Ghazwa Aldoori
University of Pennsylvania
January 24, 2009
Annotated Bibbliography

Manipulatives; a Sensory Blast from the Past

Introduction:

Today's chemistry teachers are constantly being introduced to new technologies and teaching strategies. While new things are fresh and exciting, it would be worth the time to take a trip down memory lane and revisit the teaching tool: manipulatives. This annotated bibliography is about manipulative materials, it is divided into four sections. The first section lists entries from articles that clearly define manipulatives and addresses different terminologies that are taken as synonyms to manipulatives; it also introduced concepts through objects that can be touched. The second section includes entries from articles that analyze: (A). how students successfully transfer from concrete level to the abstract level. (B). how to be aware of what students know and what us as teachers think students know. (C). are manipulative an afterthought-the frosting on the cake- or are they a given- a part of the recipe that you cannot do without. I named this section "From abstract to concrete." Entries in the third section highlights articles about using manipulatives with the learning handicapped, and the important role of these manipulatives in both science and mathematics instructions for this group of students. The fourth section "Current Researches" addresses the benefits of using manipulative in classrooms; long term use is more effective than short term use, availability as the most important factor and the greater use of manipulatives among new teachers. With training, however the use increases with all teachers. The word "manipulative" is more used in arithmetic subjects, in science; however, teachers more use the word "demonstration." It is still common in educational science literature to use the word manipulatives because teachers in classrooms tend to avoid wet activities. Demonstrations more describe wet labs while manipulatives are hands-on "concrete' materials. This annotated bibliography includes articles that speak to both science and math as well.

Ghazwa Aldoori
University of Pennsylvania
Annotated Bibbliography January 24, 2009

Manipulatives; a Sensory Blast from the Past

Articles within the sections are listed according to publication date.

1) What are manipulatives?

Hynes, M.C. (1986). Selection criteria. *Arithmetic Teacher*, 33(6), 11-13.

This article focuses on the criteria for the selection of manipulative materials and has clear definitions of them. The authors put the responsibility on teachers to use concrete models to foster understanding of abstract concepts, and to select manipulative materials effectively. There are two criteria for selecting materials for manipulatives: pedagogical and physical. Hynes says that pedagogical criteria involve 1. Clear representation of the maniplatives ideas. 2. Appropriateness for student development level 3. Interesting: to improve students' motivation and 4. Versatile: to stimulate more than one sense at the same time. He describes the physical criteria as 1.durability 2.Simplicity. 3. Attractiveness 4. Reasonable cost: The author mentions that if materials are homemade, the quality must not affect the learning negatively. **Hynes offers a table of framework for making decisions and choosing a manipulative**

Bright, G.W., (1986). One point of view. *Arithmetic Teacher*, 33(6), 4.

Bright points out that there are two different perspectives (view points) to the use of manipulatives in classrooms, while at times it can be very successful and rewarding, others they might bring harm. He adds that the carelessness of the students comes about when two different worlds (that of mathematical symbols and that of manipulative materials) are confused. Symbols and the manipulative must always reflect the same concept, while the students might not automatically grasp this connection. The author believes that oral language provides a bridge between these

Manipulatives; a Sensory Blast from the Past

symbols and manipulative. Another way that the author suggests to bridge between these manipulatives and symbols is the experience of touching and moving objects by the students. **One important thing to note is that students might fall into a trap by failing to recognize this connection regardless. In this situation, we as teachers must commit to realizing this and finding ways to incorporate manipulatives into everyday instruction, but keep in mind that manipulatives are not appropriate for every concept.**

Ennever, F.K., (2007). A Spoonfull of $C_{12}H_{22}O_{11}$ Makes the Chemistry Go Down: Candy Motivations in the High School Chemistry Classroom. *Journal of Chemical Education*, 84(4), 615-616.

The author in this article had these "candy" motivations that I think at the minimum will make students encounter something, after some thought that can be explained by chemistry. His lesson starts with intriguing observations that needs explanation, and what's better then candy, a safe, inexpensive and welcomed by students particularly around lunchtime. Ennever's article describes many food motivations he uses in his chemistry high school classrooms, some of which may take only few minutes to elicit an appropriate question to start and inquiry for the remainder of the lesson. An example I would mention the author found out skittles and M&Ms works well in explaining Entropy. This article is very much worth to look at. **It helps connect chemical concepts to the student's observable world and possibly give them the habit of noticing things to ask questions about.**

2) From abstract to concrete.

Blake,B., Kennedy. L. M. (1986). A Rational. *Arithmetic Teacher*, 33(6), 6-7.

Manipulatives; a Sensory Blast from the Past

Kennedy states his belief in the benefits of manipulative materials, and mentions how his classroom is stacked with all sorts of commercial and teacher made materials that are used daily. He emphasizes the importance of using manipulative to build a foundation of mathematical concepts. He also mentions how and why teachers are hesitant to use manipulatives. Many teachers, according to Kennedy believe that manipulatives are a lot of bother, a hassle and a waste of time. However, Kennedy provides in this article a list of learning theorists to support his belief, some of whom are Brownell (1933), Piagat (1952) and more recently Skemp (1982). Kennedy concludes that students who are more experienced with manipulatives can better bridge the abstract and concrete gap, and apply mathematical concepts to everyday life dilemmas. **This is a great article for perspective teachers because it has clear definitions of manipulative materials and a good list of sources teachers can use when demonstrating in their classrooms.**

Moser. J.M. (1986) Curricular Issues. *Arithmetic Teacher*, 33(6), 8-10.

Overlooking arguments for and against manipulatives in elementary school mathamatics classes, Moser poses the argument that teachers that are even mildly interested in incorporating manipulatives must develop theories as to why. Some examples of questions are: Should manipulatives be used by all children? Should manipulatives be an integral part of teaching. **Teachers should be wondering when to use manipulatives, how to use them and to what degree. Each of these answers is not independent of one another and that is what much of teaching is about; dealing with relationships among them.**

Heddens,. J.W. (1986). Bridging the Gap between the Concrete and the Abstract. .

Arithmetic Teacher, 33(6), 14-17.

Manipulatives; a Sensory Blast from the Past

The author starts the article by addressing the difficulty of understanding mathematics due to students' inability to make connections between the physical and abstract worlds. In defining this gap, Underhill (1972) says it is the semi concrete stage. Heddens 1984 comes to divide this stage into semi concrete and semi abstract. He has a clear figure of these ideas worth looking up. Semi concrete level represents real situations (pictures) while semi abstract involves symbols for the concrete item, but the symbols do not look like the items they stand for. He also mentions that the gap should be a continuum. Teachers can help with bridging the gap by carefully asking questions that help students move from concrete to abstract. These questions should emphasize on how and why with less emphasize on what. **Simply using manipulatives is not sufficient rather students should be guided to develop thinking skills**

Harrison, M., Harrison, B. (1986) Developing Numeration Concepts and skills. *Arithmetic Teacher*, 33(6), 18-21.

This article includes activities (up to fourth grade) that make use of 'physical objects to exemplify numerical concepts and patterns such as place value, multiples, and rounding.' This is then represented by a picture or a semi symbol to imagine the object while keeping the symbolic record, eventually being able to interpret and use it meaningfully at the abstract level. **Bold Flavell (1963, 368) highlights that intellectual development is marked by gradual transformation of overt action into mental operation.**

Silverman, H.J., Bruni, J.Z. (1986). Developing Concepts in Probability and Statistics- And Much More. *Arithmetic Teacher*, 33(6), 34-37.

Manipulatives; a Sensory Blast from the Past

James V. Bruni and Helene J Silverman are the professors at Herbert H. Lehman College of the city university of New York conduct workshops and courses for teachers. In this article they suggest a few wonderful and highly motivational activities through which the students would be involved in active learning experiences that involve the use of manipulative materials, putting in mind the weak connection between using these manipulative materials and learning the concepts for which the manipulatives were designed. To develop a concept, the authors suggest a four step teaching process for using manipulatives. 1. Introduce the model 2. Establish a record system; guidelines structured for the teachers to use to get the most out of the power of manipulatives 3. Reflection on the experience; discussion enables the transfer of experiments to tables charts and graphs. 4. Generating new experiences; extending the concept through exploration and raising new questions. **In general, the purpose of this article is to provide a structured methodology to ease teachers' experience with manipulatives.**

Shultz, K.A. (1986) Representational Models from the Learners' Perspective. *Arithmetic Teacher*, 33(6), 52-55.

A must read article for teachers willing to incorporate manipulatives in their teaching. Schultz points out a gap between students' actual understanding and what the teacher *thinks* students understood. The author discusses the teachers' following expectations: First, the type of learning; concepts, properties, facts, procedures, skills and problem solving, see figure 1. (Showder (1980), Snyder and Dessart (1980). Secondly, using certain type of learning behavior; listening, speaking, using concrete or pictorial models (Johnson and Myklebust (1964), Shultz and Strawderman (1980). Third, is the use of a certain type of representational

Manipulatives; a Sensory Blast from the Past

model chosen by the teacher; concrete pictorial and symbolic. See Figure 2.

Manipulative models demonstrated by the teachers may be considered passive manipulative but they would have an impact on the abstract materials introduced. This depends on the type of learning. Manipulative models demonstrated by the teachers are called non-manipulative and these require special visualization skills.

Joyner, J. M. (1990). Using Manipulatives Successfully. *Arithmetic Teacher*, 38(2), 6-7.

oyner explains the importance of the involvement of manipulatives in the classroom but points out an issue: managing the required material effectively. Recognizing this specific issue, she says that once one manipulative fails, it is not essential to take on a 'better' manipulative; rather one must apply specific guidelines to manage the manipulative successfully. According to Joyner, there are three of these guidelines; first, free exploration of materials, since the students' desire to explore is stronger than their desire to follow the teacher's directions. Second, packaging the material according to lesson purpose is essential: students do not wait well. Third, the author promotes clear expectations on behalf of the teacher, for lesson goals and how to handle the materials. Most importantly, the author emphasizes that teachers should model the use of these materials because that is how students value the experiment.

Thus teachers unable to implement manipulatives effectively need 1. Management guidelines and 2. Assistance in organizing their classroom.

Harris,J. & Kehoe, S.(2005). News from on line: Toying in Chemistry. *Journal of Chemical Education*.82 (10), 1458-1460.

Chemistry is all around us- even in the toy box. Toys can become tools to learn some of the basics and also more in depth chemistry concepts. From this article you can find a recipe to create your own Silicon super ball. The author of this article also

Manipulatives; a Sensory Blast from the Past

constructed a lemon-powdered clock. From a kit purchased from kids surplus at a website provided in his article. Julie and Kehoe listed all websites the used to demonstrate all their activities using common household items. The article lists titles of experiments that include websites from which the experiments are compiled**. For example if you are interested in science on a big budget, http://www.scitoys.com provides a number of fun and simple science experiments in the section entitled Science Toys You Can Make with Your Kids.**

Blake,B.,& Hogue, L.,& Sarquis, J.L., (2006). Classifying Matter: A Physical Model Using Paper Clips. *Journal of Chemical Education.*83 (9), 1317-1318.

Several years ago authors realized that simple physical models of chemical systems could be constructed using colored paper clips. In the years that they have been using this activity they found that it effectively helps students to build accurate conceptual pictures of what constitute molecules, compounds, mixtures and pure substances. Few students know the components of

brass, so they have a little chance of being able to classify it properly as a mixture of Zinc and Copper. The article has clear instructions beginning from listing materials, constructing the models, using the activity and ending with determining the formula of a pure compound. I personally applied this activity successfully in my class room and strongly recommend it**. As students struggle to learn and apply the definitions of the terms molecule, compounds, mixtures, and pure substances they are handy capped by their lack of knowledge of how the world is composed.**

Chimeno,J.S., & Wulfsberg,G.P., &Sanger, M.J., &Melton, T.J., (2006). The Rainbow Wheel and Rainbow Matrix: Two Effective Tools for Learning Ionic Nomenclature. *Chemical Educational Research.*83 (4), 651-654.

Manipulatives; a Sensory Blast from the Past

From experience chemical nomenclature is considered a constant problem for first year chemistry students and only a minimum quantity of time is devoted to it in our classroom. In this article two educational games were tested to create a working knowledge of inorganic chemical nomenclature; 1- the rainbow wheel and its new computerized version. 2- The rainbow matrix. Both games are based upon the concept of combining various cations and anaions into the formulas and then naming the compound using "The Stock method". The article also includes testing the effectiveness of the games and the qualitative results. **Several studies show game playing increases students comprehension of subject matter because it engages the student in the topic. The more engaged students are the more they learn.**

Krontiris-Litowitz, J. (2008). Using truncation lectures, conceptual exercises, and manipulatives to improve learning in the neuroanatomy classroom. *Advance in Physiology Education*, 32,152-156.

Historically students have had difficulty with the spinal track curricula unit and frequently resorted to memorization to "learn" the material. In an effort to improve learning in the spinal track unit, the curriculum was revised so that it shifted the responsibility of learning to the student and incorporated collaborative learning, formative assessment and the use of manipulatives. The study in this article demonstrate how truncation lectures, integrating students practice problem sets, and most importantly providing and image based manipulative an a functional neuroanatomy course enhanced learning. The study also showed how promoted learning occurred in content knowledge, analysis, and integration. **This study**

Manipulatives; a Sensory Blast from the Past

demonstrates that a revised curriculum composed of truncated lectures, practice problem set, and a manipulative was able to enhance learning.

3) Using manipulatives with the learning handicapped.

Thornton, C. A., & Wilmot, B. (1986). Special Learners. Arithmetic Teachers, 38(2), 38-41.

The biggest single obstacle for the learning handicapped is their inability to organize information to be learned. The author in this article suggested that structured situations involving manipulatives help these students organize their thinking so that they begin to see relationships or follow the flow of a conceptual procedure. The author lists four ideas for providing this structural flow: 1.To vary the way teachers present the manipulative. 2. To help student build important self-monitoring skills. 3. To provide consistency. 4. To carefully plan the phasing out of manipulative materials both in concept and in skill learning. **This article has focused on the use of manipulatives with two groups of special learners: those with learning difficulties and those with special abilities. It highlights different choices in concrete aids.**

Riendle,P.A. & Howorth, T. J. (1995). Chemistry and Special Education. *Journal of chemistry education*. 72(11), 72-983.

This Paper describes the political gains made in education for the disabled; it also identifies various types of mild disabilities and suggests possible teaching interventions for the chemistry teacher who has a student with a mild disability**. The article also discuss how very little information is provided for science teachers in teacher preparation courses or is available in the literature to offer concrete suggestions for teaching science to disability students.**

Manipulatives; a Sensory Blast from the Past

4) Current Researches

Cohen, H.G. (1992). Two Teaching Strategies: Their effectiveness with Students of Varying Cognitive Abilities. *School Science and Mathematics*, 92(3), 126-132.

The author introduces this research by saying that over the past ten years; little progress has been made in the field of scientific literacy. He defines scientific literacy as "Knowledge of

concepts and content, the ability to use process skills and a high level of reasoning ability." Cohen bases his research on previous work done to show that the majority of U.S. adults have a better capacity for learning at a concrete operational level (Chiappetta 1976). Thus Cohen attempts to figure out the effectiveness of two different teaching strategies; Verbal (abstract) and manipulative (concrete), on students with varying cognitive abilities. The results from Cohen's research support Chiapetta's research in that Cohen found out that students in possession of a large amount of cognitive structure tend to perform better and students with a smaller amount of cognitive structure need more concrete (manipulative) methods of teaching. **Since cognitive abilities vary so greatly, teachers must be mindful of this diversity in their classrooms and work to provide the majority of students with ample activates and manipulatives in addition to the verbal means.**

Bohan, H.J., & Shawaker, P.B., (1994). Using Manipulatives Effectively: A Drive Down Rounding Road. *Arithmetic Teacher*, 41(5), 246-248.

The authors think that it is helpful to use manipulatives to make a connection between conceptual work and procedural knowledge. It is helpful to think of using manipulatives in the context of transfer learning. The authors state that if you want this transfer to happen, you must teach for it. In this article, manipulatives have

Manipulatives; a Sensory Blast from the Past

three types, concrete, bridging and symbolic. Thus, students must be taught to transfer their understanding from manipulatives to abstract concepts. This article also has nice examples of manipulatives used to round two digit numbers and relating rounding to daily experiences in life. **Students that successfully transfer to the abstract stage will continue to use manipulatives if allowed, and they must be encouraged to put manipulative materials away.**

Howard, P., Perry, B., & Tracey, D. (1997). Mathematics and manipulatives: Comparing Primary and secondary mathematics teachers' views [Electronic version]. Paper presented at the Australian Association for Research in Education Annual Conference, Brisbane, Australia.

Howard et al points out the frequency in which maniplatives are used in both primary and secondary classrooms. They explain that due to the difficulty of maneuvering manipulatives in a secondary school environment and therefore a lack of training for secondary school teachers, these manipulatives are used decreasingly as the students transfer from primary to secondary education. As students transfer from primary to secondary schools, new teachers must be aware of past ways that these students have learned, and thus incorporate more manipulatives and be proactive in the secondary students learning. This, according to Howard et al, can be achieved by being more available and more flexible for the students' benefit. The authors emphasize that these teachers' major teaching style must be through demonstration (similarly to primary educators). **Using manipulatives increases the students' learning and are effective because students enjoy using them.**

In conclusion, the purpose of using manipulative materials is to assist students to bridge the gap between concrete environment and the abstract level. Pedagogues and educational reformers emphasize on the importance of including the five senses in the learning process.

Manipulatives; a Sensory Blast from the Past

To proceed from the easy to the more difficult, pass from the observation to the consciousness and then to speech, then comes the measuring, drawing, and writing. Most importantly it is the teacher's responsibility to use these concrete models to foster understanding by carefully asking questions that emphasize more on "how and why" and less emphasis on "what" questions. Afterwards teachers should provide practice at the abstract level to ensure the full understanding of the concept.