.Another key factor for success in geometry is the use of manipulatives.Manipulatives enable students to explore and discover geometric relationships. They provide concrete representations for relationships that students will eventually representin abstract form. Manipulatives are an essential part of any geometry class. It is also important for students to understand various geometric relationships rather than commit them to memory. Categorizing quadrilaterals provides an opportunityfor students to examine the relationship among the various figures by analyzing theircharacteristics rather than by memorizing any specific relationship. The van Hiele levels of Geometry Thinking allow a classroom teacher to generateactivities and topics that are at the appropriate geometry level for the students. When there is a mismatch between students and activities, very little learning will take place. Ifthe activities are from a lower van Hiele level, then the student has already mastered the material and any activity will be a review a best, and boring at worst. When activities aretoo advanced for students, they will be come frustrated and resort to memorizing anypertinent relationships or withdraw from an active role in the class. The study of similarity requires a sound understanding of proportionality. Ifstudents are not able to reason proportionally, then the study of similar figures is reducedto making visual identifications and substituting values onto memorized formulas andequations. Stress to your students the need for a solid understanding of proportionalitybefore their students examine the relationships between side lengths of similar figures.

3. Practical geometry

There is little doubt that geometry originated as a *practical* science, concerned with surveying, measurements, areas, and volumes. Among the notable accomplishments one finds formulas for lengths, areas and volumes, such as Pythagorean theorem, circumference and area of a circle, area of a triangle, volume of a cylinder, sphere, and a pyramid. Development of astronomy led to emergence of trigonometry and spherical trigonometry, together with the attendant computational techniques.

4. Axiomatic geometry

A method of computing certain inaccessible distances or heights based on similarity of geometric figures and attributed to Thales presaged more abstract approach to geometry taken by Euclid in his Elements, one of the most influential books ever written. Euclid introduced certain axioms, or postulates, expressing primary or self-evident properties of points, lines, and planes. He proceeded to rigorously deduce other properties by mathematical reasoning. The characteristic feature of Euclid's approach to geometry was its rigor. In the twentieth century, David Hilbert employed axiomatic reasoning in his attempt to update Euclid and provide modern foundations of geometry.

5. Geometric constructions

Ancient scientists paid special attention to constructing geometric objects that had been described in some other way. Classical instruments allowed in geometric constructions are the compass and straightedge. However, some problems turned out to be difficult or impossible to solve by these means alone, and ingenious constructions using parabolas and other curves, as well as mechanical devices, were found. The approach to geometric problems with geometric or mechanical means is known as synthetic geometry.

6. Numbers in geometry

Already Pythagoreans considered the role of numbers in geometry. However, the discovery of incommensurable lengths, which contradicted their philosophical views, made them abandon (abstract) numbers in favour of (concrete) geometric quantities, such as length and area of figures. Numbers were reintroduced into geometry in the form of coordinates by Descartes, who realized that the study of geometric shapes can be facilitated by their algebraic representation. Analytic geometry applies methods of algebra to geometric questions, typically by relating geometric curves and algebraic equations. These ideas played a key role in the development of calculus in the seventeenth century and led to discovery of many new properties of plane curves. Modern algebraic geometry considers similar questions on a vastly more abstract level.

7. Geometry of position

Even in ancient times, geometers considered questions of relative position or spatial relationship of geometric figures and shapes. Some examples are given by inscribed and circumscribed circles of polygons, lines intersecting and tangent to conic sections, the Pappus and Menelaus configurations of points and lines. In the Middle Ages new and more complicated questions of this type were considered: What is the maximum number of spheres simultaneously touching a given sphere of the same radius (kissing number problem)? What is the densest packing of spheres of equal size in space (Kepler conjecture)? Most of these questions involved 'rigid' geometrical shapes, such as lines or spheres. Projective, convex and discrete geometry are three subdisciplines within present day geometry that deal with these and related questions.

A new chapter in *Geometria situs* was opened by Leonhard Euler, who boldly cast out metric properties of geometric figures and considered their most fundamental geometrical structure based solely on shape. Topology, which grew out of geometry, but turned into a large independent discipline, does not differentiate between objects that can be continuously deformed into each other. The objects may nevertheless retain some geometry, as in the case of hyperbolic knots.

8. Geometry beyond Euclid

For nearly two thousand years since Euclid, while the range of geometrical questions asked and answered inevitably expanded, basic understanding of space remained essentially the same. Immanuel Kant argued that there is only one, *absolute*, geometry, which is known to be true *a priori* by an inner faculty of mind: Euclidean geometry was synthetic a priori. This dominant view was overturned by the revolutionary discovery of non-Euclidean geometry in the works of Gauss (who never published his theory), Bolyai, and Lobachevsky, who demonstrated that ordinary Euclidean space is only one possibility for development of geometry. A broad vision of the subject of geometry was then expressed by Riemann in his inauguration lecture *ber die Hypothesen, welche der Geometrie zu Grunde liegen* (*On the*

hypotheses on which geometry is based), published only after his death. Riemann's new idea of space proved crucial in Einstein's general relativity theory and Riemannian geometry, which considers very general spaces in which the notion of length is defined, is a mainstay of modern geometry.

9. Symmetry

The theme of symmetry in geometry is nearly as old as the science of geometry itself. The circle, regular polygons and platonic solids held deep significance for many ancient philosophers and were investigated in detail by the time of Euclid. Symmetric patterns occur in nature and were artistically rendered in a multitude of forms, including the bewildering graphics of M. C. Escher. Nonetheless, it was not until the second half of nineteenth century that the unifying role of symmetry in foundations of geometry had been recognized. Felix Klein's Erlangen program proclaimed that, in a very precise sense, symmetry, expressed via the notion of a transformation group, determines what geometry *is*. Symmetry in classical Euclidean geometry is represented by congruences and rigid motions, whereas in projective geometry an analogous role is played by collineations, geometric transformations that take straight lines into straight lines. However it was in the new geometries of Bolyai and Lobachevsky, Riemann, Clifford and Klein, and Sophus Lie that Klein's idea to 'define a geometry via its symmetry group' proved most influential. Both discrete and continuous symmetries play prominent role in geometry, the former in topology and geometric group theory, the latter in Lie theory and Riemannian geometry.

10. Modern geometry

Modern geometry is the title of a popular textbook by Dubrovin, Novikov, and Fomenko first published in 1979 (in Russian). At close to 1000 pages, the book has one major thread: geometric structures of various types on manifolds and their applications in contemporary theoretical physics. A quarter century after its publication, differential geometry, algebraic geometry, symplectic geometry, and Lie theory presented in the book remain among the most visible areas of modern geometry, with multiple connections with other parts of mathematics

and physics.

In Section 4 of this course you will cover these topics:

- Measurement: Behind The Units
- Data Analysis: The Process

Topic : Measurement: Behind The Units

Topic Objective:

At the end of this topic student would be able to:

Understand the importance of benchmarks in applying measurement to real-world situations.
Build understanding of area and volume by using polygons and polyhedrons to represent these concepts.
Recognize that conversions should be made within the metric and customary systems, and not between them.A

Definition/Overview:

Units Of Measurement: The definition, agreement and practical use of **units of measurement** have played a crucial role in human endeavour from early ages up to this day.

Key Points:

1. Units Of Measurement

The definition, agreement and practical use of **units of measurement** have played a crucial role in human endeavour from early ages up to this day. Disparate systems of measurement used to be very common. Now there is a global standard, the International System (SI) of

units, the modern form of the metric system. The SI has been or is in the process of being adopted throughout the world. In trade, **weights and measures** is often a subject of governmental regulation, to ensure fairness and transparency. The Bureau international des poids et mesures (BIPM) is tasked with ensuring worldwide uniformity of measurements and their traceability to the International System of Units (SI). Metrology is the science for developing national and internationally accepted units of weights and measures.

In physics and metrology, units are standards for measurement of physical quantities that need clear definitions to be useful. Reproducibility of experimental results is central to the scientific method. A standard system of units facilitates this. Scientific systems of units are a refinement of the concept of weights and measures developed long ago for commercial purposes.

Science, medicine, and engineering often use larger and smaller units of measurement than those used in everyday life and indicate them more precisely. The judicious selection of the units of measure can aid researchers in problem solving (see, for example, dimensional analysis).

In the social sciences, units of measurement are not yet standardized, and are based on "the assignment of numbers according to a rule".

2. Systems of measurement

2.1 Traditional systems

This derivation of the Vitruvian Man by Leonardo da Vinci, depicts nine historical units of measurement: the Yard, the Span, the Cubit, the Flemish Ell, the English Ell, the French Ell, the Fathom, the Hand, and the Foot. The Vitruvian man was drawn to scale, so the units depicted are displayed with their proper historical ratios.

Prior to the near global adoption of the metric system many different systems of measurement had been in use. Many of these were related to some extent or other. Often they were based on the dimensions of the human body. As a result, units of measure could vary not only from location to location, but from person to person.

2.2 Metric systems

A number of metric systems of units have evolved since the adoption of the original metric system in France in 1791. The current international standard metric system is the International system of units. An important feature of modern systems is standardization. Each unit has a universally recognized size.

Both the Imperial units and US customary units derive from earlier English units. Imperial units were mostly used in the British Commonwealth and the former British Empire. US customary units are still the main system of measurement in the United States despite Congress having legally authorized metric measure on 28 July 1866, as amended by Public Law 11069 Aug 9, 2007. Some steps towards US metrication have been made, particularly the redefinition of basic US units to derive exactly from SI units, so that in the US the inch is now defined as 0.0254 m, and the avoirdupois pound is now defined as 453.59237 g.

2.3 Natural systems

While the above systems of units are based on arbitrary unit values, formalised as standards, some unit values occur naturally in science. Systems of units based on these are called natural units. Similar to natural units, atomic units (au) are a convenient system of units of measurement used in atomic physics.

Also a great number of strange and non-standard units may be encountered. These may include the Solar mass, the Megaton (1,000,000 tons of TNT), the Hiroshima atom bomb and the weight of an elephant.

2.4 Legal control of weights and measures

To reduce the incidence of retail fraud, many national statutes have standard definitions of weights and measures that may be used (hence "statute measure"), and these are

verified by legal officers.

3. The foundations of measurement

The foundations of measurement are laid in elementary school, where studentslearn basic concepts of measurement through iteration of standard units. Many studentsdo not progress any farther in their understanding of measurement, and simply affix ameasurement unit to the solution of a word problem, without considering the validity ofthe unit of measurement in the solution itself. It is critical that students employmeasurement concepts and units while they solve problems so that the final solution,complete with a measurement unit, is reasonable and logical.In middle school students should fully engage both the metric and customarymeasurement systems. This dual approach will continue until the United States convertsto the Metric System. It is important for students to establish benchmarks in each systemfor some common measurements such as a foot, meter, pound, kilogram, mile, kilometer,and so forth. When students establish such benchmarks, there is very little reason toconvert measurements between systems because students have benchmark referents fordoing so.Area and perimeter are introduced in earlier grades but become a focus ofmeasurement in the middle grades. The introduction of many formulas for area andperimeter provide tools for students to solve problems, but can also lead to rotememorization. When students simply memorize formulas they have difficultydistinguishing between area and perimeter concepts and computation, as for example, theformulas for circumference and area of a circle. These formulas must be introduced andemployed in context and with clarifying applications so students do no confuse terms,concepts, or formulas.Area and volume measures are introduced in middle school and can prove confusing to students who try to remember all the conversion factors rather thanunderstand their square and cubic nature. Students require many opportunities to explorethese relationships with manipulatives before they can understand abstractrepresentations for these relationships.

4. The metric system

The metric system is a decimalised system of measurement. It exists in several variations, with different choices of base units, though the choice of base units does not affect its day-to-day use. Over the last two centuries, different variants have been considered the metric system. Since the 1960s the International System of Units ("Systme International d'Units" in French, hence "SI") has been the internationally recognised standard metric system. Metric units are widely used around the world for personal, commercial and scientific purposes. A standard set of prefixes in multiples of ten may be used to derive larger and smaller units. However, the prefixes for multiples of one thousand are the most commonly used.

One goal of the metric system is to have a single unit for any physical quantity; another important one is not needing conversion factors when making calculations with physical quantities. All lengths and distances, for example, are measured in metres, or thousandths of a metre (millimetres), or thousands of metres (kilometres), and so on. There is no profusion of different units with different conversion factors, such as inches, feet, yards, fathoms, rods, chains, furlongs, miles, nautical miles, leagues, etc. Multiples and submultiples are related to the fundamental unit by factors of powers of ten, so that one can convert by simply moving the decimal place: 1.234 metres is 1234 millimetres, 0.001234 kilometres, etc. The use of fractions, such as 2⁄7 of a metre, is not prohibited, but uncommon, as it is generally not necessary.The original metric system was intended to be used with the time units of the French Republican Calendar, but these fell into disuse. Today decimal time is not in everyday use. Submultiples of the second (the microsecond for example) are used in scientific work but for lengths of time greater than a second traditional units, with their non-decimal conversion factors, are more often used than decimal multiples of the second.In the late 18th century, Louis XVI of France charged a group of experts to develop a unified, natural and universal system of measurement to replace the disparate systems then in use. This group, which included such notables as Lavoisier, produced the metric system, which was then adopted by the revolutionary government of France. In the early metric system, there were several fundamental or base units, the grad or grade for angles, the metre for length, the gram for mass and the litre for capacity. These were derived from each other via the properties of natural objects, mainly the Earth and water: 1 metre was originally defined as 1⁄40,000,000 of the polar circumference of the Earth, the kilogram was originally defined as the mass of one litre (or, equivalently, 1 dm) of water at its melting point (this definition was later revised to specify a temperature of 4 C). The Celsius temperature scale was derived from the properties of water, with 0 C being defined as its freezing point and 100 C being defined as its boiling

point under a pressure of one standard atmosphere.The metre was later redefined as the length of a particular bar of platinum-iridium alloy; then in terms of the wavelength of light emitted by a specified atomic transition; and now is defined as the distance travelled by light in an absolute vacuum during 1⁄299,792,458 of a second. The gram, originally one millionth of the mass of a cubic metre of water, is currently defined by one thousandth of the mass of a specific object that is kept in a vault in France; however there are efforts underway to redefine it in terms of physical quantities that could be reproduced in any laboratory with suitable equipment. The second, originally 1⁄86,400 of the mean solar day was redefined in 1967 to be 9,192,631,770 periods of vibration of the radiation emitted at a specific wavelength by an atom of caesium-133. Varying choices have been made for the fourth base unit, that which is needed to incorporate the field of electromagnetics; As of 2006, this is the ampere, being the base unit of electrical current. Other quantities are derived from the base units; for example, the basic unit of speed is metres per second.

As each new definition is introduced, it is designed to match the previous definition as precisely as possible, so these changes of definition have not affected most practical applications. (See SI and individual unit articles for full definitions.)The names of multiples and submultiples are formed with prefixes. They include deca- (ten), hecto- (hundred), kilo- (thousand), mega- (million), and giga- (billion); deci- (tenth), centi- (hundredth), milli- (thousandth), micro- (millionth), and nano- (billionth). The most commonly used prefixes for multiples depend on the application and sometimes tradition. For example, long distances are stated in thousands of kilometres, not megametres.Most everyday users of the metric system measure temperature in degrees Celsius, though the SI unit is the kelvin, a scale whose units have the same "size", but which starts at absolute zero. Zero degrees Celsius equals 273.15 kelvins (the word "degree" is no longer to be used with kelvins since 1967-1968).Angular measurements have been decimalised, but the older non-decimal units of angle are far more widely used. The decimal unit, which is not part of SI, is the gon or grad, equal to one hundredth of a right angle. Subunits are named, rather than prefixed: the gon is divided into 100 decimal minutes, each of 100 decimal seconds. The traditional system, originally Babylonian, has 360 degrees in a circle, 60 minutes of arc (also called arcminutes) in a degree, and 60 seconds of arc (also called arcseconds) in a minute. The clarifier "of arc" is dropped if it is clear from the context that we are not speaking of minutes and seconds of time. Sometimes angles are given as decimal degrees, e.g., 26.4586 degrees, or in other units such as radians (especially in scientific uses other than astronomy) or angular mils.The metric

system was designed with several goals in mind.

Topic : Data Analysis: The Process

Topic Objective:

Definition/Overview:

At the end of this topic student would be able to:

Understand that data analysis is a process not an event.
See the connection between data analysis and the writing process.
Recognize the importance of having students carefully articulate the question to be addressed at the beginning of the process.
Encourage students to anticipate the type of data that will be helpful in answering their question.
Understand that careful consideration must be given to how the data are to be collected, including the sample size and sampling techniques.
Realize that summary statistics such as measures of central tendency and measures of dispersion are descriptive. Students can select those measures that aptly characterize the data set.
Understand that experience with misleading graphs heightens students awareness and adds to their knowledge base.
Recognize that multiple representations of the data lead to more robust understandings.

Definition/Overview:

Key Points:

1. Data analysis

Data analysis is a process of gathering, modeling, and transforming data with the goal of highlighting useful information, suggesting conclusions, and supporting decision making. Data analysis has multiple facets and approaches, encompassing diverse techniques under a variety of names, in different business, science, and social science domains.

Data mining is a particular data analysis technique that focuses on modeling and knowledge discovery for predictive rather than purely descriptive purposes. Business intelligence covers data analysis that relies heavily on aggregation, focusing on business information. In statistical applications, some people divide data analysis into descriptive statistics, exploratory data analysis, and confirmatory data analysis. EDA focuses on discovering new features in the data and CDA on confirming or falsifying existing hypotheses. Predictive analytics focuses on application of statistical or structural models for predictive forecasting or classification, while text analytics applies statistical, linguistic, and structural techniques to extract and classify information from textual sources, a species of unstructured data. All are varieties of data analysis.

Data integration is a precursor to data analysis, and data analysis is closely linked to data visualization and data dissemination. The term *data analysis* is sometimes used as a synonym for data modeling, which is unrelated to the subject of this article.

2. Nuclear and particle physics

In nuclear and particle physics the data usually originate from the experimental apparatus via a data acquisition system. It is then processed, in a step usually called *data reduction*, to apply calibrations and to extract physically significant information. Data reduction is most often, especially in large particle physics experiments, an automatic, batch-mode operation carried out by software written ad-hoc. The resulting data *n-tuples* are then scrutinized by the physicists, using specialized software tools like ROOT or PAW, comparing the results of the experiment with theory.

The theoretical models are often difficult to compare directly with the results of the experiments, so they are used instead as input for Monte Carlo simulation software like Geant4, predict the response of the detector to a given theoretical event, producing **simulated**

events which are then compared to experimental data.

See also: Computational physics.

3. Social sciences

Qualitative data analysis (QDA) or qualitative research is the non-quantitative analysis of data from non-numerical sources, for example words, photographs, observations, etc..

4. Phases in data analysis

The statistical analysis of data is a process with several phases, each with its own goal.

5. Data cleaning

During data cleaning erroneous entries are inspected and corrected where possible. In some cases, it is easy to substitute suspect data with the correct values. However, when it is unclear what caused the erroneous data or what should be used to replace it, it is important that no subjective decisions are made to ensure the quality of the data. Furthermore, it is important not to throw information away at any stage in the data cleaning phase. When altering variables the original values should be kept in a duplicate dataset or under a different variable name so that information is always cumulatively retrievable.

6. Initial data analysis

The initial data analysis uses descriptive statistics to answer the following four questions:

What is the quality of the data?
What is the quality of the measurements?
Did the implementation of the study fulfill the intentions of the research design?

What are the characteristics of the data sample?

Each step of the initial data analysis is described below.

7. The quality of the data

The quality of the data can be assessed in several ways. First of all the distribution of the variables before data cleaning is compared to the distribution of the variables after data cleaning to see whether data cleaning has had unwanted effects on the data. Second, the missing observations in the data are analyzed to see whether they are missing at random and whether some form of imputation (statistics) is needed. Third, extreme observations in the data are analyzed to see if they seem to disturb the distribution. If that is the case, robust techniques can be applied.

8. The quality of the measurements

When the quality of the measurement instruments used is not the main focus of the research, the quality of the measurement instruments can be checked during initial data analysis. One way to assess the quality of a measurement instrument is to perform an analysis of homogeneity (internal consistency). A homogeneity index like Cronbach's α gives an indication of the reliability of a measurement instrument.

9. The implementation of the design

In many cases, a check to see whether the randomization procedure has worked will be the starting point for analyzing the implementation of the design. This can be done by checking whether variables are equally distributed across groups. Other ways of checking the implementation of the design are manipulation checking and the analysis of nonresponse and dropout.

10. Characteristics of the data sample

In this step, the findings of the initial data analysis are documented and possible corrective actions are taken. For instance, when the distribution of a variable is not normal, the data may need to be transformed or categorized. Furthermore, a decision should be made on how to handle missing data and outliers. If the randomization procedure seems to be defective, propensity scores can be calculated and included in the main analyses as a covariate.

In Section 5 of this course you will cover these topics:

- Probability; Measures Of Uncertainty
- Teaching As A Career: The Journey Begins

Topic : Probability; Measures Of Uncertainty

Topic Objective:

At the end of this topic student would be able to:

Understand that probability is a part-whole ratio of a desired event compared to all possible outcomes (sample space).
Know that probability principles apply to random or fair events.
Appreciate that probability cannot predict the outcome of a single event, but only the tendencies of events over many trials.
Provide opportunities for students to experience the three ways the probability of a situation can be determined: compute the theoretical probability, collect experimental data, and perform simulations.
Consider the Law of Large Numbers when collecting classroom data.

Definition/Overview:

Probability: Probability is the likelihood or chance that something is the case or that an event will occur.

Key Points:

1. Probability

Probability is the likelihood or chance that something is the case or that an event will occur. Probability theory is used extensively in such areas of study as mathematics, statistics, finance, gambling, science, and philosophy to draw conclusions about the likelihood of potential events and the underlying mechanics of complex systems.

Probability is the most challenging topic in the middle school mathematics curriculum.

2. Relation to randomness

In a deterministic universe, based on Newtonian concepts, there is no probability if all conditions are known. In the case of a roulette wheel, if the force of the hand and the period of that force are known, then the number on which the ball will stop would be a certainty. Of course, this also assumes knowledge of inertia and friction of the wheel, weight, smoothness and roundness of the ball, variations in hand speed during the turning and so forth. A probabilistic description can thus be more useful than Newtonian mechanics for analysing the pattern of outcomes of repeated rolls of roulette wheel. Physicists face the same situation in kinetic theory of gases, where the system, while deterministic *in principle*, is so complex (with the number of molecules typically the order of magnitude of Avogadro constant ( ) that only statistical description of its properties is feasible.

A revolutionary discovery of 20th century physics was the random character of all physical processes that occur at sub-atomic scales and are governed by the laws of quantum mechanics. The wave function itself evolves deterministically as long as no observation is made, but, according to the prevailing Copenhagen interpretation, the randomness caused by the wave function collapsing when an observation is made, is fundamental. This means that probability theory is required to describe nature. Others never came to terms with the loss of determinism. Albert Einstein famously remarked in a letter to Max Born: *Jedenfalls bin ich berzeugt, da der Alte nicht wrfelt.* (*I am convinced that God does not play dice*). Although

alternative viewpoints exist, such as that of quantum decoherence being the cause of an *apparent* random collapse, at present there is a firm consensus among the physicists that probability theory is necessary to describe quantum phenomena.

3. Mathematical treatment

In mathematics, a probability of an event *A* is represented by a real number in the range from 0 to 1 and written as P(*A*), p(*A*) or Pr(*A*). An impossible event has a probability of 0, and a certain event has a probability of 1. However, the converses are not always true: probability 0 events are not always impossible, nor probability 1 events certain. The rather subtle distinction between "certain" and "probability 1" is treated at greater length in the article on "almost surely".

The *opposite* or *complement* of an event *A* is the event [not *A*] (that is, the event of *A* not occurring); its probability is given by P(not *A*) = 1 - P(*A*). As an example, the chance of not rolling a six on a six-sided die is 1 - (chance of rolling a six) = . See Complementary event for a more complete treatment.

If both the events *A* and *B* occur on a single performance of an experiment this is called the intersection or joint probability of *A* and *B*, denoted as . If two events, *A* and *B* are independent then the joint probability is

for example, if two coins are flipped the chance of both being heads is .

If either event *A* or event *B* or both events occur on a single performance of an experiment this is called the union of the events *A* and *B* denoted as . If two events are mutually exclusive then the probability of either occurring is

For example, the chance of rolling a 1 or 2 on a six-sided die is

.

If the events are not mutually exclusive then

.

For example, when drawing a single card at random from a regular deck of cards, the chance of getting a heart or a face card (J,Q,K) (or one that is both) is , because of the 52 cards of a deck 13 are hearts, 12 are face cards, and 3 are both: here the possibilities included in the "3 that are both" are included in each of the "13 hearts" and the "12 face cards" but should only be counted once.

Conditional probability is the **probability** of some event *A*, given the occurrence of some other event *B*. Conditional probability is written *P*(*A*|*B*), and is read "the probability of *A*, given *B*". It is defined by

If *P*(*B*) = 0 then is undefined.

4. Applications

Two major applications of probability theory in everyday life are in risk assessment and in trade on commodity markets. Governments typically apply probabilistic methods in environmental regulation where it is called "pathway analysis", often measuring well-being using methods that are stochastic in nature, and choosing projects to undertake based on statistical analyses of their probable effect on the population as a whole.

A good example is the effect of the perceived probability of any widespread Middle East conflict on oil prices - which have ripple effects in the economy as a whole. An assessment by a commodity trader that a war is more likely vs. less likely sends prices up or down, and

signals other traders of that opinion. Accordingly, the probabilities are not assessed independently nor necessarily very rationally. The theory of behavioral finance emerged to describe the effect of such groupthink on pricing, on policy, and on peace and conflict.

It can reasonably be said that the discovery of rigorous methods to assess and combine probability assessments has had a profound effect on modern society. Accordingly, it may be of some importance to most citizens to understand how odds and probability assessments are made, and how they contribute to reputations and to decisions, especially in a democracy.

Another significant application of probability theory in everyday life is reliability. Many consumer products, such as automobiles and consumer electronics, utilize reliability theory in the design of the product in order to reduce the probability of failure. The probability of failure may be closely associated with the product's warranty.

Topic : Teaching As A Career: The Journey Begins

Topic Objective:

At the end of this topic student would be able to:

Recognize the professionalism of teaching
Consider issues relating to finding the first job
Answer questions that might be asked in an interview
Consider professional development opportunities
Reflect on their individual progress in the course

Definition/Overview:

Teaching Profession: Teaching is the mechanism by which skills and knowledge are imparted to an individual, and society has entrusted teachers with the responsibility of providing the populace with the skills and knowledge deemed necessary to engage as citizens and lead productive and meaningful lives.

Key Points:

1. Teaching Profession

Teaching is the mechanism by which skills and knowledge are imparted to an individual, and society has entrusted teachers with the responsibility of providing the populace with the skills and knowledge deemed necessary to engage as citizens and lead productive and meaningful lives. To be effective, teaching must be interesting, stimulating, challenging, and satisfying, and it must result in learning that is culturally significant, is valued by society at large, and prepares individuals to meet the needs of their changing world.

The American public school system was built on the premise that the quality of education children receive can have a tremendous impact on their quality of life and their ability to become contributing members of society, especially given the demands of globalization in the twenty-first century. As the U.S. educational system struggles to deal with demands and controlling influences imposed by politicians, businesspeople, and special interest groups, as well as with the ever-increasing diversity in today's schools, it is important to understand the history of the American teaching profession in order to better understand the current and future milieu of teaching. This entry examines early teaching, development of the system of teaching credentials in the United States, the debate surrounding the professionalization of teaching, and issues that have and will continue to affect teaching in the twenty-first century.

2. Teacher recruitment

Teacher recruitment includes varied efforts to attract potential candidates to the profession and/or to vacant teaching positions. Although the United States prepares sufficient teachers to staff available openings, teacher recruitment serves two broad purposes: diversifying the teacher workforce and staffing key shortage areas. Recruitment policies and programs, leveraged by states or local districts, generally address teacher preparation, entry requirements, and hiring incentives. Some of these initiatives appear promising. However, teacher turnover threatens the success of recruitment efforts. Nevertheless, teacher recruitment plays an important role in shaping the teaching profession, especially teacher

characteristics and pathways into teaching. This entry looks at goals of teacher recruitment, strategies for accomplishing it, and teacher shortages.

3. Purposes of Teacher Recruitment

The urgency for teacher recruitment depends on supply and demand. Some studies predict nationwide teacher shortages in coming years. Other speculations are more moderate; arguing regional shortagesinequities in teacher *distribution* (rather than insufficient supply of teachers)will continue to be the norm. Regardless, two conditions drive contemporary efforts to expand the pool of teacher candidates: teacher demographics and specific shortage areas. The former has national scope, whereas the latter is somewhat more localized. Each presents its own unique set of challenges, but the concern that cuts across both is teacher quality.

4. Forcing a Shift in Teacher Demographics

There are two demographic issues pushing teacher recruitment: diversity and academic ability. The first tackles long-standing patterns of who becomes a teacher. The teaching population continues to be dominated heavily by White females. Yet student populations are increasingly more diverse, especially in areas of the country like California and Texas. The disparity between student and teacher demographics underlies efforts to diversify the teaching forcerecruiting minorities and males so that the race/ethnicity/gender of the teaching population more closely matches the student population.

A second issue concerns teacher candidates' general academic ability. Statistical studies show that students with lower college entrance exam scores are more likely to become teacher candidates than those with higher scores. These figures cause alarm about teacher quality. If education is the next generation's hope for the future, students deserve the best and the brightest as teachers.

5. Attracting Teachers to Key Shortage Areas

The No Child Left Behind Act, enacted in 2002, requires all teachers to hold credentials appropriate for their teaching position. The mandate prevents districts from hiring teachers who are out of field, a practice used to fill vacancies in the past. Consequently, there is a push to attract candidates for national shortage areas in mathematics, science, bilingual, and special educationthere are simply not enough teachers preparing for these areas. Labor market specialists point out that potential mathematics and science specialists often have a wide array of career options in industry and government, with better salary and benefits than teaching typically offers.

Certain geographic areas and types of school districts are especially prone to teacher shortages. States with large student populations (e.g., California), high-poverty urban centers, and isolated rural districts often struggle to fill vacancies with qualified teachers. Wealthier districts are more likely to have resources that attract qualified teacherssalaries, working conditions, and other incentives. Consequently, high-poverty schools are less competitive in the teacher marketa situation that leaves the neediest students at risk for substandard education. The recruitment challenge is twofold: increase the number of applicants without sacrificing quality.

6. Teacher Recruitment Strategies

Whereas local districts typically operate their own recruitment programs, many states sponsor statewide or district teacher recruitment efforts. At the federal level, Title II Teacher Quality Enhancement Recruitment Grants support state and local efforts to recruit highly qualified teachers for acute shortage areas. States/districts strapped for teachers are the most aggressive, employing multiple strategies to attract qualified teachers. Some districts, for instance, hire marketing specialists to put together recruitment campaigns that include job fairs, slick Web sites, and media coverage. Other types of strategies include specialized teacher preparation programs, streamlined licensure policies, and incentives. As might be expected from locally controlled recruitment, there are many versions, reflecting local

variation and staffing needs.

7. Specialized Teacher Education Programs

Because teacher education programs are dependent on students for their livelihood, recruiting teacher candidates goes hand in hand with teacher preparation. Although teachers tend to cite intrinsic (e.g., helping children, contributing to society) rather than extrinsic (e.g., salary) rewards as reasons for becoming teachers, job security attracts them as well. Programs targeting shortage areas can promise (and sometimes even guarantee) participants teaching positions upon completing their degrees.

Teacher education programs recruit teachers into key shortage areas in several waysearly outreach, grow your own, and shortage-specific preparation programs. Early outreach acquaints elementary and secondary students with teaching as a career through job fairs, clubs, coursework, and tutoring/teaching experiences (e.g., the Teacher Cadet program). State and district grow your own or pipeline programs produce the teachers they need themselves, often in partnership with teacher education institutions. These programs provide financial assistance for undergraduates, paraprofessionals, or teacher aides to obtain their teaching license in shortage areas, often in exchange for a multiyear teaching commitment. Teacher education institutions increasingly offer an additional approach, tailoring undergraduate and postbachelor's programs for urban districts or other shortage areasmathematics, science, bilingual, and special education. Many early outreach, grow your own, and shortage-specific programs are designed to attract men and minorities to the profession as well.

8. Alternative Certification Programs

Alternative certification programs are another method for drawing nontraditional populations, including minorities, mid-career changers, and retired professionals. Labor market specialists suggest that teacher certification requirements may keep talented individuals from pursuing teaching as a first or second career. Alternative routes, as they are sometimes called, recruit individuals with subject expertise to high-need teaching areas. These programs streamline the path into teaching, allowing college graduates to become full-time teachers sooner than state

certification would normally permit.

Alternative certification programs have mushroomed during the past decade. However, programs vary widely, from entry requirements to educational components to on-the-job support. Teach for America and Troops to Teachers are examples of national programs that recruit teachers through alternative certification pathways. At the state level, in 2006, nearly all states reported offering alternative routes to teacher certification. Moreover, districts increasingly design their own alternative route programs for shortage areas. For instance, Chicago and New York both have Teaching Fellows programs, recruiting academically and professionally successful individuals to teach full-time in shortage areas while completing teacher certification requirements.

9. Incentives

Specialized teacher education programs and alternative routes offer ready-made teaching positions as their plum. A parallel recruitment line targets the financial rewards of teaching. Monetary enticements run the gamutincreased salaries and benefits, housing assistance, loan forgiveness, scholarships, and signing bonuses. Most states use at least one of these incentives to recruit teachers. A few states, desperate for qualified teachers (e.g., California and North Carolina), use them all.

10. Impact on Teacher Shortages

It is difficult to evaluate the impact that innovative recruitment strategies have on teacher demographics and shortages. Although states and districts design recruitment with such purposes in mind, few studies rigorously examine their effects. There is still much to be learned, and results are mixed. At present, it appears that some alternative certification programs attract a population that is more diverse by ethnicity, gender, and age. Few conclusions can be drawn about teacher education or grow-your-own programs; the research is insufficient. Moreover, there are no conclusive results about the influence of these programs on teacher quality. The same holds true for incentives. Although financial rewards, to some extent, may attract more teachers, there is limited evidence about how these

incentives influence the demographics or quality of the teacher workforce.

11. Shaping the Workforce

The composition of the teacher workforce has been relatively consistent. A more open labor market heightens competition for teachers. Recruitment strategies have the potential to bring more, and demo-graphically diverse, individuals to teaching. It appears unlikely that shortage areas can attract qualified teachers without re-imagining how teachers are educated, certified, and compensated. Much more research is needed, however, on the implications of recruitment innovations on teacher quality.

Furthermore, the extent to which recruitment practices shape the teacher workforce and affect key shortage areas is moderated by teacher attrition. The teacher labor market has been described as a revolving door or a leaking bucket because of teacher turnover. Recruitment efforts can open the door or fill the bucket. However, the hiring practices and working conditions that teachers encounter can just as quickly drive them away. Recruitment, then, is not an isolated activityits impact is tightly tied to teacher retention.

12. Teaching as a Profession

Schools are labor-intensive organizations, with 75 percent to 80 percent of schools' budgets allocated for personnel cost, and how teachers are treated greatly affects their performances, personal satisfaction, and ultimately their decision to remain in a district or the teaching profession altogether. Since the early 1900s, those in teaching have fought for professional status; however, efforts in that area have proved fruitless for a variety of reasons. Many believe that the feminiza-tion of teaching in the 1850s left a legacy that the profession of teaching still endures to this day; that is, the stigmatization associated with the diminished stature of women in the workforce that imposes on teaching the categorization of little more than a domestic occupation requiring administrative control. Current demographics show that the composition of the field of teaching is 75.1 percent females and 24.9 percent males.

Others believe that teaching will remain an occupation or semi-profession until issues regarding control over the professional licensing of teachers, the competencies and qualifications for teaching, and the standards upon which licensing will be based are resolved. Meanwhile, the debate continues as teaching salaries remain noncompetitive with those of similarly educated individuals in other professions, an issue that serves to deter entry into or persistence in the field of teaching.

13. Teaching in the Twenty-First Century

The quality of education that children receive can have a tremendous impact on the quality of life they have and their ability to become contributing members of a global societyFZ. The ever-increasing diversity of American schools has added to the challenge, as the more diverse the group, the more complicated teaching becomes. Today in the United States, the field of education is struggling in a climate of change, criticism, and economic limits resulting in the steady erosion of confidence in schools.

In that vein, the Elementary and Secondary Education Act of 1965 was revised to become the No Child Left Behind (NCLB) Act of 2001, an effort intended to improve the American public education system, and teaching was at the heart of the legislation. Among the provisions of the nearly 1,000-page NCLB bill was the directive that every child be taught by highly qualified teachers, as teacher subject-matter knowledge has been correlated with student learning. Teachers are deemed to have Highly Qualified Teacher (HQT) status if they hold a bachelor's degree in the subject area in which they teach, demonstrate subject-area knowledge of the subjects they are assigned to teach, and obtain full state teacher certification. All teachers were required to obtain HQT status by 2006; however, not all states were able to meet this mandate. Currently, teaching proficiency is being gauged by the results of standardized tests; schools persistently rated as failing, as indicated by test scores, are mandated to replace certain teachers, change the curriculum, or risk restructuring or state takeover. In NCLB, teaching is clearly viewed as both the cause and the solution to many societal problems facing America today.

Undoubtedly, many factors affect student achievement, and some of the more important factors are what teachers believe, know, and can do. However, teachers deal with a plethora

of issues in their schools and classrooms over which they have no control. Limited English proficiency, special needs, poverty, drug and alcohol abuse, overcrowded classrooms, inadequate classroom supplies, outdated textbooks, and increased violence are some of the factors affecting teaching daily. With the national emphasis on improved instruction, it is critical to recognize the complexity and importance of quality teaching for high-performing schools; however, it is difficult to attract and retain well-qualified teachers in schools labeled as failing.

NCLB has had a significant impact on teaching practices in many schools, as teachers are often required to teach to the test to avoid sanctions. Some believe that this has resulted in a narrowing of the curriculum and effective teaching practices, thus altering the school experience for students and teachers alike