The Chemist
Journal of the American Institute of Chemists

Chemical Education: Reflections of a Middle School Teacher

Joshua Strate
Florida Virtual Global School - 2145 Metro Center Blvd, Suite 200, Orlando, FL 32835 (jstrate@flvs.net)

Abstract: From the explosion of idea, formulas, and provisions associated with a practical approach to learning chemistry, chemistry education has become an integral part of science education. Direct uses of chemistry education and instructional practices of chemistry education are trickling down to the middle school science level in hopes to further situate adolescent understanding of chemistry. In a study designed to ascertain the chemistry understanding of middle school science students, more than 60 percent of the students demonstrated understanding of chemistry. The survey "A Survey of Scientific Understandings" included basic chemistry questions such as "What happens to the mass of an iron bar when it rusts, assuming that none of the rust flakes off? [1]" Some of the implications of this survey are that students at the middle school level are more aware of the role of chemistry in the real world around them. Chemistry connections to other content areas could be a part of a win-win situation towards developing interests in the sciences among middle school students.

Key Words: Chemical Education, Middle School.

CHEMICAL EDUCATION

Chemical education involves the teaching and learning of chemistry at all levels of education. In early days the focus of chemical education was to train chemical technicians and chemical scientists for industries, and chemical compounders for pharmacies. Since the later half of twentieth century chemical education has become a vibrant component of science education curriculum and reform not only in the United States, but also in other developed and many developing nations around the world [2, 17]. In the school science curriculum the emphasis of chemical education often ranges from traditional academic preparation in chemistry to chemistry in everyday life [3]. At the K-12 education in the US when junior high schools were phased out in the 1980's, chemical education received a place in the middle school curricula [4].

MIDDLE SCHOOL SCIENCE ENDEAVOR

Middle school science education is a multi-faceted approach to integrate several general science disciplines with the ultimate intention of instructing students in the basics of science [4, 5]. With this approach, many middle school science teachers have obtained knowledge of many fields of science, including chemistry.

Chemistry concepts that are taught include properties of matter, changes in matter, energy and matter transformation, forms of energy, periodicity of elements, and chemical interactions in matter [6]. These chemistry concepts are taught to enrich students' understanding of the natural world. This instruction also serves the purpose of preparing students who are skilled in performing calculations and would serve the public interest if they pursued science careers.

TEACHING CHEMISTRY TO MIDDLE SCHOOL STUDENTS

Students at the middle school age are in a period of adolescence. As a middle school educator of eight years, it seems to me that the one thing that all middle school students do is test their limits. The nature of learning for most middle school students is based on prior experiences such as learning through elementary school

and home environment [7]. Chemistry to most middle school students, equates to blowing stuff up and seeing reactions. This tends to excite them about something they can usually grasp quite quickly.

Why is chemistry more interesting to middle school students?

As stated previously, students like to see science in action, that is, they appreciate and gain interest in seeing something reacting. Therefore, chemistry is quite often the most interesting subject for middle school students to learn [8]. Chemistry is one of the few subjects that require students to learn through listening, and in most cases students can learn through seeing interactions between matters by engaging in hands-on chemistry laboratory activities.

The fact that the students in my class are more interested in watching chemicals interact, such as bubbling over of acid-base reactions, fingerprint oil from human hands appearing after super glue is heated, and learning about why certain metals are reactive with water just demonstrates that they want to actively learn about chemistry in middle school. See Table 1 for results of students' chemistry understanding for studied population. The active role that middle school students play in the science classroom may be related to their scientific understanding of chemistry concepts [1, 9].

Table 1. Chemistry Understanding of Middle School Students

Question	Percentage of Students Correct
1. What happens to the weight of an iron bar when it rusts, assuming nothing flakes off?	56
2. After dissolved gases are removed from pure water, the water is heated in a pot to boiling. What gas is inside the bubbles that form as the water boils?	52
3. One pound of salt is added to twenty pounds of water. After all the salt has dissolved, what will be the mass of resulting salt/water mixture?	73
4. The density of mercury at 20 °C is 13.5 gm/cc. Representing density with the letter d, mass with the letter m and volume with the letter v, within the rectangle write an equation with which one can calculate the volume of 27 gm of mercury at 20 °C.	72

Note: Statistical data is derived from reference [1], which consisted of statistical analyses conducted on the scores of 106 students earned on the chemistry component, four questions, of a scientific understanding survey [9]. This survey was approved via the local IRB for FAU and the local school county.

Importance of Learning Chemistry Concepts

The importance of learning chemistry at the middle school level is documented by several research studies. Sheridan et al. [10] from a research study performed with middle school students, identified the importance as a foundation for students to pursue science careers that utilize chemical knowledge. Pharr [11] also supports this idea through research performed via web-based tutorials that enrich middle school student learning about chemistry. Pharr (2009) found that, even though the attitude toward science did not improve with the use of web-based tutorials, content knowledge did improve significantly. Other researchers support this concept as well. In fact, students who learn chemistry, along with other science subjects, at an earlier age on average, pursue high school science courses, and become scientists upon completing their collegiate studies [10, 12. 13].

Innovative science endeavors have increased the output of students that pursue science careers, as a result, innovative science is the direction that science education is taking in order to remediate, educate, and evaluate student interest in science careers. While middle school students do not have to choose a career path, middle school students in most states have to decide on a high school program that they will follow to in order to pursue a career track. Nanoscience education is an innovative science program that middle school students have experienced in some states. This form of nanoscience education, also known as nanotechnology is focused on the various applications of how nano-sized particles can be utilized to teach students scientific concepts [14].

A middle school teacher's reflection on chemical education

Chemistry is only one of the many subjects that middle school students learn. Middle school students in my county have units dedicated to learn Earth sciences, Life sciences, and physical sciences for them to be considered sufficiently proficient to enter high school [6]. Students are also required to earn a minimum score of 325 out of 500 on the state standardized exam for science. This requirement is undermining the high standards that education should be setting for students that are expected to enter the workforce completely prepared.

The problem for students gets complicated when an unprepared science teacher instructs them in a subject in which they have little background knowledge. Content knowledge is necessary for developing scientific understanding in students [15]. Without this essential background, science, especially the middle school general sciences, is not being communicated to students in a manner in which they will gain interest. It is this very concept that researchers believe effective teaching comes from years of practice. As a teacher who is responsible for educating students in the chemical and physical sciences, one should not blame the subject for a lack of student interest and more appropriately blame the need for quality educators.

SUMMARY & RECOMMENDATIONS

First, students at the middle school level need more than just the topical treatment chemistry taught. Chemistry should be made more interesting to students than other subjects [16]. Therefore, it is strongly recommended that middle school students learn chemistry by actively doing chemistry. As a result, we would expect to find more students pursuing careers in science than we have at the current time. Second, state officials should look into the prospect of chemical education as a means for increasing student interest in middle school science. Middle school students are fascinated with things that are visible and can engage them, so why not give them some extrinsic motivation that serves a dual purpose? They learn while doing chemistry, and at the same time they obtain a better understanding and their connection to other science subjects [17, 18]. The end result is a science-minded generation of individuals who can meet the demands of an increasingly science and technology dominated workforce and enjoy the benefits of chemistry in their everyday life.

REFERENCES

1. Klapper, M. H., DeLucia, S., & Trent, J. *A survey of scientific understandings: Comparing elementary and middle school teachers with college students*, 1993. Columbus, OH: The National Center for Science Teaching and Learning, Ohio State University.
2. Rakestraw, N. *Journal of Chemical Education*, 1958, 35(1), 18.
3. Towns, M. *Journal of Chemical Education*, 2010, 87(11), 1133-1134.
4. Bybee, RW. *Journal of Science Education and Technology*, 2003, 12(4), 343-358.
5. Cuban, L. Studies in Philosophy and Education, 1999, 18(1-2), 67-87.
6. Florida Department of Education. (2010). Next generation sunshine state standards. Retrieved from http://www.floridastandards.org/Standards/FLStandardSearch.aspx
7. Anderman, E., Midgley, C. Contemporary Educational Psychology, 1997, 22, 269-298
8. Metcalf, SJ., Tinker, RF. *Journal of Science Education and Technology*, 2004, 13(1), 43-49.
9. Strate, JM. Predictors of middle school scientific understanding. Poster presentation at the Student Research Symposium at Broward, Davie, Florida, April, 2011.
10. Sheridan, PM., Szczepankiewicz, SH., Mekelburg, CR., & Schwabel, KM. *Journal of Chemical Education*, 2011, 88(7), 876-880.
11. Pharr, C. *Journal of Chemical Education*, 2009, 86(6), 757-762.
12. Lorenzini, RG., Lewis, MS., & Monteclare, JK. *Journal of Chemical Education*, 2011, 88(8), 1105-1108.
13. Scaife, CW. *Journal of Chemical Education*, 1986, 63(9), 790-791.
14. Kumar, DD., & Maslin-Ostrowski, P. *Journal of Materials Education*, 2008, 30(5-6), 385-388.
15. Loughran, J., Mulhall, P., & Berry, A. *Journal of Research in Science Teaching*, 2004, 41(4), 370-391.
16. Kesidou, S, Roseman, JE. *Journal of Research in Science Teaching*, 2002, 39(6), 522-549. 17.
17. Kumar, DD. *The Chemist*, 1998, 75(1), 3-4
18. Tobias, K., Kumar, DD., *The Chemist*, 2006, 83(2), 6-9