Perspective of prospective pedagogy in early Algebra: US-Russian Forum on Elementary Mathematics and Measure Up Curriculum

Ching-Shu Chen

University of Hawaii Visiting Scholar

Chingshu@hawaii.edu

Abstract

Algebra is an abstract concept for younger grades. If students could successfully learn in algebra, that might lead students to successful completion of advance mathematics. This research is to give an overview of the US-Russian and measure up curriculum and how it can be implemented to help students build a solid foundation in elementary mathematics.

Key words: Algebra, Elementary Mathematics, and Mathematic Curriculum.

Introduction

Traditional Elementary algebra teaching operations are performed on symbols rather than numbers, because algebra is defined as a generalization and abstraction of arithmetic. But teachers can teach students who have no knowledge of mathematics beyond the basic principles of arithmetic. Successful work in the former Soviet Union Davydov (1991) and Bodanskii, (1991) found that even younger children are capable of learning algebra. Their approach is to introduce algebra in the early grades and focus on the concept of function. They identified previously overlooked opportunities to explore the algebraic character of early mathematics. If elementary teachers could give questions about algebra problems and find a forum to help students to solve mathematic problems with lots of clear explanations and helpful hints, then, students can have plenty of hints and shortcuts for working with unknown quantities. Teaching algebra to children would not late , as Schlieman's results suggest that 3rd and 4th grade students could learn and understand elementary algebraic ideas (Schliemann, Carraher, Brizuela, Earnest, Goodrow, Lara-Roth. & Peled, 2003).

Corresponding author：Ching-Shu Chen, E-mail:Chingshu@hawaii.edu

There is very little algebraic character in the elementary educational curriculum of Taiwan, especially in first and second grade. Currently, in the Taiwan Curriculum standards /guidelines we are trying to organize some units to teach algebra in the elementary school, but they are still not in effect. Because elementary students' cognitive development is in a preoperational period, algebra functions as a language system for ideas within mathematics and it is abstract for elementary students. In the younger grades, things are more difficult in algebra class if the teachers did not prepare the students to learn early, or do not know what kind strategies to use in teaching algebra for students in the younger grades to be able to connect as middle high students in the future. How do teachers make it through algebra in teaching first and second graders? US-Russian Working Forum and Measure up Curriculum might give an example to work it out. Hence, the purpose of research is to explore an alternative curriculum to help young students to learn algebra in elementary school. What's more the alternative curriculum proposes pedagogy and materials to guide students to learn algebra in elementary school and keep students from failing to connect in middle high school.

An alternative mathematical curriculum overview

US-Russian working forum and measure up curriculum (E-D & MU curriculum) is the Elkonin-Davydov curriculum -- a model for the US in elementary mathematics – by the Curriculum Research and Development Group (CRDG) at the Univerisity of Hawaii. The foundation of the curriculum and development is based on the work of a group of Russian psychologists, mathematicians, and educators. The objective of E-D & MU curriculum is to develop children's algebraic thinking, conceptualization, and skills in grades 1-5.

The features of the E-D & MU curriculum emphasize the teaching of generalizations before the teaching of specific cases or examples. The curriculum has been applied in the UH Lab School for five years. In the E-D & MU curriculum, first grade children start with direct comparisons of continuous quantities (length, width, area, mass, and volume) and the use of symbols to describe the relation of compared quantities as equal, greater than, and less than. Second grade children do addition and subtraction that are introduced as action with continuous quantities (like water or grain), without using numbers. The computation through actions with objects directly parallels and

models the mathematical content of the operations, which children also learn to represent through the use of other objects, graphical constructions (like line segments), symbols and letters.

Again, Measure Up is designed to approach an algebra focus in elementary school mathematics using measurement as its principal context to help all students successfully complete an algebra course in the future. In order to reach this purpose, CRDG planned a project that focuses on creating elementary mathematics materials for students and teachers employing results from Elkonin-Davydov research, designing a grades 1-5 mathematics curriculum integrating strategies appropriate to children's developmental levels and developing a classroom assessment system for grades 1-5.

A glance at the research context

The University of Hawaii Lab School applied the US-Russian and measure up curriculum in their elementary mathematics from first to fifth grade. The Project committee and staff were involved in restructuring the early research and preliminary materials from Russia. They also designed original materials that are suitable for US students. These materials blend the early research work and the new findings from research conducted during the development phrase. As for the project committee, they are all professors. The leader of the committee had visited Russia with her group members. The committee, except CRDG, is from the institute of Developmental Psychology and Best practices in Education at the University of Hawaii.

The Project staff is made up of seven mathematic teachers. The director of the staff is a UH professor and leads the staff to plan and improve the teaching. The staff has seven members and works in a teaching office. All staff has to teach mathematics, including the director. They always take turns in teaching elementary mathematics to each grade. The head teacher of the staff teaches kindergarten, while the first graders have math class, as well as teaches second grade and third grade mathematics. Obviously, the curriculum needs to recruit more teachers to support the teaching. So, the first grade and second grade teachers come from Doe school, but they are new teachers in the Lab School. Kindergarteners and first graders mix together; second graders and graders mix together to learn all subjects except mathematics. Recently, CRDC would like to disseminate materials and a professional development course nationally. In spite of the

UH Lab School implementing the curriculum, there is another connecting school in Hawaii.

A class of ten students has 45-minute lessons five days a week. The students come from diverse ethnic and socio-economic background. Ten students are selected from five different ethnic groups: two Japanese, two Philippines, two Caucasian, two Hawaiian, and two others who are all represented in the population.

The feature of E-D & MU curriculum

A significant factor of the E-D & MU curriculum project which is different from other elementary mathematics projects is to develop mathematical understanding. From grade 1, students start comparing attributes using continuous quantities. They describe the relationship between these quantities using direct and indirect measurement. But, every mathematical idea developed is connected to measurement. Here are a few of the critical themes of each grade:

Grade 1- symbolic representation of quantities, concept of unit, addition and subtraction;

Grade 2- conceptual understanding of place value and operation with multi-digit number;

Grade 3- multiplication, division, and basic mathematical properties;

Grade 4- transformational geometry, geometric measurement and numbers less than one (fractions, decimals);

Grade 5- is currently in development.

Teaching

In the classroom, teachers adopt multiple instructional strategies, like whole-class demonstrations, guide hands-on lab experiences, individual work period, student discussions, and stations. For example (Supplementary Documents for lesson sample):

The first grade teacher taught the students and applied the transitive property of equality by asking them to create a story that would match the given statements.

$$M = E$$

$$\underline{P = E}$$

$$M = P$$

The teacher asked the students to make up their own stories to go with these statements.

Today we are going to be storytellers! I will give you some statements like these. First read

the statements. Complete the statement below the line, about the quantities that were indirectly compared. After you complete the statement, write a story about the statements. Your story should tell what attribute was compared, and how the quantities compared. After you write the story you may draw and color a picture to go with it.

When the students had done that, the students shared their stories and hung them up for all to enjoy.

In another case, the first grade teacher asked the children to use the 'The inequality Symbols'.

Which Volume is greater? How do you know? The teacher showed > and < symbols to the students.

How do the volume container T and volume container S compare? How do you know? Or, how did you decide?

The volume in T and S is not equal. The teacher asked the students to record a statement about the quantities using the not equal to (≠) and greater than (>) signs.

We read this as volume T is greater than volume S. Record this in your notebooks.

T > S.

The second grade teacher taught the students with multiple unit-measures to create a quantity. Quantities are recorded as equations, arrow notations, part-whole diagrams and line segments.

This is length A. She showed students the two unit-lengths K and E.

If we measured length A with length-unit K, and we measured length A again with length- unit E, which length-unit would we have to use more times? Let's measure length A. Which length-unit would take less time to measure length A?

Had a student use length-**unit** E to complete the measurement**.**

Let's represent length A by drawing a line segment on the board.

Because length A is made up of three length-unit K and two length- unit E, there are really two parts that make up length A. What other ways can we record the information from length A? Have students record other representations (arrow notation, part-whole diagram, equation) and discuss as needed.

3K+2E=A

Assessment

Students are assessed throughout the program. Students' class work, homework, participation in class, written assignments, and oral and written tests give teachers information related to each child's progress. However, the Lab School students will attend a state test in the third grade. Homework is one part of the assessment. It is assigned, occasionally in grades1-3, daily by grades 4 and 5. The attached 'tips' offer suggestions for how parents can support their children when they have homework.

Discussion

When looking at the CRDG make efforts to implement the E-D & MU curriculum, the curriculum would shed light on the learning of algebra in elementary grades. The curriculum implicates some thoughts in elementary mathematics teaching. Such as, in which grade can algebra be taught? Could it be taught in the younger grades? What is the key concept of algebra should be taught in elementary school? Does it work to incorporate other subjects in teaching algebra?

First, The E-D& MU curriculum proposes a striking opinion that children can learn in algebraic context early. Students begin early by building on informal knowledge in context. First-grade children can start with comparisons of continuous quantities and use symbols to describe the relation of compared quantities. Likewise, the E-D & MU

curriculum develops proficiency in algebra which provides students the opportunity to learn with everyday life concrete objects to replace abstract symbols.

Second, algebra taught in elementary school is difficult. One factor is a misconception of the meaning of the equal sign. It often is thought to be an operator symbol by students, and also to be a cue to do something, instead of an expression of relationship (Falkner, Levi, & Carpenter, 1999; Filloy, & Rojano,1989). The curriculum could clarify and deliver the key concept for students to resolve the algebraic misconception and make a new way to learn algebra in elementary grades.

Third, Kaput (2001) suggests that teaching algebra can be integrated into other subject matter. The project committee and staff create elementary mathematics materials for teachers to instruct algebra in a diversity of ways. Teachers apply story telling, hands-on lab, and station to recall doing algebraic problem solving. These actions are based on the rationale that is a reference to a Vygotskiian (Elkonin-Davydov) distinction between spontaneous and scientific concepts. Spontaneous or empirical concepts were developed when students could abstract properties from concrete experience or instances. Dealing with an unknown quantity is to teach with objects in the early grades, so that students learn basic function to help them excel at math.

Besides, students solve algebraic sequenced measurement problems with equal and unequal concepts as a result of many months of teaching which permits children to discover that various types of real numbers and their operations are interconnected. These connections would give children a strong foundation for advanced studies.

Conclusion

Since CRDG has undertaken the E-D & MU curriculum of development and research for five years, the group endeavors to put theory into practice. Their efforts inspire educators to greater efforts of innovation in curriculum and teaching. The implementation of E-D & MU curriculum not only is an example for innovation curriculum in Taiwan but also might verify that children could learn early through an algebraic context and achieve better middle school and high school mathematics grades. So, through the E-D & MU curriculum, algebraic notation and concepts can be introduced from the very beginning of mathematics instruction, even though the curriculum is an ongoing project.

After over viewing the E-D & MU curriculum, some suggestions might be considered for the curriculum. The key factor which influences the implementation of results is professional teachers. Right now the project staff undertakes to develop material and teaching. They need more expert teachers to be involved in the project. It is necessary to create a professional development program for pre-service teachers.

Equally important, in having ten students in a class, the amount might not make competition for students in a small group. Moreover, the fact that only a few students are used in the experiment to test the theory of E-D& MU curriculum might make it difficult to be generalized in the future. Much more can be achieved if children participate in early algebra activities on a daily basis, as part of their regular curriculum.

In brief, Taiwan is strong on algebra learning in late elementary school, but E-D & MU curriculum teaches it from the younger grades and builds as it goes on to each of the grades. From the curriculum's experience, it would encourage the innovation of Taiwan curriculum of elementary mathematics to act to build a solid foundation for elementary students in algebra.

References

Bodanskii, F. (1991). The Formation of an Algebraic Method of Problem Solving in Primary School Children. In V. Davydov (Ed.), *Soviet studies in mathematics education.* (vol. 6, pp. 275-338).

Davydov, V. (Ed.). (1991/1969). *Soviet studies in mathematics education, vol. 6: Psychological abilities of primary school children in learning mathematics*. Reston, VA: NCTM.

Filloy, E., & Rojano, T. (1989). Solving Equations: The Transition from Arithmetic to Algebra. *Forth Learning of Mathematics, 9* (2), 19-25.Herscovics, N. & Linchevski, L. (1994). A Cognitive Gap Between Arithmetic and Algebra. *Educational Studies in Mathematics, 27*, 59-78.

Falkner, K. P., Levi, L., & Carpenter, T. P. (1999).Children's Understanding of Equality: A foundation for algebra. *Teaching Children Mathematics*, 6(4), 232-6. Available at www.wcer.wisc.edu/ ncisla].

Kaput, J., & Blanton, M. (2001). Algebrafying the Elementary Mathematics Experience. Part I. In H. Chick, K. Stacey, J. Vincent, & J. Vincent (Eds.), *Proceedings of the 12th ICMI Study Conference* (vol. 1, pp. 344-350). The University of Melbourne, Australia.

Schliemann, A. D., Carraher, D. W., Brizuela, B.M. , Earnest, D., Goodrow, A., Lara-Roth. S. & Peled, I. (2003). Algebra in elementary school. In N. Pateman, B. Dougherty, & J. Zilliox (Eds.) *Proceedings of the 2003 Joint Meeting of PME and PME-NA*. CRDG, College of Education, University of Hawaii: Honolulu, HI, Vol. 4, pp. 127-134.