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STRENGTHENING MATHEMATICS INSTRUCTION FOR ALL STUDENTS THROUGH DIFFERENTIATED TEACHING STRATEGIES

Introduction. Brain research confirms what experienced teachers have always known: no two children are alike; no two children learn in the identical way; an enriched environment for one student is not necessarily enriched for another; in the classroom we should teach children to think for themselves [1, c.2]. Students and their parents are well aware of their own differences related to learning readiness, cultural background, interests, gender, talents, intelectual characters, and learning styles. The diversity has always been a part of American education. «In the United States our goal is to educate all comers,» says Dr. Carol A. Tomlinson, a 20-year veteran and a proponent of the mixed-ability classroom [3]. But teachers very often ignore student differences and use the «teach-to-the middle» or «one-size-fits-all» approach, where every student is expected to read the same textbook, do the same activities and exercises, work at the same pace, do the same homework, sit in the same place, and take the same tests. The result is frustration on the part of many students and their parents. Research conducted in the most successful Piedmont School District in California, USA, has shown that only 55% of the 8th graders took Algebra 1, 6% took geometry and the average score was 25% on a test designed by University of Berkeley to predict success in Algebra 1. Some students find the work to be unchallenging and lessons to be boring, others find the work to be too complicated and lessons to be rather challenging. Parents are concerned that learning styles and intelectual strengths of their kids are not addressed by the schools. It is happening at the times when all Californian middle schools are moving in the «algebra for all» direction and the state Board of Education voted to make California the first state in the nation to require its schools to tests students in Algebra 1 in middle school [12].

Braking the monotony of educating all children with the same option, a differentiated instruction applies an approach to teaching and learning that gives students multiple options for mastering the content and applying it. True differentiation requires the realization that all learners vary in their readiness, interests, and learning profiles (C. Tomlinson, G. Gregory, C. Chapman) [3, c.4]. Jumping off from this point, teachers can set up classrooms where everybody works toward essential understandings and skills, but uses different content, processes, and products to get there. Therefore, differentiation is all about giving every student choices and options in learning that the standard classroom will never give.

«Differentiation calls on us to make big leaps in the way we think about the classroom and the curriculum. It takes a willingness to be a teacher who partners with kids in teaching and learning – who's more of a facilitator than a dictator. It challenges the sense that the curriculum is just coverage of facts» [3]. In other words, differentiated instruction is a teaching theory based on the premise that instructional approaches should vary and be adapted in relation to individual and diverse students in classrooms. The model of differentiated instruction requires teachers to be flexible in their approach to teaching and adjust the curriculum and presentation of information to learners rather than expecting students to modify themselves for the curriculum. The differentiated classroom becomes a student-centered environment where the focus is shifted from teacher's instruction to student's learning. Many teachers and teacher educators have recently identified differentiated instruction as a method of helping more students in diverse classroom settings experience success [3; 4; 6; 7].

This article examines information on the theory, research and experiences behind differentiated instruction and the intersection with Team Accelerated Instruction (TAI), a

curriculum designed approach to increase flexibility in teaching and decrease the barriers that frequently limit student access to materials and learning in mixed-ability classrooms.

The purpose of this article is to introduce some points of view on the ways of strengthening instruction for all students through differentiated teaching strategies.

The main body. According to Bob Sullo, teaching over the past quarter-century has become more professional due to the emergence of a number of «best practices» that have significantly affected curriculum and instruction. «A sampling of innovations includes differentiated instruction, Understanding by Design, the emergence of state standards, the development of curriculum frameworks, scope-and-sequence charts that inform teachers of what to teach and when to teach it, the expanded use of technology in education, active literacy, curriculum mapping, and the proliferation of professional learning communities. Formative assessment informs instruction like never before» [11]. Differentiation as a philosophical change in teaching has started in the early 90's. The concept has been around for at least two decades for gifted and talented students in USA. Ukrainian pedagogical universities were also among the first educational institutions to conduct special seminars on differentiation. The future teachers were prepared to organize a process which would allow all students to learn in their most efficient manner. The seminars were designed to strengthen instruction for all pupils through differentiated teaching strategies based on best practices in domestic and foreign education, uncluding the U.S. experience. It was a surprise to discover that differentiation was not often used by the teachers in the American schools 14 years ago. There are a lot of seminars and workshops on differentiation going around a school year in each educational district nowdays. But the differentiated aproach, which is highly ranked among active learning strategies to teach any subject and it is now recognized to be an important tool for engaging students and addressing the individual needs of all students, has still to find it way to the American classrooms. Teaching mathematics and physics at Middle School in California, we have started with the respond to the learner's needs, style, and basic knowledge by adjusting the pace, level, and content of instruction. Consequently, it necessarily followed that although essential curricula goals were similar for all students, methodologies employed in a classroom had to be varied to suit to the individual needs of all children. It meant that learning had to be differentiated to be effective. The school community and parents supported the idea of streaming students in math and spanish and using differentiated instruction in the classrooms. We can agree with C. Tomlinson that implemantation of differentiated approach into practice takes from 7 to 10 years of experiments, trials and fails. We also support her idea that a teacher must be an expert in the subject and should go through a special training on differentiation. But the most important is acceptance of the differention phylosophy by students, teachers, school administration and community. Differentiated instruction, Socratic teaching and Lev Vigotsky's sociocultural theory became the core of the BPC school's philosophy for many years.

We have started from the idea that differentiated instruction did not simply focus on curriculum taught but rather what the student learned and would apply from the curriculum. That is why the heads of school departments created the Learning Pyramids, Curriculum Maps and Cycles in each subject from the 1st to the 8th grades. It meant creating multiple paths so that students of different abilities, interest or learning needs experience equally appropriate ways to absorb, use, develop and present concepts as a part of the daily learning process. Planning and organization of lessons have been scutinized and the recomendations of the National Training Laboratories, Bethel, Main, were adopted that the teaching others or immediate use of learning took 90% of teaching time, practice by doing 80%, group discussion 50%, live demonstration 30%, audio-visual teaching 20%, reading 10%, and lecturing 5%. It allowed students to take greater responsibility and ownership for their own learning, and provided opportunities for peer teaching and cooperative learning.

Differentiating instruction also became an essential tool for integrating technology into classroom activities. The most difficult way to integrate technology was to consistently take all students in to the school computer lab to work on the same activities at the same time. It was

effective for many other subjects, but not for mathematics and science. In the interest of efficiency and minimizing expenditures (the students has calculated that 1 minute of lesson delay = 4 lost lessons per year) , it was most appropriate to organized special math and science classrooms with laptops, overhead projector, graph board, portfolio cases, collaboration bulletin board, choice board, the month bulletin board with math club activities and other teaching aids. Using an overhead projector in combination with the Internet helped us to introduce a global overview, to use an attention-grabbing activity that helped students to undestand how the material was relevant and meaningful in real life. Using computer learning programs helped to accommodate different groups, especially the math accelerated team.

There are generally several students in any classroom who are working below or above grade level. It is important to offer students learning tasks that are appropriate to their learning needs rather than just to state the objectives from the standard text books and teaching resourses. This means providing 3 or 4 different options for students in any given class (not 30 different options). In a differentiated classroom all students have equally engaging learning tasks and they reflect their level of readiness (ability), learning styles and interest that vary between students and even within an individual over time of a lesson. Carol Tomlinson indicates that many teachers wrongly consider that differentiated classroom occurs when they give assignments of varying levels of difficulty, let students, who finished early, play games for enrichment or give extra work to do after completing a regular work. She concludes that «asking students to do more of what they already know is hollow, asking them to do the regular work and plus extra work inevitably seems punitive to them» [3]. Amy Benjamine, Diane Heacox and Carol Tomlinson have come to conclusion that a differentiated classroom has the following characteristics:

1. Concept-based and principle-driven instruction provides varied learning options, stresses understanding rather than retention, enables struggling learners to grasp and use powerful ideas, encourages advanced learners to expand their understanding and application of the key concepts and principles.
2. On-going assessment of student readiness and growth provides support when students need additional instruction and extends options when a student is ready to move ahead.
3. Flexible grouping is consistently used. «If you don't use flexible grouping, it's almost impossible to differentiate instruction» (C. Tomlinson). Flexible grouping means the students move in and out of teams of students based on different factors (readiness, interests, learning style) and work in many patterns (individually, in pairs, or in groups). The whole-class instruction is usually used for introducing new topics and for sharing learning outcomes.
4. Student-centeredness makes students to be active explorers, to take responsibility for their own work and to become independent in thought, planning, and evaluation. The teacher works more as a guide or facilitator of learning than as a dispenser of information [3; 6; 7].

In preparation for differentiating, the teacher diagnoses the differences in readiness, interests and learning style of all students in the class, using a variety of performance indicators. The most effective are placement tests that all students are required to take. At the beginning of each chapter or unit, all students are asked to demonstrated how much of the upcoming work they have already mastered. Based on the result of placement test, the Math Achievement Groups (MAGS) for the chapter or unit are created. We have adapted Robert Slavin's method, called TAI (Team Accelerated Instruction), so that all students are not held back by the learning needs of other students in heterogeneous groups [5]. The students who have mastered almost all the upcoming material (90% or higher) usually form Math Accelerated Team (MAT). The group works by a Learning Contract more independently (the Learning Contract includes the advanced or regular content to be mastered, enrichment, working conditions, pretest and final test). This group is working individually, but it is important to engage these students in the class activities daily in order to document their mastery and to involve them into cooperative work. They often become teacher assistants, help to check

quizzes, solve problems of the week and deliver discoveries, reports, and projects made during their independent work. The students who have little or no knowledge, some knowledge and less than 85% of mastery of content, form at least three team (we believe the american psychologists that the learning is effective when the result is not lower than 85%) . Each team usually includes representation from the three lists of students. Coloborative work of different-level-student groups helps to improve performance of all students. In this case the improvement point system works well, because the students who make the greatest learning gains (they are mainly from the first group) contribute to the group the most points. According to the final assessment, if a student does not achieve 75 points, he/she becomes a member of a «math hospital» (the students gave this name to the special remedial group), facilitated by a school math specialist. Working in cooperation with the teacher and the math specialist, the student eventually catch up with the main group.

The main question in the differeniated classroom is what elements of curriculum to differentiate? All educators agree that there are four ways to differentiate instruction. Differentiation can occur in the content (what), process (how), product (outcomes) and environment (with who and where) in the classroom.

1. Content is the subject matter: knowledge, skills, and attitudes that teachers want students and students are ready to learn (the purpose of the teaching). Content can be differentiated through acceleration, compacting, variety, reorganization, flexible pacing and the use of more advanced or complex concepts, abstractions, and materials. Differentiating content requires that students are pre-tested so the teacher can identify the students who do not require direct instruction. Students demonstrating understanding of the concept can skip the instruction step and proceed to apply the concepts to the task of solving a problem. This strategy is often referred to as compacting the curriculum. Another way to differentiate content is simply to permit the apt student to accelerate their rate of progress. They can work ahead independently on some topics and cover the content faster than their peers. There are 3-4 students out of 40 in our school every year who finish Algebra 1 and Geometry by the middle of the 8th grade and start working on Algebra 2 and Trigonometry topics. The rest of our students finish Algebra 1 and Geometry by the end of the 8th grade. It should be noticed that usually American students take Algebra 1 in the 9th grade, Geometry in the 10th grade, Algebra 2 and Trigonometry in the 11th grade and Calculus in the 12th grade.

2. Process is the skills included in the curriculum and the steps to get there. Differentiating the processes means varying learning activities or strategies to provide appropriate methods for students to explore the concepts, to organize group interactions, flexible pacing, and self-management. It is important to give students alternative paths to manipulate the ideas embedded within the concepts. For example, students can be challenged by questions that require a higher level of response or be open-ended questions that stimulate inquiry, active exploration, and discovery.

3. Product is the output of learning or form of communication such as writing assignments of three levels, graphing or constructing, solving sets of problems (warm-ups or work-outs), designing math games, making reports, writing math essays or completing project. Differentiating the product means varying the complexity of the product that students create to demonstrate mastery of the concepts and the ability to manipulate ideas. Students working below grade level may have reduced performance expectations, while students above grade level may be asked to produce work that requires more complex or more advanced thinking. Every student has an own portfolio where all work is kept, including personal tasks and suggestions. The portfolios are examined by the teachers, parents and peers officially at least once per quarter during curriculum nights and students presentations. Students very often have their own ideas about the product. For example, solving rate-time-work problems in Algebra, the students discovered a formula for two workers in order to have a short-cut. Some students extended the product by discovering formulas for three and more workers. Differentiating process requires to address real problems, concerns and audiences; synthesize rather than summarize information; and organize a student self-evaluation process.

4. There has been a great deal of work on learning styles and environment over the last 2 decades. In Creating a Differentiated Mathematics Classroom, Richard Strong, Ed Thomas, Matthew Perini, and Harvey Silver indicated that student differences in learning mathematics tend to cluster into four mathematical learning styles:

a) Mastery style--tend to work step-by-step.

b) Understanding style--search for patterns, categories, reasons.

c) Interpersonal style--tend to learn through conversation, personal relationship, and association.

d) Self-Expressive style--tend to visualize and create images and pursue multiple strategies [10].

Students can work in all four styles, but tend to develop strengths in one or two of the styles. Each of these styles tends toward one of four dimensions of mathematical learning: computation, explanation, application, or problem solving. «If teachers incorporate all four styles into a math unit, they will build in computation skills (Mastery), explanations and proofs (Understanding), collaboration and real-world application (Interpersonal), and nonroutine problem solving (Self-Expressive)» [10, p. 74].

Strengthening instruction, teachers who use mastery strategies focus on increasing students' abilities to remember and synthesize. «They motivate by providing a clear sequence, speedy feedback, and a strong sense of expanding competence and measurable success». When focusing on interpersonal strategies, teachers use «teams, partnerships, and coaching» to help students better relate to the curriculum and each other. Understanding strategies help students to reason and use evidence and logic. Teachers «motivate by arousing curiosity using mysteries, problems, clues, and opportunities to analyze and debate.» Self-expressive strategies highlight students' imagination and creativity. Teachers employ «imagery, metaphor, pattern, and what ifs to motivate students' drive toward individuality and originality.» Finally, it's possible to use all four styles at the same time to achieve a balanced approach to learning [10, p. 74-85].

From the comparison of traditional and differentiated instructions (diagram 1) follows that within these four ways for differentiating there are embedded many learning strategies which are used in conjunction with each other. The analysis of literature [3; 4, p. 6-10] and our experience show that the most important strategies are

– Flexible grouping is the essential feature of differentiated instruction.

– Use of multiple texts, suplementary materials, computer programs are nesessary to provide different learning opportunities for all students.

– Using tiered or ranked activities, where the teacher keeps the concepts and skills the same for all students but provides appropriate routes of access to the topic that are different in terms of abstractness, complexity, open-endedness, and format

– Using stations, interest centers or group investigations involves layouts for setting up a classrom where students work on various tasks simultaneously. The stations use flexible grouping and depend on tiered activities.

– Compacting is used after students assessment and before a study of a topic. Students who do well on preassessment do not continue work on what they already know. The teacher pin points for them the items they missed in order to complete the topic and take the final test. A learning contract is one of the forms of compacting.

– Complex instruction is very effective when groups are working on three levels of difficulty (remedial, average and advanced) and opened-ended tasks. Teachers should move among groups as they work, asking questions and checking their thinking and progress. The groups can be called to the blackboard for tutoring or coaching. Sometimes, they can be taken to a spare room in order to have discussions on the advanced topics.

– Problem-based learning is the key strategy that places students in the active role of solving problems in much the same way adult professionals perform their work.

– Using agendas helps to set the list of personal tasks that each student has to accomplish in a specified time.

– Choice boards strategy gives every student a chance to select a level of difficulty and entry point to the topic.

– The entry points strategy is Howard Gardner's idea. He proposes student exploration of a given topic through five avenues: narration (presenting a story), logical-quantitative (using inductive or deductive reasoning and numbers), foundational (examining vocabulary, concepts, relationships and principles), aesthetic (focusing on a beauty of mathematics), and experimental (hand-on activities). For example, some students choose a story about the school's wheelchair ramp that was rebuild twice to fit the standards when they start learning the topic about slopes. The others prefer to explore the graphs or study vocabulary or watch a fragment of movie or do the set of exercises to grasp the concept of a slope of a line [2].

The following table illustrates the essential differences in traditional and differentiated instructions.

Table 1

	Traditional instruction	**Differentiated instruction**
Content	The same for all, required, curriculum-oriented	Modified, integrated, student-oriented
Process	Structured activities, focus on the teaching	Intelectually demanding activities, developing research skills, focus on the learning and open-ended tasks
Environment	Indifferent, judgmental, teacher-centered	Receptive, nonjudgmental, student-centered
Product	Standardized, non-personal, reflects knowledge, summarized, evaluated by a teacher	Wide variety of forms, personal, reflects student's knowledge and the ability to manipulate ideas, synthesized, self-evaluated
Testing-out procedures	Standardized tests and quizzes	Authentic assessment
Thinking	Reflective thinking	High-order thinking
Grouping	Rigorous, by ability	Flexible,heterogeneous, by readiness, interest and learning style
Connections within and across systems of knowledge	Chronological, in breadth, subject-mattered	Interdisciplinary, thematic integration, in depth, universal by themes
Curriculum	Canonical, top-down structured, rigorous, interpersonal	Inclusive, challenging, coherent, teacher-created, student-oriented
Ultimate goal	Academic mastery	Cultivation of individual talents, maximizing student learning
Options	Student have one choice to work hard to master the material	Students have multiple choices of entering and learning the topic
Resourses	Standard resourses help to teach all students the same material	Use of multiple texts, supplementary materials, computer programs help teachers to offer different opportunities for students

Conclusion.

1. The goal of differentiated instruction is to ensure effective learning for all. This practice adheres to about 13 key principles demonstrated in our acticle. Consequently, in order to be effective the differentiated instruction must be student-centered, flexible, built on differences and strengths, balanced with teacher design and student choice, balancing rigor with joy and interest, using on-going assessment, reflective, collaborative, democratic, cognitive, developmental,

constructivist, challenging with choices to achieve «personal best» and students taking responsibility for their learning.

2.We have also discovered that strengthening instruction through differentiated teaching strategies requires to make a commitment to 4 dimensions of math learning- computation, explanation, application, and problem solving. Teachers should include all four dimensions of mathematical learning in every unit they teach; help students recognize their own mathematical learning styles–Mastery, Understanding, Interpersonal, or Self-Expressive–along with their strengths, their weaknesses, and where they need to grow; use a variety of teaching strategies to explore mathematical topics; and create assessments to reflect all four dimensions of mathematical learning and all four learning styles that students use to approach those dimensions.

3. Some of the described strategies might be controversial in the classroom, for example, grouping by skill level. There is reluctance, especially from parents, to allow students of similar ability to work together. But the fact that bright students are often paired up with struggling students in learning tasks brings objection from the bright ones because they wish to go ahead of the group. Our experience shows that the gifted students, as well as struggling students, need also special groupings. The implementation of Math Accelerated Instruction and Remedial Instruction helps to solve this problem.

4. Using differentiated approach in regular classrooms helps not only students, but also benefits teachers. The practice shows that diffentiation helps young teachers to develop the gross motor skills of teaching. On the other hand, young teachers can use differentiated instruction only if they develop the right set of habits that will lead them to differentiation. Although many argue the pros and cons of differentiation, there»s no dispute that successful implementation requires significant staff development, including seminars, workshops, individual coaching and teacher mutual visits.

Mathematics can take the lead in showing other disciplines how to combine unity of focus and commitment with thoughtful differentiation to create a new world of student achievement.

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В статті розглянуто питання впровадження диференційованого підходу до викладання математики в американській середній школі. Виходячи з власного досвіду, автор аналізує наступні диференціації змісту, процесу, результатів та середовища з метою підвищення ефективності навчання та впровадження роботи зі здібними учнями та учнями, що потребують допомоги. Порівнюючи традиційні та диференційовані підходи до навчання, розкрито основні стратегії та принципи поліпшення роботи вчителя математики.

***Ключові слова**: диференційований підхід, здібні учні, ефективнфість навчання, американська школа.*

В статье рассмотрен вопрос внедрения дифференцированного подхода к преподаванию математики в американской средней школе. Исходя из собственного опыта, автор анализирует следующие дифференциации содержания, процесса, результатов и среды с целью повышения эффективности учебы и внедрения работы со способными учениками и учениками, которые требуют помощи. Сравнивая традиционные и дифференцированные подходы к учебе, раскрыты основные стратегии и принципы улучшения работы учителя математики.

***Ключевые слова**: дифференцированный подход, способные ученики, американская школа.*

In the article the question of introduction of the differentiated going is considered near teaching of mathematics at American high school. Coming from own experience, an author analyses the following to differentiation of maintenance, process, results and environment with the purpose of increase of efficiency of studies and introduction of work with apt pupils and students which require a help. Comparing the traditional and differentiated going near studies, basic strategies and principles of improvement of work of teacher of mathematics are exposed.

***Keywords**: the differentiated approach, apt pupils, American school.*

УДК 378.2:7.05
ББК 74.58

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РАЗВИТИЕ ТВОРЧЕСКОЙ АКТИВНОСТИ СТУДЕНТОВ ФАКУЛЬТЕТОВ ИЗОБРАЗИТЕЛЬНОГО ИСКУССТВА И ДИЗАЙНА НА ЗАНЯТИЯХ ПО ТЕКСТИЛЬНОМУ ИСКУССТВУ

Развитие творческой активности студентов на занятиях по текстильному искусству предполагает создание в процессе обучения условий, необходимых для ее проявления. Разработка таких условий должна осуществляться с точки зрения *системного подхода* в педагогике.

Общедидактические условия развития творческой активности как качества личности могут представлять частичную систему, которая функционирует в структуре целостного образовательного процесса на факультете изобразительного искусства и дизайна. При этом необходимо учитывать, что частичная система должна обладать характерными системными признаками: целенаправленностью, управляемостью, динамизмом, взаимодействием с системами более высокого порядка.

Переменными составляющими процесса развития творческой активности выступают педагогические средства активизации учебно-творческой деятельности студентов. Они включают содержание учебного материала, методы обучения, материальные средства обучения (наглядные, технические, учебники, учебные пособия и др.), организационные формы обучения как процесса и учебной деятельности студентов. Они должны быть связаны и взаимообусловлены в зависимости от цели обучения и его конечного результата. Система педагогических условий развития творческой активности объединяет в себе компоненты, связанные с формированием мотивационно-потребностной сферы личности студента и с созданием на занятиях по текстильному искусству возможностей для ее реализации.

Поддержание у студентов устойчивого интереса к предмету является важным условием развития творческой активности при обучении какой-либо конкретной