2009

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Joram, E., Roberts-Dobie, S., & Davidson, E. (2009). Health Literacy in the Mathematics Classroom: The Iowa Core Curriculum As An Opportunity to Deepen Students' Understanding of Mathematics. Iowa Council of Teachers of Mathematics Journal, 36, 38-54.

# *Health Literacy* in the Mathematics Classroom: The Iowa Core Curriculum As An Opportunity to Deepen Students' Understanding of Mathematics

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By 2012, all high schools in Iowa will be required to incorporate the new Iowa Core Curriculum, followed by elementary and middle schools in 2014 (Iowa Department of Education, 2009). The Iowa Core Curriculum addresses the question: "How is Iowa's educational system preparing our youth for successful lives in the 21st-century global environment?" (Davidson, 2009). It consists of core content standards, and identifies essential concepts and skills for content areas. The Iowa Core Curriculum also includes the "21st Century Skills" of "health, financial, technology, and civic literacy, and employability skills. These skills are to be infused into existing subject matter rather than taught as separate stand-alone subjects.

Clearly, incorporating these newly identified essential concepts and skills is a daunting task for today's teachers in Iowa, in part, because they are not yet accompanied by suggestions for specific ways they can be implemented. In this paper, we discuss potential linkages between mathematics and one of the 21st Century Skills, health literacy, and provide suggestions for how Iowa's mathematics teachers can incorporate this aspect of the Iowa Core Curriculum into their lessons. Our discussion and suggestions are intended to serve as an example; similar points could be made about the relationship of mathematics to financial literacy, another 21st century skill. In this way, we hope to move the discussion about the Iowa Core Curriculum forward, from identifying essential concepts and skill sets as "big ideas," to thinking about specific

issues of classroom implementation. We intend to show how the Iowa Core Curriculum can be viewed as an opportunity to take mathematics into an out-of-school context that will ultimately deepen students' understanding of mathematical concepts.

### *The 21st Century Skills*

Health literacy is one of the 21st Century Skills that form part of the Iowa Core Curriculum. The Iowa Department of Education has identified expectations for the 21st Century Skills, specific to each skill and grade band. For example, the following expectations are listed for the grade 3-5 grade band for Health Literacy (Iowa Department of Education, 2009):

- obtain, interpret, understand and use basic health concepts to enhance personal, family, and community health;
- utilize interactive literacy and social skills to establish personal family, and community health goals;
- demonstrate critical literacy/thinking skills related to personal, family, and community wellness;
- recognize that media and other influences affect personal, family and community health; and
- demonstrate behaviors that foster healthy, active lifestyles for individuals and the benefit of society.

To meet these expectations, teachers would teach health literacy in the context, for example, of existing health, mathematics, science, and language arts classes. In this paper, we provide ideas for how health literacy can be integrated into the K-12 mathematics classroom.

### *Definitions of Health Literacy and Numeracy*

The currently accepted definition of *health literacy* from *Healthy People 2010* is "the degree to which individuals have the capacity to obtain, process, and understand basic health information and services needed to make appropriate health decisions" (US Department of Health and Human Services, 2000). A branch of health literacy that deals with numerical information in health and medical contexts has been referred to as *health numeracy*, and this is where we see many fruitful possibilities for the integration of health literacy with the K-12 mathematics classroom.

Peters et al. (2006) define health numeracy as "the ability to process basic probability and numerical concepts" (p. 407). Golbeck and colleagues (Golbeck, Ahlers-Schmidt, Paschal, & Dismuke, 2005) advance a more specific definition of *health numeracy* adapted from the definition of *health literacy* given above: "Health numeracy is the degree to which individuals have the capacity to access, process, interpret, communicate, and act on numerical, quantitative, graphical, biostatistical, and probabilistic health information needed to make effective health decisions" (p. 375). This can range from relatively simple tasks such as comprehending quantitative concepts imbedded in texts, such as nutritional information, to more challenging situations such as making medical decisions based on risk and probability information. It is clear, from these definitions, that knowledge of mathematical concepts is essential for accomplishing just the first Iowa Core Curriculum expectation listed above for health literacy which is to "obtain, interpret, understand and use basic health concepts to enhance personal, family, and community health."

### *How is Health Literacy/Numeracy Related to Mathematics?*

We suggest that the mathematical concepts that are essential for health literacy/numeracy are shared with the typical K-12 mathematics curriculum (National Council of Teachers of Mathematics, 2000); in other words, there are no new mathematical concepts that need to be taught in order to be health literate or numerate. What is unique to health literacy and numeracy, however, is that individuals must be able to effectively apply these mathematical concepts to health and medical contexts. For over 100 years, educational psychologists have consistently found that *transfer*, the application of knowledge gained in one context to a different context, is often very difficult, and is certainly not automatic nor guaranteed (National Research Council, 2000). We can assume, therefore, that simply learning mathematical concepts in the context of mathematics classes may not be sufficient to ensure that students are able to successfully transfer these concepts to relevant health and medical contexts.

Recent research has revealed that many adults have difficulty with basic health literacy/numeracy tasks such as accurately estimating portion sizes (e.g., Huizinga et al., 2009), correctly reading and interpreting prescription labels (Davis et al., 2006; Schillinger, 2006; Wolf et al., 2007), and using probabilistic information to make medical decisions (Peters et al., 2006). Not surprisingly, researchers have found that individuals with high levels of health literacy/numeracy perform much better on these tasks than those with low health literacy/numeracy levels (Nelson, Reyna, Fagerlin, Lipkus, & Peters, 2008). Therefore, it is crucial to teach students to interpret and use health information so that they can maintain a healthy lifestyle, and later on be able to prevent and manage disease. Health and medical contexts that are relevant to K-12 students can

also provide interesting and relevant everyday contexts in which students can flex their mathematical muscles. For example, understanding serving size information on nutritional labels may involve measurement, computation, and problem solving.

In summary, students who become fluent with the application of mathematical ideas to health and medical contexts will be better prepared to navigate their own health, including and the self-care of diseases they may encounter now and as adults, and the health of their families and communities. In addition, through explorations of mathematical concepts in health contexts, students may deepen their mathematical knowledge. Below, we offer some suggestions for ways that teachers can incorporate health literacy into the mathematics classroom.

***Mathematics Instruction and Health Literacy/Numeracy: The Case of Nutrition***

In this section, we provide an example of how health literacy/numeracy can be integrated into mathematics curricula, with respect to major standards and expectations in mathematics for different grade bands (National Council of Teachers of Mathematics, 2000). We focus on nutrition, which is a very rich context for examining a broad range of mathematical concepts, from the early elementary grades through high school. A greater number of suggestions are presented for elementary-level students than middle- or secondary-level students because more curricular material has been developed for these students. We have selected several mathematics standards to focus on, where the fit between nutrition education and mathematics education seems particularly fruitful. Standards and expectations (National Council of Teachers of Mathematics, 2000) are indicated below by bold text.

In addition to our own research and experiences in mathematics classrooms (e.g., Joram, 2003), we draw on lessons that have been developed for several programs in which nutrition education has been integrated with mathematics and science education: *FoodMASTER* (Duffrin, Phillips, & Hovland, 2009), the *Science of Food and Fitness* (Moreno, Clayton, Cutler, Young, & Tharp, 2006), and *The Science of Energy Balance* (National Institutes of Health, 2009a). Although the *Science of Food and Fitness* and *The Science of Energy Balance* were designed to teach science, some of the lessons cover topics that overlap with the K-12 mathematics curricula, such as measurement, and are therefore appropriate for the mathematics classroom. Alternatively, elementary-level teachers could teach an integrated mathematics/science unit that incorporates health literacy/numeracy, and middle- and secondary-level mathematics teachers may be interested in partnering with science teachers for the same purpose.

Materials discussed here are available, free of charge, either on the program websites or by placing a request on the website for teachers' manuals and student exercises (Duffrin et al., 2009; Moreno et al., 2006; National Institutes of Health, 2009a, 2009b). In addition to the programs above, we discuss lessons that have been posted on the National Council of Teachers of Mathematics *Illuminations* website (National Council of Teachers of Mathematics, 2009).

### *Measurement Standard – Example for Elementary Level Students*

From prekindergarten through grade 12, the National Council of Teachers of Mathematics measurement standard specifies that students should be able to "**understand measurable attributes of objects and the units, systems, and processes of measurement**," and they are also expected to be able to "**apply appropriate**

**techniques, tools, and formulas to determine measurements**" (National Council of Teachers of Mathematics, 2000). Nutrition offers an ideal context in which to work on these expectations because food is often in the form of continuous or mass quantities that must be measured rather than counted, and because measurement serves an important real-life purpose in nutritional contexts, such as cooking or controlling portions sizes. Although most available lessons we reviewed are designed for grades 3 and up, we suggest that Pre-K-2 students can explore measurement in nutritional contexts by getting a sense of the **relative magnitude** of different foods and liquids with respect to their weight, liquid capacity, and volume. One activity that we have used successfully with students is to have them place foods of different weights, arranged from lightest to heaviest, on a long table. This will help them work on the standard "**compare and order objects according to attributes"** (National Council of Teachers of Mathematics, 2000). Students at this age may have difficulty separating weight from volume, and may assume that a food object with a larger volume will also weigh more. Having students pick up objects of increasing weights, that vary in volume, should help them distinguish the two measurement attributes of weight and volume and lay a foundation for later representing these attributes numerically.

Both lower and upper elementary students can also pick up each food item and then estimate and check its weight. In this way, they will gain experience connecting the perceived weight to its numerical representation, and gain practice in using a scale (**using tools to measure**). Our experience shows that students usually enjoy this kind of "guess and check" activity, especially if presented as a game, where students in groups see who can come closest to the actual measurement with their estimate. These measurement

activities can be completed using both U.S. Customary and metric units, thus giving students practice in grounding measurement units for both systems in real world referents, as suggested by the National Council for Teachers of Mathematics (National Council of Teachers of Mathematics, 2000). This activity should help students meet the measurement expectation: "**become familiar with standard units in the customary and metric systems**" (National Council for Teachers of Mathematics, 2000).

Using **benchmarks for measurement estimation**, which is part of the measurement standard, can easily be integrated with nutrition – in fact, health educators often use benchmarks to represent appropriate portion sizes, such as a deck of cards to represent an appropriate portion size of meat (Iowa Department of Public Health, n.d.). In Activity 4 of *The Science of Food and Fitness* (Moreno et al., 2006), students are introduced to "Quick Hand Measures" for common foods, such as the tip of one's thumb to represent a teaspoon of butter. Some of these benchmarks are presented along with their standard measurement while others are not. We suggest that it will be important to include standard measurements with all benchmarks that are used, so that students learn how to represent the measurement as well as the appropriate food portion. For example, instead of simply equating an appropriate serving of meat with a deck of cards, teachers can identify the portion size as 3 ounces, and in this way, the benchmark (i.e., the deck of cards) will represent the measurement of 3 ounces, which in turn is the appropriate portion size. A chart found in The Science of Energy Balance, Lesson 1 "Burning It Up" (National Institutes of Health, 2009a) is helpful in this regard: it lists benchmarks for portion sizes, accompanied by their measurements.

Using benchmarks for measurement estimation promises to enhance students' meaningful representation of standard units of measurement as well as help them gain knowledge of appropriate food portions. This is an excellent way **to build connections between measurement units and their referent quantities.** In addition, learning to estimate appropriate portion sizes addresses the Iowa Core Curriculum expectation that students should "obtain, interpret, understand and use basic health concepts to enhance personal, family, and community health" (Iowa Department of Education, 2009). Although we have presented these activities in the context of the elementary classroom, they would be appropriate for older students as well.

FoodMASTER includes a set of lessons entitled "Measuring Up," that consists of baking activities through which students explore measuring dry and wet ingredients, using both customary U.S. and metric units for making chocolate chip oatmeal cookies. Although the second lesson culminates in actually baking the cookies, students can measure and mix ingredients for a no-bake recipe, if teachers do not have access to a stove. In addition to learning about standard measurement units, students can learn about **appropriate units** in this context – for example, teachers can ask students what unit should be used to measure flour for a given recipe: teaspoons or cups.

### *Numbers and Operations Standard: Example for Middle Level Students*

Percents, fractions, and decimals can be introduced in the context of nutrition, for example, by examining the percentage of the US Recommended Daily Value (DV) that a serving of a given food provides. Students can bring in packaged food containing food labels for these activities. Interesting problems can be posed to students, for example, asking them what it means to read on a nutrition label that the DV of Vitamin C provided

by an orange is 110% (**"develop meaning for percents greater than 100 and less than 1"**).

The National Institutes of Health website has an activity called *Portion Distortion*, in which pictures of portion sizes 20 years ago and now are shown, and the viewer has to identify what the difference in calories is between the two (Department of Health and Human Services: National Institutes of Health, 2009). For example, the website informs us that a bagel 20 years ago that measured three inches in diameter had 140 calories, and then asks us to choose either 350, 250, or 150 calories for today's much larger bagel which is shown. After selecting the correct answer (the website immediately provides feedback about which response is correct), students could also compute the percent increase in size of the bagel from 20 years ago, as well as the mean percent increase in food portion sizes for all the foods on the quiz.

Planning a meal for a larger or smaller number of people than for a typical recipe would be an excellent way to introduce middle school students to the measurement standard "**solve problems involving scale factors using ratios and proportions**." Students could be asked to half, double, or increase a recipe by 2.5 times to prepare needed quantities of food. This is an authentic activity in our experience, because one often has to adjust the quantities of recipes for different numbers of people.

### *Problem Solving: Example for Secondary Level Students*

The National Council of Teachers of Mathematics (2000) has identified the following standards for problem solving for secondary students: **"solve problems that arise in mathematics and in other contexts; apply and adapt a variety of appropriate strategies to solve problems."** Food labels provide an excellent authentic context for

problem solving and computation for secondary-level students. For example, a food label may state that a single serving of chips has 120 calories and that there are 2.5 servings per bag. Students can figure out how many calories they would consume if they ate the entire bag of chips, or what quantity of chips they should eat if they only want to consume 100 calories. The article entitled "The Newest Vital Sign" includes a food label with accompanying questions – although designed as an assessment of health literacy, the questions pose interesting problems that students could solve, requiring them to calculate calories, number of grams of fat, etc. based on a food label describing the nutritional components of ice cream (Weiss et al., 2005). In addition to providing students with problem solving experiences, becoming aware of food labels and how to perform such computations mentally can help them estimate and control the amount of food they eat. Websites such as the US Department of Agriculture's Nutrient Data Laboratory (U.S. Department of Agriculture, 2009b) provide a wealth of information from which problem solving activities can be designed. For example, students could keep a food diary for one week, and then compute the mean number of calories, fat, sodium, etc. they consume each day, comparing these to the recommended amounts (Iowa Department of Public Health, n.d.; U.S. Department of Health and Human Services: U.S. Department of Agriculture, 2005). Activity Seven, *Nutritional Challenges*, of the Science of Food and Fitness (Moreno et al., 2006) includes a list of dietary requirements for individuals who have different dietary needs and restrictions, for example, a pregnant woman, someone who is lactose intolerant, or a person who has Type II Diabetes, and students are asked to construct a one-day menu for these individuals. The Food Guide Pyramid website (U.S. Department of Agriculture, 2009a) has nutritional information available for different

ethnicities, so students can also work on developing healthy menus for people who eat foods common to a certain ethnicity, thereby integrating an awareness of ethnic diversity with mathematics and nutrition education.

Similarly, the *Science of Energy Balance* (National Institutes of Health, 2009a, 2009b) includes lessons entitled *Burning it Up* and *A Delicate Balance*, in which students are asked to keep food and activity diaries and enter their data onto a website. They can then examine the data for patterns and make predictions based on these patterns. In the web-based student supplements for *Burning it Up* students are introduced to profiles of teenagers and their "energy in/energy out" patterns, and are asked to make predictions about their weight gain and loss over time.

Activities such as those described above will give secondary-level students opportunities to "**formulate and refine problems** because problems that occur in real settings do not often arrive neatly packaged" (National Council of Teachers of Mathematics, 2000, p. 334). As recommended by the National Council of Teachers of Teachers of Mathematics (2000), teachers can present students with the goal to be achieved, for example, to come up with a menu that is appropriate for a person with specific dietary restrictions but that meets the Food Guide Pyramid requirements, allowing students to specify the information and the source of that information, that is relevant for solving the problem.

### *Additional Resources*

The National Council of Teachers of Mathematics' website, *Illuminations* (National Council of Teachers of Mathematics, 2009) has a number of lessons available on nutrition and mathematics, for grades K through 8. Clicking on the "Lessons" tab, and searching for the word "food" reveals 19 lessons that relate mathematics and nutrition.

However, for the purposes of promoting health literacy in the mathematics classroom, it is important to make sure that lesson objectives include both health and mathematics. For example, a lesson that uses M & Ms to teach counting to young students may offer benefits in terms of mathematics concepts learned, but not in terms of nutritional information.

An example of a lesson that promotes both mathematics and nutritional concepts is "What is the Best Chip?: Conducting a Sales and Marketing Investigation," geared for Grades 3-5. Students choose quantitative dimensions such as amount of fat, sodium, and calories, and then compare different brands of chips on these dimensions. Students discuss relative values on these dimensions in terms of their nutritional properties, and compare the nutritional value of the chips to other foods, with reference to information on websites that describe nutritional information such as the food guide pyramid (U.S. Department of Agriculture, 2009b, 2009c). Explorations like this one promise to enhance students' understanding of both mathematics and nutrition.

## *Conclusions*

Although we anticipate that many teachers may first feel overwhelmed when hearing that they now must incorporate health literacy into their curriculum, we have tried to show how teachers can embrace health an interesting and relevant context in which students can examine a broad range of mathematical concepts. We have discussed one rich context in which students can explore the intersection of health and mathematics, and we have provided examples of activities for different grade bands that address several key mathematics standards. Many more mathematics standards could be addressed for the purpose of integrating the 21st Century Skill of health literacy into the mathematics

classroom, such as data analysis and probability, connections, etc. There are also many contexts in addition to nutrition in which mathematics and health intersect include, for example, examining probability and statistics through education on risk behaviors such as smoking, which would be appropriate for middle and high school students.

In addition to those activities described above, there are many others that teachers can make use of in their classrooms that have already been developed, although there are relatively more activities available at the elementary level than for middle or secondary level students. As we suggested above, teachers can create activities themselves, making use of information such as that provided in the Nutrient Data Laboratory (U.S. Department of Agriculture, 2009b), or that students find themselves (on food labels, the internet, etc.) and bring to their classroom.

Incorporating health literacy into the mathematics classroom allows teachers to go beyond simply teaching mathematics concepts plus health concepts. Because health represents an applied, personally relevant context, integrating mathematics instruction with health literacy has the potential to increase students' number sense, or in the example of measurement applied to nutrition given above, their measurement sense (Joram, 2003). For example, teachers can discuss the different needs in precision when measuring certain ingredients in recipes (e.g., "a pinch of salt") in contrast to measuring medicine, which requires a high level of precision.

Higher levels of health literacy and numeracy can also have direct and immediate benefits for students' current level of health and well being, in addition to enhancing their mathematical understanding. For example, a recent assessment conducted in the spring of 2007 revealed that a mean of 37.2% of Iowa's 3$^{rd}$ through 5$^{th}$ graders were overweight or

obese, a statistic that has doubled for girls and tripled for boys just since Fall 2005 (Iowa Department of Health, 2007). Teaching children to more accurately estimate appropriate food portion sizes, as described above, may lead to a reduction of childhood overweight and obesity, leading to a healthier life today and in the future.

Seeing a personally relevant, real world application of mathematics to health contexts may increase students' motivation to learn mathematics. In addition, working on mathematical problems in real world contexts can make the mathematics more meaningful for students. This should have the effect of increasing their understanding of mathematical concepts, making it more likely that they will transfer these concepts to other situations. The ideal outcome of incorporating health literacy into the K-12 mathematics curriculum is that students' knowledge of mathematics will be deepened and in addition, they will be much better prepared to navigate everyday health and medical situations in the 21st century.

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