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ABSTRACT

The Health Sciences and Technology Academy (HSTA), administered through West Virginia University, provides professional development to science teachers who partner with higher education faculty in a science and math enrichment program for financially disadvantaged African American students. This program focuses on human nutrition and has incorporated the use of graphing calculators. This paper describes the application of graphing calculators to several sample human nutrition data sets. (Contains 11 references.) The calculators facilitate understandings about experimental design and other cross-disciplinary concepts and how science and math connect to human health. This project provides one context for secondary teachers and teacher educators to collaborate towards integrating science and math instruction. (WRM)

CONNECTING SCIENCE, MATHEMATICS, AND HUMAN HEALTH: APPLICATIONS OF THE GRAPHING CALCULATOR IN TEACHER PROFESSIONAL DEVELOPMENT AND STUDENT ACADEMIC ENRICHMENT

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The Health Sciences and Technology Academy (HSTA) (http://nt-hsta.hsc.wvu.edu/health), administered through West Virginia University (WVU), provides professional development to science teachers (n ~ 48) who partner with higher education faculty in a science and math enrichment program for financially disadvantaged and African-American students (n ~ 450) (Rye, 1998, Bock, 1996). The long-range goal of HSTA is to increase the number of underrepresented students in West Virginia who complete a post-secondary degree in the health sciences or secondary science teaching and remain in West Virginia as primary care givers or teachers. With the assistance of Eisenhower Professional Development Program funding, HSTA has included a focus on human nutrition for science and math enrichment, and in doing so, has incorporated the use of graphing calculators. The graphing calculator has been applied to data sets on the nutrient composition of food to facilitate understandings about experimental design and other cross-disciplinary concepts, and how math and science connect to human health. Driving questions are posed about nutrient intake and health in the context of examining and analyzing these data sets. Human nutrition content and applications of the graphing calculator to that subject matter, as illustrated in this session, provides one context for secondary teachers and teacher educators to collaborate towards integrating science and math instruction.

Background

Human nutrition is grounded in the principals of biology and chemistry (Spallholz, 1989) and is rich in opportunities to apply mathematical concepts (Rye, in press). Accordingly, a focus on human nutrition provides for the development of cross-disciplinary science concepts and reveals the integrated nature of science and mathematics. Moreover, it provides for the types of learning experiences necessary for a "lived curriculum," as advocated by Hurd (1997). Post-secondary faculty in mathematics, anatomy, chemistry, and teacher education have created HSTA Summer Institute experiences for HSTA teachers and "year 3" HSTA students that integrate studies of food composition, osteoporosis, and cardiovascular disease with the use of the Casio® graphing calculator (Casio, 1998). The calculators are applied to generate descriptive statistics, mean and median box and whisker plots, and scatter plots, which are examined to develop understandings about such concepts as percentile, correlation, linear regression, and dependent and independent variable. Past funding has been sufficient to allow teachers and students to keep the calculators, making them available for use during the subsequent school year.

Following are descriptions of HSTA Summer Institute experiences that apply the graphing calculator to human nutrition content. The "Fruity Investigation" was utilized in the

1996 and 1997 Summer Institutes and is described fully elsewhere (Rye, 1997). The "Calcium Intake and Bone Health" experience utilized in the 1997 Summer Institute emanated, in part, from the pre-pilot testing of a lesson within the theme of "special concerns in nutrition," subsequently published in the *Secondary Level Interdisciplinary Curriculum* (Campbell & Meyers, 1997). Portions of the third description, "Dietary Factors and Cardiovascular Disease," were utilized during the 1997 and 1998 HSTA Summer Institutes.

Fruity Investigation

This investigation seeks to determine the sugar concentration of a solution at which a grape will become buoyant. Box and whisker plots of the data are generated to illustrate the range of values produced by each small group that completes the experiment, and to discuss the concepts of median, percentile, natural variance, and experimental error. Hypotheses also can be set forth about the sugar concentration of different types of grapes (e.g., white as opposed to red), and the independent samples t-test can be applied to the data generated from experimentally determining the sugar concentration in randomly selected samples of these grapes. Most of the data shown in Table 1 was generated by the students who completed this experiment. The "percent mass as sugar of solution at buoyancy" approximates the actual sugar concentration of the grapes--approximately 18% according to food composition tables (e.g., Pennington, 1998). Further discussion can be generated about "body composition" (percent mass as water) of grapes (about 80%) as opposed to humans (50 to 60%), which leads to an appreciation of water as the nutrient needed in the greatest quantity by humans.

Table 1
Fruity Investigation Data and Respective Calculations: Percent Sugar Solution at Which Red and White Seedless Grapes Become Buoyant

	Mass (g) of Sugar Added to Water to Achieve Buoyancy		Mass (g) of Sugar Solution at Buoyancy		Percent (%) Mass as Sugar of Solution at Buoyancy[a]	
Group	Red Grape	White Grape	Red Grape	White Grape	Red Grape	White Grape
1	11	11.5	69.7	70.8	15.8	16.2
2	11.5	12	81.6	81.7	14.1	14.7
3	14	15	75	76	18.7	19.7
4	11.5	12.5	70.3	75.5	16.4	16.6
5	15.5	14.5	66.2	65.2	23.4	22.2
6	10	9	72.9	72.8	13.7	12.4
7	10	12	72.9	72.8	13.7	16.5
8	15	18	84	87	17.9	20.7
9	16	17.5	76.5	76.1	20.9	23
10	11.5	12.5	72.1	72.5	16	17.2

[a]Percent Mass as Sugar calculation: (Mass of Sucrose Added to Achieve Buoyancy/Mass of Sugar Solution at Buoyancy) * 100. Example for Group 1, Red Grape: (11/69.7) * 100 = 15.8%

Calcium Intake and Bone Health

This experience in human anatomy includes examining normal and osteoporotic bone, and learning about risk factors for osteoporosis. Amongst the nutrition-related risk factors is a diet that is chronically inadequate in calcium (Ca). Data sets of the energy value (kcal) and Ca content of various types of food, such as dairy and green vegetables (see Table 2 for samples) are examined and manipulated to answer questions about (a) the range of Ca present per serving and on a Ca per kcal basis and (b) the extent to which various foods satisfy recommended dietary allowances for Ca (e.g., 1200 mg/day for males and females, ages 11-24 years). Bioavailability constants also can be applied to food composition data in order to examine relationships between Ca in the food as opposed to the amount absorbed (Sizer & Whitney, 1997). For example, from 1 cup cooked broccoli, 38 mg of Ca (72 mg Ca per cup * .53 bioavailability) are absorbed whereas 95 mg of Ca (298 mg Ca per cup * .32 bioavailability) are absorbed from 1 cup 2% low-fat milk. Thus, taking into consideration the kcal values of and the Ca bioavailability from each of these foods, a revelation unfolds: The broccoli turns out to be a better source of Ca (on a per kcal basis) than does the 2% low-fat milk: 38 mg Ca/44 kcal = .86 mg Ca per kcal of broccoli; 95 mg Ca/121 kcal = .79 mg Ca per kcal of 2% low-fat milk. The previous exercise allows students to "look beyond" the Nutrition Facts on food labels and illustrates the complexity that underlies human systems and nutritional needs.

The experience continues through a chemistry investigation (Campbell & Meyers, 1997) where various dairy products are titrated for calcium, and descriptive statistics and box and whisker plots of the data are generated and discussed. Findings are compared to Nutrition Facts on the food label.

Table 2

Calorie (Kcal) and Calcium (Ca)[a] Content of 1 Cup Servings of Select Dairy Products and Green Vegetables

Food (1 cup each)	Kcal	Ca (mg)
Milk, Whole	150	290
Milk, 2 % Low-fat	121	298
Milk, 1% Low-fat	102	300
Milk, Non-fat	86	301
Yogurt, Vanilla, Low-fat	194	388
Asparagus (from frozen, cooked & chopped)	50	42
Broccoli (from fresh, cooked and chopped)	44	72
Brussel Sprouts (from fresh, cooked)	60	56
Cabbage (raw, shredded)	17	33
Lettuce, loose-leaf (chopped)	10	38

[a]Kcal and Ca values obtained from Sizer & Whitney (1997).

Dietary Factors in Cardiovascular Disease

The food composition data provided by this experience allows students to think about food intake from the perspective of the health of the cardiovascular system. For example, in the human anatomy component of the Summer Institute, students were asked to consider how a heart attack and stroke affect an individual's health and lifestyle. Relative to the latter, dietary intake becomes an important consideration. Students examine the nutrient composition of various types of animal products--such as red meat and dairy (see Table 3 for sample)--to determine if relationships existed between fat and kcal content or between fat and cholesterol content. Linear regression reveals that there is a strong and positive correlation between fat and kcal in both types of food: $r = .998$ for red meat and $r = .820$ for the dairy foods. However, the relationships between fat and cholesterol are dissimilar amongst the dairy foods and meats: There is a strong positive correlation ($r = .997$) in the former (as fat is reduced, the cholesterol content of dairy food appears to decrease by the same proportion), but only a weak and negative correlation ($r = -.293$) in the latter (reducing fat appears to have little impact on cholesterol content of meat).

Data sets also were constructed for "Voracious Carnivore," "Moo Cow," and "Flatulent Flatus"--names that humorously reflected the diet (meat, dairy, or legumes, respectively) of three fictitious characters. For these data sets, box and whiskers plots and scatter plots can be generated, and linear regressions can be performed, in association with questions such as "Who has the greatest range of total fat in their diet?" "Does there appear to be any relationship between kcal and total fat in these diets?" "If Moo Cow and Voracious Carnivore ate only the low fat items in their diet, who would obtain the most cholesterol and why?"

Chemistry experiences are added to the above through a "chips lab." Here, the fat and sodium content of "unknown" snack chip samples are quantified through laboratory analyses, e.g., for sodium, the distilled water "wash" of crushed chips is titrated with a $AgNO_3$ solution. Analyses of the new fat free potato chips yielded a "surprising" result: Students were able to extract a measurable amount of fat from the sample. This finding allowed for discussion about bioavailability and food technology: The "fat" used to prepare these chips--actually a sucrose polyester known as olestra that has some structural similarity to fat--is non-absorbable, and thus unavailable from a metabolic standpoint (Sizer & Whitney, 1997).

Implications

Teacher professional development efforts that bring together mathematics and science, such as those described above, support achievement of the National Science Education Standards (NSES)(National Research Council, 1996). At the program level, these standards convey that such coordination "provides opportunity to advance instruction in science beyond the purely descriptive" (p. 214) and "reinforces the perspective of investigation and experimentation that is emphasized in the National Council of Teachers of Mathematics standards" (p. 218). Further, human nutrition subject matter provides an authentic context for learning science and mathematics and the opportunity to develop student understandings within the NSES content

Table 3

Approximate Kcal, Fat, and Cholesterol Content[a] of Select Cooked Red Meats and Dairy Products

Food & Amount	Kcal	Fat (g)	Cholesterol (mg)
Beef, Chuck Roast, Lean & Fat, 4 oz	394	29	112
Beef, Round Roast, Lean, 4 oz	249	11	109
Pork, Shoulder Roast, Lean & Fat, 4 oz	373	26	124
Pork, Shoulder Roast, Lean, 4 oz	277	14	127
Venison, Roast, 4 oz	179	4	127
Milk, Whole, 1 cup	150	8	33
Milk, 2 % Low-fat, 1 cup	121	5	18
Milk, Non-fat, 1 cup	86	0.4	4
Yogurt, Vanilla, Low-fat, 1 cup	194	3	11
Ice Cream, Vanilla (~10% fat), 1 cup	267	15	59

[a]Kcal, fat, & cholesterol values obtained from West Diet Analysis (1997) and Sizer & Whitney (1997).

standards of "Life Science" and "Science in Personal and Social Perspectives." Applications of the graphing calculator in this context contribute to teachers' and students' competence in the use of learning technologies.

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