

Food Science and Technology (FST) Education System

As the Minneapolis Food Science and Technology planning team refined its goals, Shari Keivit, a Chemical Engineer with General Mills, Inc., asked the question: "Do we propose to teach food science for its own sake, or as a more effective means of teaching science to diverse groups of students?" The answer was, "Both." To those ends, the planning group is requesting NSF-Advanced Technology Education (ATE) funds to build a Food Technology Associate's degree, complete with a public school outreach and feeder system, and transition services to 4-year degrees and challenging careers in the growing food bioscience industries.

Multi-disciplinary focus: According to the Institute for Food Science and Technology, based in the UK: "*Food science* integrates several contributory sciences. It involves knowledge of the chemical composition of food materials, their physical, biological and biochemical behavior; human nutritional requirements; the nature and behavior of enzymes; the microbiology of foods; the interaction of food components with each other, and with oxygen, additives, contaminants, and packaging materials; pharmacology and toxicology; the effects of manufacturing operations and storage conditions; and the use of statistics for experimental work " (2004). Moreover, according to the Institute of Food Technologists, based in Chicago, then: "*Food Technology* is the application of food science to the selection, preservation, processing, packaging, distribution, and use of safe, nutritious, and wholesome foods" (Institute of Food Technologists, 2004).

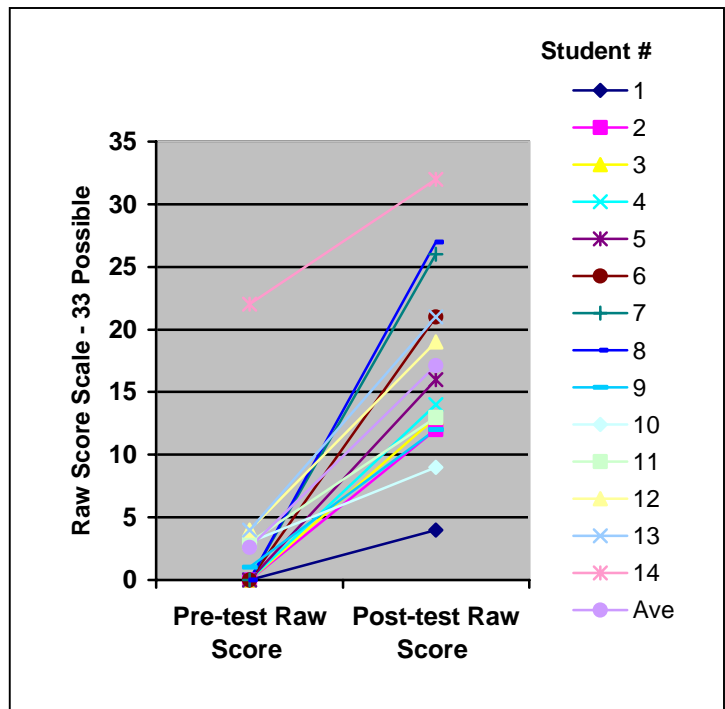
Education in other disciplines is also critical to the success of FST professionals, including ethics, law, core business disciplines, world languages/cultures, and other fields. The breadth of bioscience career opportunities, and students' interest in *edible science*, is a winning combination for the focus of an engaging, rigorous educational system.

Intellectual merit: The Minneapolis Food Science/Technology planning team has undertaken research and professional development to build knowledge of: 1) what students and parents want in an educational program, 2) what the food/bioscience industries need in their workers, and 3) how educators can bridge this gap. This work was supported by over \$100,000 in in-kind service from the project partners, and two small grants: an equipment/training grant from the Minnesota Agricultural Education Leadership Council and a planning subgrant from a regional Learn and Serve America partnership. The intellectual merit of the proposed project is first described in terms of three perspectives on food science education that have been investigated to date.

What Students and Parents Want/Need Minneapolis Food Science and Technology project planners know that even the highest quality educational program will fail if students and their parents are disinterested. Minneapolis Public Schools teachers have attended university/industry sponsored training and piloted a course, Exploring Food Technology, at the middle school level. The same group of teachers has designed a high school course that is being piloted in 2004-05: Food Science and Biotechnology. Out of this teaching laboratory, project planners have been able to conduct marketing research, a student interest survey related to the proposed Food Technology AAS degree, and pre- and post-testing that shows promising academic and motivational results with Minneapolis Public Schools students.

Marketing research: Not surprisingly, the 29 students and their parents who participated in focus groups and a brochure review process want "fun" but challenging academics that lead to a college education and high-paying, respected career opportunities. The six marketing images that were rated highest by focus group members all feature white-coated professionals, surrounded by high-tech accoutrements (see picture in project summary and page 1 of the Supplemental Materials section). These customer preferences are in keeping with the needs of industry for skilled technicians. However, students' dreams are too often disconnected from their skill levels and educational choices, as shown in the low bioscience pre-test scores of typical middle schoolers in Minneapolis (see chart on next page).

Pre- and post-test results from the pilot Exploring Food Technology middle school course suggest that food-oriented science education provides a realistic way to move students toward their dreams, a path made much more certain if it crosses through advanced STEM education (STEM=Science, Technology, Engineering and Math). As shown in the chart below, eight of the 14 students taking both the pre- and post-test began with a score of “0” in their basic bioscience knowledge. However, the hands-on pilot course, supported by a traveling lab from the Science Museum of Minnesota, boosted students’ basic science knowledge (full pre-/post-test summary in Supplemental Materials section, page 2). Since many City students become disengaged in school and particularly STEM coursework during middle school, local planners know that the ultimate success of project goals – like increasing diversity among post-secondary science students and food technology professionals – depends on igniting and supporting student interest at a young age. So far, the Exploring Food Technology pilot lessons seem to do that. But teachers want to further test and improve the efficacy of the courses through independent evaluation, more training, and more industry and higher education input during the NSF-ATE grant period.



The Student Interest Survey that is currently being conducted through the Dunwoody College of Technology website is showing results that are consistent with informal exit polling done in the pilot course classrooms. That is, about half of the students who are exposed to the world of food science and technology through a hands-on curriculum are interested in additional food science studies. About one-third of students are strongly interested and 10% say they would definitely enroll in the AAS program if it is created (Student Interest Survey summary results-to-date in Supplemental Materials section, page 3). In addition, the demographics of students interested in the proposed AAS degree (__% students of color) are in keeping with the goals of diversifying the post-secondary food science student population, and ultimately, the food science and technology workforce.

Middle College model. Like most students and parents, participants in Minneapolis’s food science market research define “success” as attaining college education. Minnesota students are fortunate to have free college credit available to them as high school students. Thus, the proposed educational system is being designed to transition qualified students into Dunwoody’s Food Technology AAS courses as early as 11th grade. This model will provide state-of-the art bioscience education to high school students, will help them create or build a STEM-rich college transcript, and will prepare students for Bachelor’s programs and/or high-paying jobs. Further, the system design will make the dream of a college education affordable through free college credit and connections to employer educational benefits.

What Industry Wants Food science and technology was selected as a programmatic focus for the ATE project due to the historical strength of the food industries in Minnesota, as well as the increasing demand for highly skilled bioscience workers. The skill gap between urban residents and the emerging bioscience

jobs will further widen if action is not taken now. For this reason, General Mills has made an extraordinary commitment to the project by assigning a .2 FTE pro-bono Principal Investigator, along with making extensive additional contributions to preliminary curriculum design, competency analysis and training. Other employers, including Land O'Lakes, [add others....] have indicated interest and support as well, as documented in the Supplemental Materials section (starting on page ____).

Competency Analysis This fall, a research assistant will be hired through the University of Minnesota Food Science Department who will organize the input of 10-20 food industry employers into a formal Competency Analysis Profile. This profile, based on the WorkKeys model developed by Dr. Tom Applegate of the University of Texas, will determine the competencies to be taught in the Food Technology AAS program, as well as the foundational STEM skills that must be reinforced in the public school courses. The University of Minnesota is very interested in participating in the Competency Analysis process as well, to better inform its Food Science, Nutrition and related degrees. Likewise, Minneapolis Public Schools teachers are eager to participate to improve the quality of the middle school and high school courses. The use of Dr. Applegate's model has been shown to predict career success of students, a major goal of all project participants.

In anticipation of the formal competency analysis for the AAS degree, and in order to provide a preliminary outline of the AAS program, a Senior Scientist and Chemical Engineer from General Mills', and a Trainer from Lloyd's Barbeque, compiled a list of competencies that the 2-year Food Technology degree should cover:

Chemistry and food safety – Specialized food chemistry for quality technicians; biological, chemical and physical hazard controls; sanitation; formula conformance; metal detection; GMPs (good manufacturing processes)

Mathematics and statistics – Algebra, geometry, data collection, averages, standard deviation, process control and capability

Basic mechanical skills – physics, levers, gears, equipment troubleshooting and vendor communication

2-year graduates also need an array of additional technical skills according to this preliminary analysis, including instrumentation/control, facilities and utilities skills. However, the hiring manager for General Mills' Chanhassen plant stresses that communication, teamwork and basic employability skills are as important to career success as the quality of employees' technical skills (see Supplemental Materials, page ____). Conducting a full Competency Analysis will ensure that the Food Science and Technology courses integrate instruction in basic workplace and communication skills, as well as technical education. This means that the curricula to be developed through the project will be highly transferable to other majors if students so desire.

Workforce studies Under the direction of Governor Tim Pawlenty, the State of Minnesota has taken leadership in assessing the needs of Minnesota companies to emerge as national and international leaders in the Biosciences. The state is supporting this NSF-ATE project because the success of economic development initiatives, in Minnesota and across the nation, will depend on the evolution of the educational system. The MN Department of Employment and Economic Development (DEED), in collaboration with the Governor's Bioscience Council, conducted a Bioscience Workforce Study in early 2004. Respondents included 81 Bioscience companies employing 1,134 people, and anticipating 750 new jobs by 2008; this is an expected growth rate of 66%.

It is important to note that the survey respondents represented many small companies, and that several of the larger employers did not respond. For example, the primary industry partner on this ATE project,

General Mills, hires more food professionals in the Twin Cities metro area than all of the firms replying to the State's Bioscience survey put together. Beyond General Mills, total hiring in job classifications connected to the proposed food science and technology education system is estimated to number over 50,000, with a 4% overall job growth rate. However, the State's Bioscience Workforce Study findings underscore an important trend. Job expansion rates are much higher among the skilled bioscience job classifications, and are actually falling in the unskilled job classifications of yesterday. The proposed project is thus critical to the future of bioscience business in the upper Midwest, and to the employment prospects of Minneapolis students.

Many of the firms responding to the State's Bioscience Workforce survey deal in food-related applications of bioscience, including agricultural biotechnology, animal biologicals/diagnostics, nutraceuticals, industrial bio-processing, and national security. The study shows the need for Associate's-level degree programs; 23% of the jobs are lab technicians (DEED, page 4). There is also a solid market for students who progress to 4-year degrees or higher. Scientists make up 28% of employees, and engineers comprise 15% (DEED, page 4). This reinforces the employment statistics of recent graduates of the Food Science program at the University of Minnesota – College of Agricultural, Food and Environmental Sciences. Of students responding to the University's post-graduation survey 2003, 100% were employed at an average full time starting salary of \$38,856. Most received multiple job offers.

From the perspective of Minneapolis students, who may lack the skills and/or financial resources to undertake a traditional 4-year degree path right out of high school, it is important to note that well-paying jobs, as well as excellent educational benefits, are available to high school graduates who have strong science skills, and/or coursework toward an Associate's degree. General Mills's hiring range for Sanitors, Production Workers, and Quality Technicians is in the \$25-37 K range, with \$6000 per year available in educational benefits, plus company-paid training. Of the 50,000-plus metro-area jobs related to industrial food processing, prospects for qualified high school and 2-year graduates are excellent in several growing job classifications.

Growth of Selected Job Classifications, in order of job expansion rate	Twin City Metro Percent Change	Metro Est. # Jobs 2000	Metro Projected # Jobs 2010	Metro Numeric Change	Turnover Openings	Metro Total Openings- 10 Yr	Median Wage Metro 03	Median Wage MN 03	Median Wage US 03
Dietetic Technicians	+23.90%	205	254	49	53	102	\$16.16	\$15.26	\$11.12
Biological Technicians*	+22.80%	307	377	70	71	141	\$15.23	\$15.91	\$16.18
Chemical Technicians*	+21.60%	656	798	142	153	295	\$17.68	\$17.10	\$18.38
Bakers	+17.20%	1,969	2,308	339	311	650	\$11.41	\$11.09	\$10.32
First-Line Supervisors/Managers of Food Preparation	+11.80%	7,624	8,520	896	1,923	2,819	\$13.61	\$12.35	\$12.12
Agricultural and Food Science Technicians	+7.60%	170	183	13	39	52	\$15.86	\$14.98	\$14.24
Agricultural Inspectors	+5.30%	57	60	3	14	17	\$21.55	\$18.47	\$14.23
Chefs and Head Cooks	+2.90%	848	873	25	261	286	\$16.79	\$15.53	\$14.10
Forensic Science Technicians*	(Trend data not yet established)						\$19.25	\$19.01	\$20.81
Totals	12.99%	11,836	13,373	1,537	2,825	4,362			

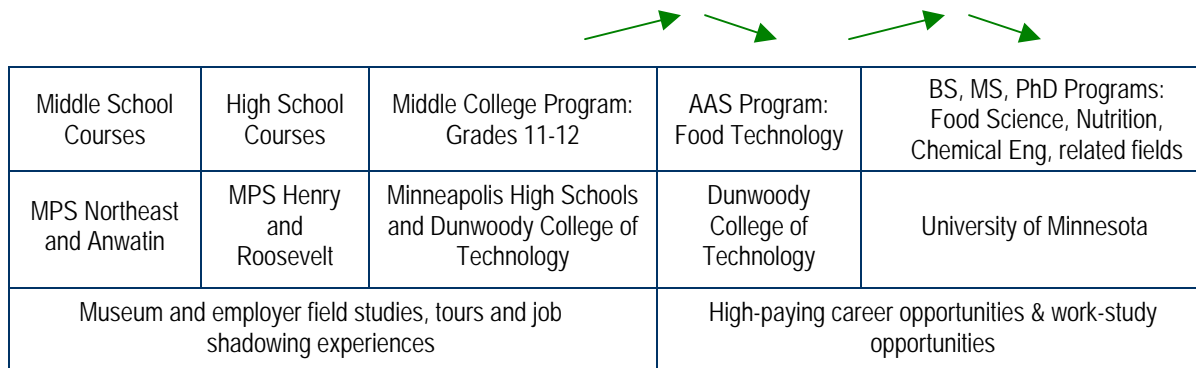
*Three of the classifications included in the chart include both food industry and non-food-industry applications. The classifications are included because many of the jobs are food product related (for

example, turning corn into ethanol). Moreover, food technology students will develop many transferable skills that would allow them to change career paths into non-food applications if desired.

What Can Educators, Employers and the Community Do to bring together the needs and interests of students with those of employers and the regional economy? The proposed Food Science and Technology Outreach and Education System will serve this purpose.

A Multi-institutional System

The Food Science and Technology Outreach and Education System will include articulated courses and programs provided by cooperating educators, employers and community organizations.



The arrows above the chart show articulated and overlapping programs. Students may take multiple pathways through the system, depending on their needs, motivation and skill levels. One high school student, for instance, might be ready to enroll in University-level chemistry as a junior or senior in high school. This opportunity already exists, but the option is generally accessed by the more advantaged students who have followed a traditional, accelerated STEM preparation pathway beginning in 6th or 7th grade. The proposed new system provides a bridge that more students can travel. In this system, an 11th grader who has done well in a high school Food Science class may be ready to enroll in Dunwoody's Introduction to Food Science and Food Science Lab as an 11th grader. This would provide credit toward a marketable AAS degree, and also prepare the student for later study at the University in STEM disciplines if he or she so desires. In either case, courses at the University of Minnesota and Dunwoody College of Technology count toward high school graduation. Upper level courses taken at Dunwoody will actually count in three places: toward a high school diploma, toward an AAS, and as part of a BS from one of the articulated programs at the University. Because the AAS will include a substantive student internship, the coursework will also "count" on the students' resume in the work experience category.

Currently, the most motivated students can graduate from high school with two full years of free University credit. However, by creating the new system, a more typical student can graduate from high school having completed most of the work toward an Associate's degree, having logged one year of credit toward a BS, and looking forward to a well-paying internship in food technology.

Curriculum Development

At this time, different levels of the Food Science and Technology Educational System are in different stages of development. The middle school course has been developed and piloted, and is being expanded to a second school. The high school course has been approved and will be piloted in the 2004-05 school year. After this year, the public school courses will enter a continuous quality improvement phase, based on the

results of early implementation. The teachers are very interested in having the opportunity to work with an NSF-funded evaluator to formally assess and improve these promising courses.

The goal of the Food Science/Technology Planning Team is to complete development of the AAS degree in stages, with pilot courses and recruitment taking place in 2005-06, the entire grade 13 curriculum being piloted in 2006-07, and grade 14 being piloted in 2007-08. At that time, the fall of 2008, all levels of the FST educational system will be operational in a continuous improvement stage. The first cohort of AAS graduates will be ready to enter high-paying jobs and/or U of M degree programs.

The articulated courses and programs included in the system are outlined below.

Minneapolis Public Schools Middle School Course (Grades 6-8) – “Exploring Food Technology”

18 Week - Elective course

Status: Piloted in 2004; currently expanding to a second school and entering an evaluation and improvement stage.

Statement of Purpose

- Module 1: To create an awareness of the farm-to-table process and its influence on our lifestyles
- Module 2: To teach biology, physics and chemistry concepts through food science; to provide students with experiential learning opportunities that promote lab skill development and understanding
- Module 3: To expose students to complex scientific concepts related to biotechnology; to teach students how to think critically and to identify questions that can be answered through scientific investigation
- Module 4: To stimulate student interest in scientific careers in the food industry

Units of Study

Module 1: Food Production

- Overview of agriculture in the U.S. and globally: what is produced and why-climate, terrain, culture, technology etc. Experiment: Wheat plant growth
- Food processing and production
- Retail and home: label reading, safe food handling, marketing techniques
- Future foods: functional food, food trends, food as medicine, etc.

Field Trips: 1) to Mill City Museum for their middle school program [add program name], and 2) to a food production facility.

Module 2: Food Science

- Microorganism growth: use in food processing and production, food safety, food borne illness.
-Bacteria: fermenting cultures. Lab: yogurt.



Minneapolis Public Schools students at work in the new food technology course. Students are now asking “What can I take next?”(Pederson, 2004).

-Yeast: fermentation. Experiment: Measure the gas produced as a result of yeast growth. Lab: bread.

-Molds: growth and control. Experiment: growth promoters and inhibitors.

- Preservation Techniques: drying, freezing, refrigeration, irradiation. Experiment: compare bacterial growth using a variety of variables. Lab: Fruit Roll-ups®.

- Physical and chemical changes in food.

-Freezing and boiling. Experiment: texture comparison.

-Enzymatic browning and ripening. Experiment: anti-oxidation product comparison. Lab: fruit kabobs.

-Steam production. Experiment: effect of moisture content in popcorn volume. Lab: cream puffs.

-Sugar concentration and crystallization. Experiment: rock candy. Lab: lollipops.

-Starch thickening properties. Experiment: compare gel properties of different thickening agents. Lab: cheese sauce for nachos (genetic modification tie-in).

-Protein coagulation. Experiment: use of heat and enzymes to coagulate milk protein, and cheese making (tie-in to nacho cheese sauce). Lab: fruit parfait (with cottage cheese) or custard.

-Properties of eggs. Experiment: structure and composition. Experiment: stability of egg foams. Lab: meringue shells or baked Alaska.

-Fat emulsions and suspensions. Experiment: emulsion stability. Lab: homemade salad dressings and salad bar (tie-in to anti-oxidation).

-Chemical leavening. Experiment: leavening chemistry. Lab: quick bread product.

- Sensory testing: using a variety of products, conduct sensory tests for taste vs. flavor, texture etc.

Food science lab skills: prepare and inoculate petri dish for culture growth, accurately conduct a plate count, practice aseptic technique, measure accurately, recognize abbreviations, calculate equivalents.

Module 3: Biotechnology

- What is biotechnology: definition, historical timeline, products and foods used today as a result of biotechnology.
- Cell structure: basic parts, animal vs. plant cells. Lab: cell "pizza," and cell "pudding."
- DNA structure, bases, and replication. Lab: DNA extraction.
- Genetics: genes, chromosomes, recessive/dominant, genotype/phenotype, transgenic products, genetically modified (GMO) vs. identity preserved (IP) products.
- DNA fingerprinting: what it is, how it is used in society and forensics. Lab: electrophoresis.
- Ethics and moral dilemmas, risks and benefits, current research in food, health, medicine, and environmental issues. Lab: case studies and mock trials.

Biotechnology lab skills: equipment and tool identification, pipette and micropipette technique, making an agarose gel, loading gel chambers, calculating concentrations and dilutions of solutions, micro measuring.

Module 4: Careers in Food Industries

- Food related careers
- Education and training opportunities
- Future job outlook and trends

Field Trips 1): to Dunwoody College of Technology; and 2) to a food research and development facility.

Middle School Curriculum Resources

Science and Our Food Supply – FDA teaching kit.

S.O.S. curriculum and teaching kit – Minnesota Department of Public Health.

The Science Chef, by Joan D'Amico & Karen Drummond, ISBN 0-471-31045-X.

Exploring Science in the Foods Lab, by Carol Byrd-Bredbenner, ISBN 1-56637-719-6.

Food Science and Technology Curriculum Guide, available from Instructional Materials Laboratory, University of Missouri-Columbia, 10 London Hall, Columbia, MO 65211 314-882-2883.

Volume IV: Food and Science, and Volume I: Classroom and Laboratory Management, parts of the Food Nutrition and Science Curriculum, available from Department of Family and Consumer Sciences Education, Applied Technology Education, Utah State Office of Education, Salt Lake City, Utah.

Project Food, Land and People Resources for Learning, 2nd edition, by project Food, Land & People, P.O. Box 7600, Chandler, Arizona, 85246-7600, 480-963-0187.

Biotechnology School Enrichment grades 5-6, and Biotechnology School Enrichment grades 7-8, available from Iowa State University, 119 Printing and Publications Building, Ames, IA 50011-1050, 515-294-5247.

General Mills's Traveling Science Show experiments.

Cognitive Discovery Labs – incentive for high-performing students to attend day-long labs at the University of Minnesota Food Science program.

Minneapolis Public Schools High School Course (Grades 9-10) – "Food Science and Biotechnology"

18 week - elective course / alternative science credit

Status: pilot stage, 2004-05

Statement of Purpose

The purpose of the course is to use scientific inquiry and reasoning to study the production, processing and creation of food. Experiments and research will be conducted to analyze the composition of food and its nutritional effects. Biotechnology will be explored as it is used to improve plants, animals, and micro-organisms for food production.

Units of Study

I. Introduction activities (one week)

Getting acquainted with food science and technology

Lab safety

Equipment use procedures

II. Food science

Food safety, sanitation

Metric measuring practice

The use of science in preparing cheese, ice cream, bread, candy, jelly, gelatin, pickles, dehydrated food, canned foods.

Lab experiences making the above list of foods.

Field trip: Mill City Museum for their high school program [_____add name of hs program]

III. Biotechnology and foods

DNA extraction from kiwi fruit, wheat germ, onion skin

DNA as videotape

DNA dance

Construction of a DNA model

Genetically modified foods, what are they? How are they engineered? Risks and benefits.

Field trip: University of Minnesota Biotechnology lab

IV. The ethics of food biotechnology

Use of case studies to help students explore the issues.

V. Food Science Careers

Chemical engineers at General Mills – Field trip

Biotechnologists at Cargill – Field trip

Plant and animal researchers at the U of M.

Nutritionists.

Food scientists at many food companies.

Working for the Food and Drug Administration.

Food industry inspectors.

VI. Culminating project

Individual research into food science issue of the student's choice

High School Curriculum Resources

Student text:

Mehas, Kay Yockey and Rodgers, Sharon Lesley. Food Science: The Biochemistry of Food and Nutrition. 2002.

Mehas, Kay Yockey and Rodgers, Sharon Lesley. Food Science: The Biochemistry of Food and Nutrition Lab Manual. 2002.

Teacher Reference:

Kreuzer, Helen and Massey, Adrienne. Recombinant DNA and Biotechnology. 2001.

Additional resources:

Cognitive Discovery Labs – incentive for high-performing students to attend day-long labs at the University Food Science program.

Due to space limitations in the project description, additional important information about the middle school Exploring Food Technology course and the high school Food Science and Biotechnology course is included in the Supplemental Materials section, starting on page __. This information includes: National Science Standards, National Family and Consumer Science Standards, and Minnesota Academic Standards in Science that are addressed in the course; methods of instruction and evaluation; integration of Food Science studies within Smaller Learning Communities; and quality features associated with approved Career and Technical Education courses.

Dunwoody College of Technology Food Technology AAS Degree Program

2-year Associate of Applied Science degree, articulated with high school and University programs.

Status: Competency Analysis, curriculum development - 2004-05, piloting to start in 2005-06.

Development and implementation of a Food Technology AAS degree is a primary goal of the Food Science and Technology planning team from 2004-06. To ensure the relevance of the program to current and emerging industry needs, Minneapolis Public Schools, Dunwoody College of Technology, the University of Minnesota, and 10-20 food industry representatives will complete a Competency Analysis Profile with the assistance of Dr. Tom Applegate during school year 2004-05. This profile will drive:

- Content and pedagogy in the new AAS program that results in 2-year graduates having the skills to succeed in food technology careers, and to transfer 1-2 years of credit to 4-year degree programs at the University of Minnesota or other universities.
- Improvements to academic courses piloted at the middle school and high school levels, to ensure that students have the foundational skills needed to succeed in college courses and degree programs.
- Improvements to University of Minnesota Food Science and related degree programs.

All Dunwoody degrees are focused on a core professional preparation program, with instruction in general academics that is specifically tied to industry applications. Program directors (to be hired initially through the NSF grant) must have six industry contacts per year, and submit the curriculum for industry approval. By applying the [quality management] framework used to improve all Dunwoody programs, the Food Technology AAS will be, not only a unique degree option, but “best in class” quality.

Preliminary Draft: Food Technology AAS to be Developed and Implemented through the ATE Project (2005-2008)

A 2+ year Associate of Applied Science (AAS) degree with internship; preliminary design by co-Principal Investigators Jonathan Keiser of Dunwoody College of Technology and Karalyn Littlefield of General Mills.

Courses	# Cr	Qtr
Introduction to Food Science	5	1
Introduction to Food Science Laboratory	3	1
Math 100*	5	1
Computer 100*	3	1
Food Science Seminar (integrates guest speakers from industry)	1	1
	17	
Food and Consumerism Lecture	2	2
Dilutions and Solutions Lecture	3	2
Dilutions and Solutions Laboratory	2	2
English 101*	3	2
Physics 101*	5	2
Food Science Seminar	1	2
	16	
Food Chemistry Lecture	3	3
Microbiology Lecture	3	3
Microbiology Applications Laboratory	2	3
Math 150 – Introductory Statistics	3	3
Workplace Diversity *	3	3
Communications 100 *	3	3
Food Science Seminar	1	3
	17	
Food Manufacturing Technology	5	4
Food Manufacturing Technology Laboratory	2	4
Math 225 Quality Concepts and Statistics *	3	4
Biotechnology Applications in Food	3	4
Biotechnology Applications Laboratory	2	4
Food Science Seminar	1	4
	16	
Biotechnology Applications in Food II	3	5
Biotechnology Applications Laboratory II	4	5
Conceptual Food Engineering	3	5
Economics 100 *	3	5
Food Plant Sanitation and Food Safety	3	5
Food Science Seminar	1	5
	17	
Product Development and Sensory Evaluation	3	6
Quality Assurance in the Food Industry	3	6
Fundamental Principles of Food Manufacturing	3	6
Humanities/Arts Elective *	3	6
Sophomore Honors Project *	2	6
Food Science Seminar	1	6

Note: To receive the AAS, Food Technology students will be required to complete an internship in an industrial setting in addition to completing the listed

Asterisks (*) in the chart indicate existing courses at Dunwoody College of Technology.

Preliminary descriptions of the proposed Food Technology courses are outlined below, drafted by co-Principal Investigator, Karalyn Littlefield of General Mills, Inc.

[Insert Karalyn's course descriptions.....]

The proposed AAS program will provide the missing link between typical Minneapolis high school students and the types of higher learning opportunities and challenging careers available in the food industry in our community.

University of Minnesota Food Science and Related Degrees Programs

The University of Minnesota offers a Food Science BS degree that is approved by the Institute of Food Technologists. Students may choose from three different concentrations: Engineering, Microbiology and Chemistry. A sample course plan is shown below, and a full listing of courses/ course options is provided in the Supplemental Materials section, beginning on page __.

The proposed ATE project will create a feeder system that will prepare more students, and more diverse groups of students, to take advantage of the excellent resources in Food Science and related fields at the U of M. With a strong basic science background, interested students who have taken MPS Food Science

courses and/or an AAS in Food Technology through Dunwoody, may consider entering many different University degree programs. Degrees to be articulated with the new AAS and feeder system include: Animal Science, Applied Plant Science, Environmental Horticulture, Environmental Science, Food Science, Nutrition, Ag Industries and Marketing – Food Industry concentration.

In the process of developing the AAS program, industry and curriculum specialists will work with Minneapolis Public Schools teachers, the U of M Transfer Curriculum Coordinator and U of M faculty to determine which of the AAS courses will automatically transfer for credit in which of the BS programs. It is anticipated that one to two years of AAS coursework will count toward a BS, depending on the major selected by the student. When necessary and appropriate, credit transferability will be decided on a case-by-case basis, depending on grades, testing and other factors.

Sample University of Minnesota BS in Food Science

Freshman Year	
Fall Semester	Spring Semester
MATH 1271 Calculus 1 (4)	MATH 1272 Calculus 2 (4)
FSCN 1102 (3) Food: Safety, Risks & Technology <i>CPE</i>	BIOL 1009 General Biology (4)
CHEM 1021 (4) Chemical Principles 1 <i>ENVT</i>	CHEM 1022 (4) Chemical Principles II <i>ENVT</i>
RHET 1101 (4) Writing to Inform and Persuade <i>CD, CPE, ENVT</i>	Arts/Humanities (4) <i>lit</i>
Sophomore Year	
Fall Semester	Spring Semester
FSCN 3102 Intro. to Food Science (3)	MicB 3301 Biology of Microorganisms (5)
CHEM 2301 Organic Chem 1 (3)	CHEM 2302 Organic Chem II (3)
*PHYSICS I (4-5)	*PHYSICS II (4-5)
RHET 1223 Oral Presentations in Professional Settings (3)	*Biochemistry (3-4)
Junior Year	
Fall Semester	Spring Semester
Social Science (4)	FSCN 4121 Food Micro & Fermentations (3)
FSCN 4111 Food Chemistry (3)	STAT 3011 Statistical Analysis (4)
FSCN 1112 Principles of Nutrition (3)	FSCN 4122 Lab in Micro & Fermentations (2)
RHET 3562 (4) Technical and Professional Writing	FSCN 4332 Food Process Engineering II (3)
BAE 4744 Engineering Principles for Biological Scientists (4 cr)	History (4) <i>IP</i>
Senior Year	
Fall Semester	Spring Semester
FSCN 4312 Food Analysis (4)	FSCN 4xxx Elective with capstone component (3-4)
FSCN 4131 Food Quality (3)	Humanities/Arts (4)
*LABORATORY SKILLS (2-4)	

More than one course will satisfy this requirement

[Dawn, this is where the information from the old preliminary application starts.]

The standards and program models informing the Food Science and Technology (FST) system design include the following (see references for full citations and more supporting research):

American Association for the Advancement of Science. *Benchmarks for Science Literacy* (1993), *Designs for Science Literacy* (2000), and *Atlas of Science Literacy* (2001).

Food, Land and People, Inc. (2003). *Resources for Learning*.

Institute of Food Technologists. *IFT Undergraduate Education Standards for Degrees in Food Science* (2001) and *Guidebook for Food Science Programs* (2004).

[Dawn, here are the NSF-funded projects that we THINK connect to our project. The project numbers and full citations are in the Citation list at the end of this file]

→National Science Foundation. *Collaborative Biotechnology Program for Delaware* (2001), *Crossing Boundaries: a 2-year and 4-year College Collaboration in Science Education for K-12 Teachers* (2001), *Community College Leadership in Providing Opportunities for Disadvantaged High School Students in Science-based Careers* (2002), *High School Technology Initiative* (2003), *Ag Knowledge: The National Center for Agriscience and Technology Education* (2003), *Conference of Food Engineering* (2003), *Evaluation of Materials Produced by the ATE Program* (2003), *A Biotechnology Curriculum and Teacher Education Project for High Schools* (2004), and approximately 25 other NSF-funded projects and reports.

Minnesota Department of Education. (2003-2004). *Minnesota Academic Standards*.

National Research Council. *National Science Education Standards* (1996) and *Inquiry and the National Science Education Standards: A Guide for Teaching and Learning* (2000).

[Dawn, I would also like for you to write a blurb about how the next book connects to our project, if you can find enough info on line to write about it. If you can't, I have bought the book and I can get it to you when I get back. NSF is big on this book, I guess.]

→Wiggins and McTighe. *Understanding by Design* (1998).

Elements of existing four-year Food Technology degree programs will be integrated into the FST education system. Programs approved by the Institute of Food Technologists are based at the following universities: Alabama A&M, California-Davis, Delaware, Georgia, Iowa State, Kansas State, Louisiana State, Michigan State, Mississippi State, Oregon State, Cook College/Rutgers, San Jose State, Tennessee, Texas A&M, Texas Tech, Wisconsin-River Falls, and Virginia Polytechnic. **It is important to note that there are no two-year Food Technology degree programs in the U.S. that are equivalent to the proposed program.** Similar degree programs include a number of NSF-funded Biotechnology programs, as well as Kansas State's non-degree certificate program in Food Science, Rochester Institute of Technology's food-focused Laboratory Technology program, and Kirkwood Community College's food-focused Agricultural Technology program (Cedar Rapids, IA).

The proposed FST education system will integrate model field education and professional development activities developed by General Mills Inc., the Science Museum of Minnesota, and Mill City Museum (a site of the Minnesota Historical Society).

Workforce preparation in the FST education system will be supported by Dr. Tom Applegate of TNA Associates. He is the Executive Dean of Customized Training at Austin Community College, President of the Association for Career and Technical Education, and has consulted on other NSF projects. He will assist Minneapolis partners in using his Competency Analysis Profile to inform the scope and sequence of the FST education system by identifying career competencies and foundational skills needed by students. Program planners will also integrate standards promulgated by the U.S Department of Homeland Security, the U.S Department of Agriculture (USDA), and the many food industry organizations registered with the USDA (<http://www.nal.usda.gov/fnic/etext/000103.html>).

The project evaluation by Dr. James Barufaldi of the University of Texas and Dr. Linnea Fletcher of Austin Community College will be designed to support the quality of professional and curriculum development, and assure progress toward quantitative goals. The evaluators have experience with NSF projects and will draw on NSF's *User-Friendly Handbook for Mixed Method Evaluations* (2004).

Intellectual Merit

General Mills, Inc. (GMI) became involved in this project because there are no 2-year degree programs to prepare food technologists for careers with GMI or the other 70 food production companies based in Minnesota. There is also no bridge from Minneapolis's diverse student population to high paying jobs in the food industry that provide company-paid training. Such resources are sorely needed by the 67% of Minneapolis Public Schools students who are low income. However, even entry-level workers must have strong STEM skills (STEM=science, technology, engineering, math).

In focus groups, students of color and their parents state the desire for a college education and high-paying careers. However, students of color are underrepresented among high school graduates in Minneapolis: they account for 62% of graduates vs. 75% of the overall student population. This pattern is magnified in post-secondary technical education where 81% of students at Dunwoody College of Technology are white. The pattern becomes even more pronounced at higher levels of the FST educational system. 2003 graduates of the University of Minnesota's Food Science degree program were 100% white.

The good news is that minority students are interested in STEM content if they see the coursework as fun and lab-based (Palazzo, 2004). They are likewise interested in the lucrative career options resulting from STEM education (Palazzo, 2004). Engaging diverse groups of students in accessible but rigorous STEM curricula will provide the missing link between the region's strongest employers, training institutions, and its increasingly diverse citizenry.

Project goals and objectives:

Overall goal: Develop a FST education system that attracts diverse groups of students and prepares them for more advanced STEM coursework, post-secondary education and high-paying careers.

- Conduct a FST Competency Analysis Profile and analyze the findings with other research in educational standards and model programs (national and international). Participation: 20 partners, including employer representatives (10), educators (7), and community agency partners (3).
- Based on the research, create a coherent FST system that allows for dual enrollment of high school students at Dunwoody College of Technology; credit transfers between Dunwoody, the University of Minnesota, and other four-year institutions; the integration of field learning into degree programs; and various "stopping out" points/ career options. Participation: 35 partners, including teachers/professors (17), counselors/administrators (10), industry representatives (5), and community agency partners (3).
 - Revolutionize Family and Consumer Science courses, developing them into lab-based food science and technology courses meeting state/national science standards and reinforcing foundational skills.
 - Create a best-in-class Food Technology AAS degree program at Dunwoody College of Technology, an NCA accredited 2-year college.
 - Create a 2+2+2 Food Science and Technology degree option through the University of Minnesota.
- Promote enrollment and completion of FST courses and programs by students reflecting the diverse demographics of Minneapolis Public Schools: 75% students of color. Annual service targets when the system is fully operational include (targets are scalable if demand indicates): 75 students enrolling in FST courses at 3 middle schools (per year), 50 students enrolling in FST courses at 2 high schools, 25 students enrolling in the new Food Technology AAS program, and 12 additional students enrolling in 4-year degree programs at the U of MN or other 4-year institutions. Also, 25 students will be placed into FST employment annually.

- Drive continual improvements in the new FST education system through evaluation, dissemination, and expanded collaboration, to build long-term support for alternative STEM education.

Proposed outcomes and evaluation of those outcomes: To evaluate the project, Dr. James Barufaldi of the University of Texas and Dr. Linnea Fletcher of Austin Community College will work with the FST partner organizations and their respective research departments. The evaluators have experience with NSF-funded projects; for example, Dr. Barufaldi is the evaluator and Dr. Fletcher is the Principal Investigator of *A biotechnology curriculum and teacher education project for high schools* (2004). Also, Dr. Fletcher is the Director of South Central Regional Bio-Link, part of a network of NSF-funded Bio-Link Centers out of the City College of San Francisco.

Year I outcomes to be evaluated for the FST project include: completion of the Competency Analysis Profile, creation of an articulated food science and technology curriculum with transfer agreements in place (2+2+2 system), completion of necessary training/licensing work by teachers, acquisition of supplies, student recruitment, and piloting of courses and modules. The core FST courses and programs to be evaluated include one middle school course, two high-school courses, the Food Technology AAS program at Dunwoody, and the degree options offered through the University of Minnesota and other institutions. Formative evaluation of the curriculum and teacher skills will include observation of the courses/ lessons and student assessments in relation to state and national academic standards, national professional development standards, Institute of Food Technologists standards, and career competencies identified in the Competency Analysis Profile. Evaluators will recommend additional training as needed.

Year II and III outcomes to be evaluated include trial implementation and continuous improvement of the courses and programs, as well as teacher skills. Quantitative evaluation will commence, centering on student enrollment, demographics and performance. Aspects of performance to be studied include attendance, credit attainment, program completion, grades, and test scores of FST students relative to non-participating, but demographically matched, students. The guiding question for the evaluation is whether the project purpose has been attained: to prepare greater numbers of more diverse students for advanced STEM coursework, post-secondary programs and careers in food science/technology or other disciplines.

Leadership/staffing to deliver outcomes: The Principal Investigator, Wendie Palazzo, is the Career and Technical Education Coordinator with Minneapolis Public Schools. She is a certified Quality Auditor and an experienced grant manager. She will ensure that evaluation findings are immediately applied to program development and will coordinate use of the district's recruitment and school choice system to feed students into the FST courses and programs. The co-Principal Investigators are Jonathan Keiser, Principal Science Instructor with Dunwoody College of Technology, and Karalyn Littlefield, Senior Research Food Scientist with General Mills. Keiser and Littlefield will oversee the quality of courses and programs developed. Keiser will ensure that the curriculum is pedagogically sound, using student-centered instruction and assessments. Littlefield will ensure that the curriculum is aligned with industry standards and embedded with authentic industry practices. Full bios of the PI and Co-PIs are provided. Other members of the FST planning team will assist in developing and piloting the courses and 2+2+2 degree programs, with leadership from the new Food Science Principal Instructor who will be hired initially with grant funds. Other key contact people include the following:

Shari Keivit, Cereal School Manager for General Mills, will continue to connect the project to company resources including guest speakers, externships/tours, and career opportunities.

Julie Tesch, Executive Director of the Minnesota Agricultural Education Leadership Council will continue to connect the project to her legislative and industry council – a who's who of Minnesota FST leaders.

Benjamin Leonard, Mill City Museum, and Dawn Cameron, Science Museum of Minnesota, will coordinate museum-developed teacher training and field learning programs into the FST education system.

Ann Hill Duin, Associate Dean of the College of Agricultural, Food and Environmental Sciences at the University of Minnesota, and Jessica Krueger, Transfer/Scholarship Coordinator, will facilitate involvement of University professors and development of transferable courses.

Why food science and technology? The rationale for selecting food as a focal point for STEM education is multi-faceted. The economy of Minneapolis – known as Mill City since the 1800s - was built on the strength of its food

industries. Today, food companies employ 53,000 Minnesotans and are adding approximately 371 jobs per year (State of MN, 2001). Governor Pawlenty's Biosciences Initiative is guaranteeing continued leadership through tax incentives to companies pioneering new products and technologies (State of MN, 2003). Minnesota also leads the Midwest in venture capital invested annually per capita (State of MN, 2a003).

At the same time, FST job opportunities are strong nationally and internationally. Demand for graduates of 4-year Food Science programs in the U.S. is 10-15% higher than the supply (University of Tennessee, 2004). Further, FST graduates who are world travelers can find employment opportunities with companies and research facilities in Australia, Canada, Denmark, Mauritius, New Zealand, Thailand and the UK.

Beyond the strength of career opportunities in FST, Minneapolis Public Schools is continually seeking ways to engage students in STEM coursework and to close the achievement gap between white students and students of color. The oft-discussed achievement gap is wider in STEM disciplines than in language arts. For example, 65% of African American students pass the state's basic skills writing test on the first attempt, compared to only 23% passing the math test on the first try (MDE, 2004). Failing to pass the state's basic skills tests on the first or second attempt impedes students' opportunity to pursue advanced STEM education since they must continue to enroll in courses focused on basic skills. The achievement gap is thus linked to reduced diversity in the STEM workforce.

Diversifying the pool of qualified workers in FST and other STEM industries requires intervention early in the educational process. For this reason, MPS volunteered to lead development of the FST system and related grants, in order to give more students real access to their college and career aspirations.

One strategy that is working to improve academic achievement in Minneapolis is the delivery of rigorous career and technical education programs. These programs combine traditional classroom instruction with hands-on learning opportunities linked to industry certifications and post-secondary credit. Students in such programs are more likely than non-participating counterparts to attend school regularly, graduate, and obtain post-secondary credit (Palazzo, 2003). Today's career and technical education programs thus bridge the gap between the students' *interest* in college, and the reality of preparing and paying for it.

Creating rigorous food courses is part of a larger strategy in Minneapolis to ramp up expectations in programs serving diverse groups of students. Before the proposed project, food courses had dwindling enrollment and respect. Aligning these courses to rigorous science and math standards, and showing that STEM learning can be fun, will give more students the skills to succeed in advanced coursework and careers. In addition, placement of food science content in Family and Consumer Science (FACS) courses supports sustainability of the system. Courses taught by vocationally-licensed teachers can receive Carl D. Perkins funds. Moreover, FACS teachers are trained to address the ethical side of food science: If we *can* make a product, *should* we, even if there are negative consequences?

Use of Learning Technologies: FST courses at MPS and Dunwoody will follow the model used in industry of about 50% hands-on learning. The portion of instruction taught in the lab or field will rely on industry process emulation to develop students' academic and career competencies. Classroom instruction will also rely on technology tools for data analysis, Web research, publishing and virtual field trips.

Assessment: In addition to state and national standardized testing, assessment of learning in the FST programs will be hands-on, allowing students to demonstrate competencies demanded in industry. This builds student confidence and employability skills while providing a basis for teachers to help students strengthen their testing skills.

Facilities, Resources and Institutional Commitment: Members of the FST planning group began working together in December of 2002. The group garnered two small grants to support early planning and training: one from the Minnesota Agricultural Education Leadership Council (\$5,000), and one from Campus Compact Consortium (\$10,000). These grants, along with investments of Carl D. Perkins funds, aided in development of pilot courses showing that lab-based food science lessons can attract diverse students and deliver STEM content at or above grade level. Project planners have also gathered focus group, industry and higher education input and participation. The expanded leadership group is preparing grants to NSF, the Campus Compact Consortium, and several corporations in order to build the system. Additional resources supporting progress to date include the following:

- Faculty members have already begun attending training with the Minnesota Agricultural Education Leadership Council (based at the U of MN), the University of Wisconsin, the Minnesota High Tech Council, MN-BIO, the Science Museum of Minnesota, Mill City Museum and General Mills.
- MPS and Dunwoody both have instructional kitchens that can be supplied at a reasonable cost to teach lab-based FST courses. One high school and one middle school are already fully supplied.
- Qualifying 11th and 12th graders may participate in the state-funded Post Secondary Enrollment Option. State-paid college credits will support accessibility and sustainability of the FST system. A full-time PSEO counselor works with students enrolled at Dunwoody to ensure that their college courses meet high school graduation requirements.
- Female FST students will be invited to join the High Tech Women's Society and the Women of Dunwoody club. In these groups, female STEM professionals and students provide support and mentoring to one another.

With evidence of strong interest from employers and students, Minneapolis FST partners feel comfortable in committing to long-term support of the proposed courses and programs. At the same time, the partners want to start the programs on a small scale to ensure achievement of qualitative and quantitative goals.

Broader Impacts

Responsiveness to current and future needs of business and industry for technicians: Dunwoody consulted with Cargill, General Mills, Land O' Lakes, and Schwann's in determining the demand for a Food Technology AAS program in the Minneapolis area. General Mills emerged as the major partner in this grant due to the company's willingness to contribute leadership, as well as its dominance in food technology hiring in the metropolitan area. Dunwoody reports that their graduates strongly prefer to take jobs in the metro area. Moreover, the number of graduates, in the beginning, is expected to be small (25 annually). GMI states that it would be able to hire this many qualified graduates each year, although students will be counseled on their full range of options.

To ensure portability of student skills, as well as diverse career opportunities, the FST planning group has identified companies to be consulted to complete the Competency Analysis Profile, to recruit students, and to keep the program up to date. These include: 3M, Aerotek Scientific, Archer Daniels Midland (ADM), Associated Milk Producers, Birds Eye, Bongard's Creameries, Cargill, Cass Clay Creamery, Crystal Farms, Ecolab, General Mills, Golden Plump, Hormel, Jenny O, Kellogg's, Land o' Lakes, LeSueur Cheese, Malt-o-Meal, Marigold Foods/Kemps, Old Home Foods, Schwann's, Sno Pac Foods, Sunnysfresh Foods, Target, the State of Minnesota, U.S. Department of Agriculture, U.S. Department of Homeland Security, and University of Minnesota Extension Service.

Enhancing the Status of Technician Education: Project planners conducted focus groups specifically to determine ways to raise esteem for FST education and careers. Without student and parent demand, even the best program will fail. In the focus groups, students and parents expressed a strong preference for a professional FST image, high-level academics, and hands-on learning. Conversely, respondents vehemently rejected food service images. An overriding concern was that a food-focused program would narrow the students' options. At the same time, a short tour of Dunwoody's baking center showed the enthusiasm generated by the hands-on FST learning environment.

Project planners will address these customer concerns by continuing to involve students and parents in program development. Marketing of the system will emphasize the skilled nature of FST professions and the high pay earned by technicians. Students may not want to continue their education uninterrupted from high school through a post-graduate degree, but FST marketing will emphasize the limitless nature of the fields. Students will be informed of pay rates at different exit points and will receive counseling and mentoring to make informed decisions.

Integration of science and technical education into the academic programs at participating schools: Dunwoody's Food Technology AAS program will be fully thematically integrated to explore food applications in communications, mathematics and social sciences. At the high school level, the FST courses will be integrated into the Smaller Learning Communities (SLCs). All students choose an SLC as incoming 9th graders, and may transfer to another SLC upon request. Half of the district's SLCs are career themed but provide a broad-based curriculum. Demand for the FST courses will determine whether MPS ultimately offers a food-oriented SLC. In any case, students will be encouraged to enroll in Dunwoody's AAS courses beginning in 11th grade.

Placement of the FST initiative in the Career and Technical Education Office with Minneapolis Public Schools allows for coordination of the project with other technical education activities. The PI will be positioned to expand the engineering dimension of the FST system to a third high school in Year II of the NSF project. Faculty at North High will offer the biotechnology module of the Project Lead The Way pre-engineering program. Rochester Institute of Technology will offer post-secondary credit for students completing these courses and passing qualifying tests.

Contributions to knowledge base on activities that enhance student learning; dissemination of results; usefulness to other communities; potential for improved content and pedagogical preparation of STEM faculty: This project contributes to the research base affirming the value of hands-on STEM pedagogies in educating diverse groups of students. The evaluation will examine the impact of the curriculum on student attendance, retention, achievement, post-secondary credit attainment, graduation and employment. The evaluation will also assess the quality of curricula developed, instruction and professional development. Evaluation reports will describe local economic and educational systems, project methods, student population, teacher qualifications, training experiences and in-kind contributions, such that other communities can adapt the program. The project will be of interest to communities wanting to develop or maintain a bioscience economy and the educational resources to support it. The project is also relevant to school districts that want to revolutionize Family and Consumer Science programs. More generally, the project is valuable to educators who are interested in closing the achievement gap.

Potential for development of products, plus plan for producing, marketing and distributing these products: The PIs, faculty and evaluators will produce reports and curricula and disseminate them at annual conferences of the Association of Career and Technical Educators, American Education Research Association, Institute of Food Technologists, National Science Teachers Association, Tech Prep Association and other organizations. Curricula and reports will be Web-published for free distribution, or distributed in print at cost.

Supplemental Materials

[Insert Dunwoody Marketing Piece as page 1]

Pre- and Post-tests: 14 Students Enrolled in Minneapolis Northeast Middle School Pilot Food Science Course

A pre-test and post-test was designed to determine how the pilot food science middle school curriculum, taught during school year 2003-2004, impacted student understanding of biotechnology and science concepts. The tests had 11 open-ended questions (example available upon request). An external reviewer used a four-point scale to assess students' responses. This scale shows a continuum of understanding from zero, reflecting no understanding of the concept, to three, reflecting a thorough understanding of the concept. The rater then interpreted overall raw scores using the following criteria. The highest possible score was a 33.

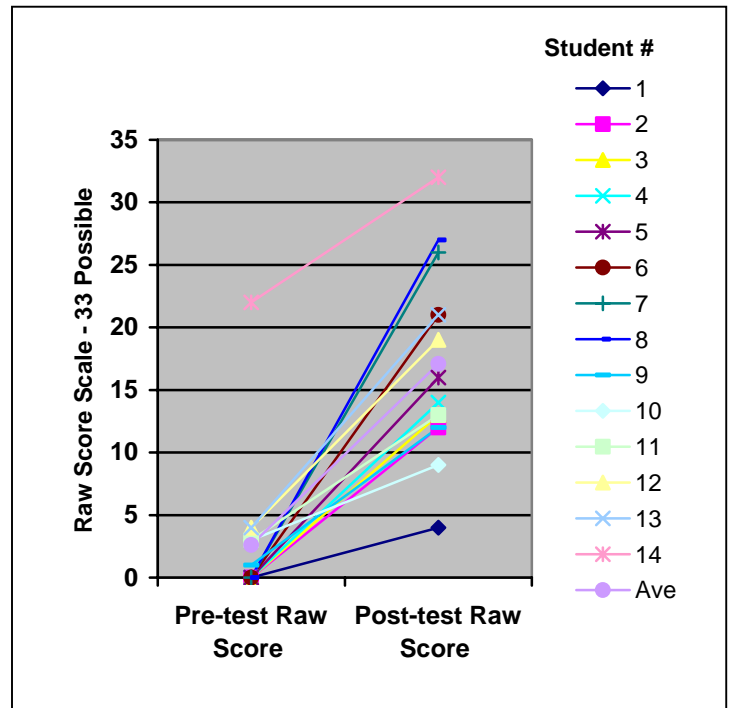
Overall raw score

- 0 - 8: little to no understanding
- 9 - 16: moderate, fair understanding
- 17 - 24: good, sound understanding
- 25 - 33: thorough, in-depth understanding

On the pre-test eight of the 14 students scored a zero; five students scored four or less; only one student showed anything more than a very minimal understanding of the concepts in question. The extreme lack of understanding of these fundamental science concepts, even at the most novice level, is a concern because it shows that the typical Minneapolis middle school student is almost devoid of basic science knowledge.

As one can see from the post-test data below all students improved their science knowledge, and 13 of the 14 students showed a dramatic improvement in their overall understanding of biotechnology and food science concepts. Seven students' post-test scores reflected a moderate to fair understanding, three students' scores reflected good and sound understanding, and three students' scores reflected a thorough and in-depth understanding of the targeted science concepts. The average overall raw score improved from 2.6, reflecting little or no understanding, to 17.1, reflecting a good and strong understanding of these vital concepts.

Student #	Pre-test Raw Score	Post-test Raw Score
1	0	4
2	0	12
3	0	13
4	0	14
5	0	16
6	0	21
7	0	26
8	0	27
9	1	12
10	3	9
11	3	13
12	4	19
13	4	21
14	22	32
Ave	2.6	17.1



From a qualitative perspective, students' post-test responses reflected a much more sophisticated understanding of the targeted biotechnology and food science concepts. Their answers contained more examples and were richer in detail. Most importantly, their responses tended to be constructed from their own thoughts rather than leaving questions blank, or providing simple, rote, memorized definitions.

Submitted by Jonathan Keiser, Sr. Science Instructor, Dunwoody College of Technology

More about Food Science and Technology Studies within a Comprehensive Middle School and High School Course of Study

Minneapolis students attend school within Smaller Learning Community programs. This model provides the support of a team of teachers to each student, and will allow the Food Science and Technology teachers to coordinate course content with science, math and communications teachers. Interested high school students will be counseled and supported in taking a course of study suitable for future pursuit of a college degree in a STEM discipline, including:

- Four years of math (Integrated Math Program or traditional math sequence)
- Four years of science including chemistry and physics
- Two years of foreign language
- Microsoft Office User certification

Methods of Instruction in the Food Science and Technology Courses

The teaching approach in the middle school and high school courses is to pose problems of relevance to the students about the major concepts covered in the class. Students will build on their prior knowledge through teacher-led instruction, research, inquiry, reasoning and reflective thought. Students will have labs or field learning experiences weekly (on average) to illustrate the science concepts and engage them in the coursework. Students work cooperatively on lab assignments.

Evaluation

Students will be assessed on all class assignments providing data for both formative and summative evaluation. Formative evaluation is used to determine students' progress and to inform instruction. Tools used are objective tests, teacher observation of lab procedures, records related to student participation in discussion and cooperative lab assignments, and analysis of examples of student work. A performance assessment will be used at the high school level to evaluate the students' design and conduct of a scientific investigation, based on state rubrics. Student work on other assignments will be evaluated through teacher and student developed rubrics. Grades will be based on completion and quality of all assignments, with each assignment receiving a specific number of points.

Standards Addressed in Food Science/Technology Courses

National Science Standards

Science as Inquiry: The student will identify questions that can be answered through scientific investigations; design and conduct a scientific investigation; use appropriate tools and techniques to gather, analyze, and interpret data; develop descriptions, explanations, predictions and models using evidence; think critically and logically to make the relationships between evidence and explanation; recognize and analyze alternative explanations and predictions; communicate scientific procedures and explanations; use mathematics in all aspects of scientific inquiry.

Physical Science: The student will understand properties and changes of properties in matter, and transfer of energy.

Life Science: The student will understand structure and function in living systems; reproduction and heredity; regulation and behavior; populations and ecosystems; diversity and adaptations of organisms.

Science and Technology: The student will identify appropriate problems for technological design; design a solution or product; implement a proposed design; evaluate completed technological designs or products; communicate the process of technological design.

Science in Personal and Social Perspectives: The student will understand the roles of science and technology in society.

History and Nature of Science: The student will understand science as a human endeavor; the nature of science; the history of science.

National Family and Consumer Science Standards

Consumer and Family Resources: The student will evaluate management practices related to human, economic and environment resources.

Food Production and Services: The student will integrate knowledge, skills and practices required for careers in food production and services.

Food Science, Dietetics and Nutrition: The student will integrate knowledge, skills and practices required for careers in food science, dietetics and nutrition.

Nutrition and Wellness: The student will demonstrate nutrition and wellness practices that enhance individual and family well-being.

MN Academic Standards - Science

Chemical Reactions: The student will differentiate between chemical and physical changes.

Energy Transformations: The student will understand that energy exists in many forms and can be transferred in many ways.

Scientific World View: The student will understand that science is a way of knowing about the world that is characterized by empirical criteria, logical argument and skeptical review.

Scientific Inquiry: The student will use multiple skills to design and conduct scientific investigations. The student will understand that scientific inquiry is used by scientists to investigate the natural world in systematic ways.

Scientific Enterprise: The student will know that science and technology are human efforts that both influence and are influenced by society.

Scientific Historical Perspectives: The student will understand how scientific discovery, culture, societal norms and technology have influenced one another in different time periods.

Cells: The student will understand that all organisms are composed of cells that carry on the many functions needed to sustain life.

Heredity: The student will understand that heredity information is contained in genes which are inherited through both sexual and asexual reproduction.

Biological Population Change Over Time: The student will understand how biological evolution provides a scientific explanation for the fossil record of ancient life forms, as well as for the striking similarities observed among the diverse species of living organisms.

Earth Structure and Processes: The student will investigate the impact humans have on the environment.

Interdependence of Life: Student will describe how the environment and interactions between organisms can affect the number and diversity of species in an ecosystem.

Career and Technical Education Approval Process

As an approved career and technical education program, the Food Science and Biotechnology courses:

- Are advised and evaluated with the help of a multi-sector partnership
- Link learners with school-based, work-based and connecting activities
- Include in-depth exposure to career applications of course content
- Assist students with career planning
- Identify and address key workplace competencies and national skill standards related to course content
- Prepare learners for college-level programs in related fields, including possible advanced placement
- Provide instruction in use of industry tools/equipment, including industry-specific safety instruction
- Maintain appropriate class size in relation to instructors and equipment
- Are designed to meet the varied learning needs of diverse groups of students, including supplemental instruction/learner support as needed
- Are taught by appropriately licensed career and technical education instructors
- Are evaluated and continually improved based on performance data in keeping with career and technical education program requirements

More about the University of Minnesota BS Options: Course Descriptions and Pre-requirements

MATH 1271 Calculus: 4 credits

Prerequisite: QP-=1142, =1211, =1251, =1351, =1551, 4 yrs high school math including trig or placement test or grade of at least C- in 1151; SP-=1142, =1371, =1571, 4 yrs high school math including trig or placement test or grade of at least C- in 1151 or 1155.

Differential calculus of functions of a single variable. Introduction to integral calculus of a single variable, separable differential equations. Applications: max-min, related rates, area, volume, arc-length.

MATH 1272 Calculus II: 4 credits

Prerequisite: QP-=1261, =1353, =1552; [1252 or equiv] with grade of at least C-; SP-=1372, =1572; [1271 or equiv] with grade of at least C-. Techniques of integration. Calculus involving transcendental functions, polar coordinates. Taylor polynomials, vectors/curves in space, cylindrical/spherical coordinates.

RHET 1101. Writing to Inform, Convince, and Persuade 4 credits

No prerequisites. Writing effectively in an academic setting. Emphasis on analyzing and creating logical arguments; standards of clarity, cohesion, and correctness. Readings and discussion of issues related to increasing cultural diversity of the United States.

RHET 1223. Oral Presentations in Professional Settings 3 credits

No prerequisites. Techniques for analyzing an audience, determining a purpose, developing an argument, and delivering a presentation. Emphasis on using presentations and basic communication theories.

RHET 3562. Technical and Professional Writing 4 credits

Prerequisite (QP-[EngC 1011 or 1101 or 1151 or equiv], jr; SP-[EngC 1011 or 1101 or 1152 or equiv], jr; A-F only)

Written/oral communication in professional settings. Gathering information, analyzing audience, assessing conventional formats. Drafting, testing, revising documents. Oral presentation of final reports.

Physics I and II: Select one of the following Physics Sequences. We prefer the 1301-1302 or the 1201-1202 sequences.

PHYS 1301 Introductory Physics I: 4 credits

Prerequisite: (QP-Math 1252 or Math 1352 or Math 1552H; SP-=Phys 1401; &Math 1271 or &Math 1371 or &Math 1571)

Use of fundamental principles to solve quantitative problems. Motion, forces, conservation principles, structure of matter. Applications to mechanical systems.

PHYS 1302. Introductory Physics II 4 credits

Prerequisite: (QP-1252, [Math 1261 or Math 1353 or Math 1553H]; SP-=1402; 1301, [&Math 1272 or &Math 1372 or &Math 1572])

Use of fundamental principles to solve quantitative problems. Motion, forces, conservation principles, fields, structure of matter. Applications to electromagnetic phenomena.

OR

PHYS 1201, General Physics I 5 credits

Prerequisites: (QP-[High school or college] calculus, trigonometry, algebra; SP-[High school or college] calculus, trigonometry, algebra). Fundamental principles of physics. Description of motion, forces, conservation principles, structure of matter. Applications to mechanical systems, including fluids, waves, heat. Lab.

PHYS 1202 General Physics II 5 credits

Prerequisites: (QP-1104, 1105; SP-1201). Fundamental principles of physics. Motion, forces, conservation

principles, structure of matter. Applications to electromagnetic phenomena, including optics, atomic structure. Lab.

OR

PHYS 1101 Fundamental Physics I 4 credits

Prerequisites: (QP-High school algebra, plane geometry, trigonometry; SP-High school algebra, plane geometry, trigonometry; primarily for students interested in technical areas). Fundamental principles of physics in the context of everyday world. Use of kinematics/dynamics principles and quantitative/qualitative problem solving techniques to understand natural phenomena. Lecture, recitation, lab.

PHYS 1102 Fundamental Physics II 4 credit

Prerequisites: (QP-1041; SP-1101; primarily for students interested in technical areas). Fundamental principles of physics in the context of everyday world. Use of conservation principles and quantitative/qualitative problem solving techniques to understand natural phenomena. Lecture, recitation, lab.

BIOL 1009 General Biology 4 credits

Prerequisite: (QP-high school chemistry, 1 term college chemistry recommended; SP-high school chemistry, 1 term college chemistry recommended). Introduction to major concepts of modern biology. Topics include molecular structure of living things, energy recruitment and utilization, flow of genetic information through organisms and populations, principles of inheritance, ecology, and evolution. Includes lab.

Either BIOC 3021 or BIOC 4331 and BIOC 4332

BIOC 3021 Biochemistry 3 credits

Prerequisites (QP-Biol 1009 or 1202, 8 cr organic chemistry; SP-Biol 3021; Biol 1002 or 1009, Chem 2301). Fundamentals of biochemistry including structure and function of proteins, nucleic acids, lipids and carbohydrates; metabolism and regulation of metabolism; quantitative treatments of chemical equilibria, enzyme catalysis and bioenergetics; the chemical basis of genetic information flow.

OR

BIOC 4331 Biochemistry I 4 credits

Prerequisites: (QP-[Biol 1009 or Biol 1202], two qtrs organic chemistry] or #; SP-[Biol 1002 or 1009], Chem 2302)

Advanced survey of structure/catalysis, metabolism/bioenergetics.

AND

BIOC 4332 Biochemistry II 4 credits.

Prerequisites: (QP-5332 or #; SP-4331 or #). Advanced survey of molecular biology, mechanisms of gene action, and biological regulation.

CHEM 1021. Chemical Principles I 4 credits

Prerequisite: (QP-Primarily for science or engineering majors; 1001 or passing placement exam; SP-Primarily for science or engineering majors; 1011 or passing placement exam). Atomic theory; periodic properties of elements; thermochemistry; reaction stoichiometry; behavior of gases, liquids, and solids; molecular and ionic structure and bonding; organic chemistry and polymers; energy sources and environmental issues related to energy use.

CHEM 1022 Chemical Principles II 4 credits

Prerequisite: (QP-1051 or equiv; SP-1021 or equiv). Chemical kinetics; radioactive decay; chemical

equilibrium; solutions; acids and bases; solubility; second law of thermodynamics; electrochemistry and corrosion; descriptive chemistry of the elements; coordination chemistry; biochemistry; applications of chemical principles to environmental problems.

CHEM 2301 Organic Chemistry I 3 credits

Prerequisites: (QP-1052 or equiv; SP-1022 or equiv). Important classes of organic compounds, their constitutions, configurations, and conformations and reactions; relationships between molecular structure and chemical reactivity/properties; spectroscopic characterization of organic molecules.

CHEM 2302 Organic Chemistry II 3 credits

Prerequisites: (QP-3301; SP-2301). Reactions, synthesis, and spectroscopic characterization of organic compounds, organic polymers, and biologically important classes of organic compounds such as lipids, carbohydrates, amino acids, peptides, proteins, and nucleic acids.

Select one of the following Laboratory Courses:

CHEM 2311 Organic Laboratory 4 credits

Prerequisites (QP-3302; SP-2302 or &2302). Lab techniques in synthesis, purification, and characterization of typical organic compounds.

FSCN 4612 Experimental Nutrition 2 credits

Prerequisites: FScN 3612, BIOC 3021, and STAT 3011. Laboratory experience in chemical and biochemical methods of analysis of nutritional status.

BIOC 4025 Laboratory in Biochemistry 2 credits

Prerequisites (QP-3021 or 5331; SP-3021 or 4331 or Biol 3021). Theory and principles of the fundamental techniques used in modern biochemistry laboratories as well as the practical use of these techniques during the laboratory part of the course.

CHEM 2111 Introductory Analytical Chemistry Lab 2 credits

Prerequisites (QP-5130; SP-2101 or &2101). Lab for 2101. High precision methods, acidimetry and complexometry, single and multicomponent analysis by spectrophotometry, analysis of mixtures by ion exchange and gas chromatography, enzymatic and rate methods.

STAT 3011. Introduction to statistical analysis. 4 credits

Prerequisite (QP=Two yrs high school math; SP=5021; two yrs high school math). Describing data/relationships. Discrete/continuous random variables. Sampling distributions. Confidence intervals. 1-/2-sample significance tests. Simple linear regression.

MICB 3301 Biology of Microorganisms 5 credits

Prerequisites: (QP=Biol 5013, =MicB 3103, =VPB 3103; BioC 3021 or Biol 5001 or BioC 5331 or #; SP=Biol 3301; [&Biol 1002, &Chem 2302] or [&Biol 1009, [&Biol 3021 or & Bioc 3021]]; A-F only). Taxonomy, anatomy, physiology, biochemistry, pathogenesis, immunology, ecology of microbes. Molecular structure in relation to bacterial function/disease. Includes lab.

FSCN 1102 Food: Safety, Risks, and Technology 3 credits

Prerequisites: None. Introduction to the inherent risks and safety of the food supply and the use of public policy and food technology to reduce or control those risks. The course will survey microbiological, chemical and environmental risks and government and industry controls used to ensure food safety including the new US Food Safety Initiative.

FSCN 1112 Principles of Nutrition 3 credits

Prerequisites: None. Introduction to nutrition: fundamental concepts, nutrient functions, human nutritional

requirements, food sources, evaluating nutrition information, food safety, role of nutrition in chronic diseases, nutrition policy, nutrition and the environment.

FSCN 3102 Introduction to Food Science 3 credits.

Prerequisites: CHEM 1022. Introduction to the composition and the chemical and physical properties of foods; interaction, reaction, and evaluation of foods due to formulation, processing and preparation.

FSCN 4111 Food Chemistry 3 credits

Prerequisites: BIOC 3021. Nature and chemical behavior of food constituents. The chemical changes of food components that occur during processing, storage and their effects on quality.

FSCN 4121 Food Microbiology and Fermentations 3 credits

Prerequisite: MICB 2032 or MICB 3301. Relationship of environment to occurrence, growth and survival of microorganisms in foods, methods of evaluation, general and species of importance, control of foodborne pathogens and spoilage organisms in foods and the use of microorganisms in food fermentations.

FSCN 4122 Laboratory Methods in food Microbiology and Fermentations 2 credits.

Prerequisites: Concurrent registration in FSCN 4121 required. Microbiological methods for analysis of foods, and the use of microorganisms for the production of foods.

FSCN 4131 Food Quality 3 credits

Prerequisites: FScN 4121 and FSCN 4111. Management systems applied in the processing and distribution of foods to insure food quality along with the information on food laws and regulations. Areas include quality Management, HACCP, Audits, Plant/Equipment design for Sanitation, Specifications, Recalls, SPC, and control Systems.

FSCN 4312 Food Analysis 4 credits

Prerequisites: FScN 4111, STAT 3011. Examination of the components in foods with analytical measurement as the primary focus. Chemical, physical and sensory techniques will be utilized to identify and characterize major and minor components in food systems.

FSCN 4331 Food Process Engineering I 3 credits

Prerequisites: Math 1272, Physics sequence completed. Specific applications of engineering principles (heat and mass transfer, kinetics, and thermodynamics, etc.) to unit operations in food production.

FSCN 4332 Food Process Engineering II 4 credits

Prerequisites: FScN 4331. Application and integration of engineering principles to unit operations used in food production, including equipment design and effects of processing on food quality (chemical and microbiological).

FScN 4xxx Food Science Elective with Capstone Option. Choose one of the following:

FSCN 4341 Sensory Evaluation of food quality 3 credits

Prerequisites: FScN 4131 STAT 3011. Fundamentals of sensory perception. Test designs and methods used in studying the sensory qualities of foods. Group project on matching the sensory and physical properties of a commercial product. Design a quality control system for microbiological, sensory and nutritional quality of the selected product.

FScN 4343 Processing of Dairy Products 3 credits

Prerequisites: FSCN 4111, 4121 and 4331. Demonstration and application of the basic concepts of food engineering and processing to the production of fluid, concentrated and dehydrated dairy products.

FSCN 4345 Flavor Technology 3 credits

Prerequisites FSCN 4111, 4331 and 4121. Flavor/off-flavor development in foods. Industrial production of food flavorings and their proper application to food systems.

FScN 4342 Properties of water in Foods 4 credits

Prerequisites FSCN 4331. Principles involved in processing, handling, and storage of frozen, dry and

intermediate moisture biological materials (foods, drugs, biologics) with emphasis on the physico-chemical properties of water in food.

FScN 4346 Regulatory, Biochemical and technological Basis for nutraceuticals, Functional Foods and Dietary Supplements 3 credits.

Prerequisites FScN 4111, 4121, 4122 and 4131. Overviews of the application of regulatory principles, food science and nutritional science to the development of nutraceuticals, functional foods and dietary supplements. Overview of the principles and processes necessary to evaluate and manufacture such products. Areas include scientific basis, technologies, legal requirements, animal and clinical evaluation, consumer usage versus need along with review of products available in the world markets with a focus on the United States. Special dietary products will be reviewed and evaluated including infant formula, weight control products, sports supplements and herbal based dietary products designed for a wide range of structure function claims. The course will serve as a capstone course through a group project in which the students will select a specific special dietary food or nutraceutical area, do a literature search on the target disease state the product is designed for, develop a prototype product and process and evaluate the critical microbiological criteria for GMPs.