INTEGRATION OF SCIENCE AND MATHEMATICS INTO HOME ECONOMICS TEACHING – A WAY TO IMPROVE THE QUALITY OF LEARNING?

Anna-Liisa Rauma
Riikka Himanen
Pertti Väisänen
University of Joensuu

The purpose of this study was to examine Finnish Home Economics (HE) teachers' Science and Mathematics integration practices and teaching practices in general. The data (n = 212) with a response rate of 41% was collected by a postal survey sent to 514 teachers belonging to the Finnish Federation of HE Teachers (N = 1030). The majority (74 – 94%) reported integrating Science and Mathematics into HE teaching. Mathematics was integrated into HE more often than the Natural Sciences. Chemistry, Biology and Microbiology were integrated "sometimes" and Physics "seldom". Integration usually occurred when explaining phenomena and the relationships between cause and effect. The results suggest that HE teachers' competence to integrate Science and Mathematics into HE was not sufficient; uncertainty and inadequate knowledge were considered as limiting factors. The main obstacles to the implementation of integration were lack of supporting material and time. The most important factor influencing teaching and its planning was the teacher's own opinion of the importance of certain content areas and elements of HE.

In the Science of Home Economics various phenomena, observations, and incidents are explained on the basis of both Behavioral and Natural Sciences (Darling, 1995; Davis, 1993; Richards, 2000; Yoo, 1999). Due to the expanse extent of the science on which it is based, the scope of the Home Economics in the curriculum of comprehensive school is also wide (National Core Curriculum for Basic Education, 2004). In the Finnish Home Economics curriculum, practical everyday management is emphasized and is an important part of a lesson's pedagogical content. In addition, the broad basis of Home Economics also provides the teacher with opportunities to orient pupils toward science education (Adey & Shayer, 1994; Kivilehto, 2002). Working methods of science education, such as project-type studying, experimentation and explaining phenomena by using models, are also suitable for application in Home Economics lessons since learning in this context has been strongly bound to practical action (Darling, 1995; Peterat & DeZwart, 1991). Food preparation is nearly always included in Home Economics lessons. When preparing food, the pupils have to measure, mix and usually also heat substances. Changing conditions allow pupils to follow reactions and make observations. A deeper understanding of reactions and phenomena require, however, that pupils master the basics of Chemistry, Biology and Physics. Therefore, it is also necessary that the teacher first masters the basics of these sciences and knows how to integrate the elements of these subjects into Home Economics teaching.

Integration has been defined as the organization of domains of teaching into wide units of knowledge where different substances assimilate. As a replacement for fragmented division of knowledge, the active searching for interface and nodes of different subjects and connecting them to each other is emphasized in order to support students to develop solid knowledge structure that exceeds borders of subjects and disciplines (Lederman & Niess, 1997). The need to integrate teaching in order to get high-quality learning has been justified from the very beginning of the last century (Czerniak, Weber, Sandman & Ahern, 1999), and the justification and reasons given have not changed much.

Interestingly, there is little data on the extent to which HE teachers integrate science into their teaching. A pilot study (Rauma & Väisänen, 2003) suggests that integrating Chemistry and Microbiology into Home Economics is not very common at least among Finnish HE teachers. The aim of this study was to find out Home Economics teachers' Science and Mathematics integrating practices in Finnish comprehensive schools. The study subject is relevant, since in Finland the National Board of Education launched a development program in Science and Mathematics (LUMA) in 1996 - 2002; the main idea was to raise the scientific and mathematical knowledge of Finnish pupils to the international level. The best assurance for high-quality learning was thought to be motivated and enthusiastic teachers who change their teaching methods and apply science in their teaching (LUMA Support Group, 2002).

The Aims of the Study

The purpose of the study was to examine Home Economics teachers' Science and Mathematics integration practices and teaching practices in general. Factors such as frequency and forms of the integration, Home Economics teachers' science learning experiences in pre-service training, self-assessed competence to integrate Science and Mathematics, and factors affecting and limiting the integration of Science and Mathematics into Home Economics were examined. In addition, it was examined whether different groups of HE teachers in regard to their integration practices could be identified.

Methods

The data was collected in 2003 by a self-administered questionnaire sent to 514 Home Economics teachers belonging to the Finnish Federation of Home Economics Teachers (N = 1030). By using a systematic random sampling technique every other teacher was chosen after a random starting point. The total number of respondents was 212 with a response rate of 41%. The sample represented well the population because any non-response bias was not found with respect to age (Chi Square = 3.430, $p = .843$) and distribution of residence (Chi Square = 8.151, $p = .086$) of the respondents.

The majority of questions were on Likert type five-point scales, also open-ended questions were used. The questionnaire was pre-tested, and it was possible to complete in a reasonable time. On the five-point scale questions, teachers were asked about their teaching practices and methods of teaching Home Economics (12 items), the frequency of deliberate integration of Home Economics and other subjects (12 items), the context of possible science education integration practices (6 items), their self-assessed competence to integrate Science and Mathematics into Home Economics (5 items) and factors affecting (10 items) and limiting (7 items) integration. The open-ended questions comprised of respondents' background variables, such as age, place of residence, university degree, major and minor subject of the degree, and work experience as a Home Economics teacher. They also included questions concerning respondents' science learning experiences, "How did you experience the instruction of Natural Sciences in your Teacher Education Program at the university?" and experiences of co-operation with Science teachers "Do you co-operate with Math and Science teachers in your instruction of Home Economics? If yes, with which subjects and what kind of co-operation?"

Statistical Analyses

The data was analyzed by using the following statistics. Chi Square Test was used to analyze the independence between the categorical variables. Correlational analyses were conducted to study the interrelations between the scale variables. Depending on the normality of the distribution of the dependent variables, Student's t-test for independent samples or Mann-Whitney U-Test (Z-statistic) were used to analyze the mean differences between groups of teachers. Principal Components Analysis was used to reduce the number of variables concerning teachers' reasons for integration and to detect a hidden structure in those variables. Finally, Cluster Analysis was undertaken to identify teachers who differ in their integration practices. The level of significance was set at $p < .05$. Internal reliability of the scales was measured by using Cronbach's alpha.

Results

Basic Characteristics of the Respondents

All respondents were females. The mean age of the respondents was 43 (range, 24 - 62). Table 1 summarizes other characteristics of the respondents with regard to their degree, minor subject, work experience, and participation in HE in-service training.

Table 1

Basic Characteristics of the Respondents (n = 212)

	n	%
Degree (n = 212)		
Master's Degree (Home Economics Teacher)	101	48
Bachelor's degree	107	51
Unqualified	4	2
Minor subjects (n = 91)		
Mathematics	14	15
Home Economics	12	13
Education	12	13
English	11	12
Other (e.g. History, Finnish language)	42	46
Work Experience as Home Economics Teacher (n = 210)		
0 - 5 years	45	21
6 - 10 years	37	18
11 - 20 years	69	33
Over 20 years	59	28
Participation in HE in-service training (n = 206)		
Basic courses (n = 205)	137	67
HE courses (n = 191)	38	20
Science or Mathematics in-service training (n = 206)	28	14

Home Economics Teachers' Science Experiences in Pre-Service Training

Teachers were asked to describe their science learning experiences in pre-service training by using an open-ended question. The question was analyzed by using both qualitative and quantitative content analysis. The teachers' answers (n = 167) were classified to neutral, negative and positive statements. More than half (59%) of the respondents reported of negative science learning experiences; 21% were positive and 20% neutral. Teachers complained that science education at the university level was too abstract and too far from the every-day life (40 answers/references). Natural Science classes in the curriculum was also complained to be too small (49 answers/references). *"Too theoretical, links between Home Economics and e.g. chemical reactions missing. Integration absent!"* (teacher number 140) *"Insufficient and distant = connection to Home Economics teaching unclear, how to make use of Science?"* (teacher number 117). These comments illustrate well the problem cited often concerning university teaching (Gallagher, 2000; Rauma & Väisänen, 2003; Vermunt & Verloop, 1999). Even though it is known that teaching can be very effective when it is linked to student's every-day life, this seems to be difficult for college teachers to put into practice.

Integration Practices

By using a five-point scale, the teachers were asked "How often do you deliberately integrate content of the following subjects into Home Economics?" (See Table 2).

Table 2
Frequency of deliberate integration of other disciplines into Home Economics (1 = never, 2 = rarely, 3 = now and then, 4 = often, 5 = all the time).

Discipline	Mean	Standard deviation	Median
Health education	3.67	0.90	4
Consumer education	3.10	0.95	3
Mathematics	2.95	0.93	3
Chemistry	2.79	0.84	3
Biology	2.79	0.87	3
Microbiology	2.78	1.03	3
Geography	2.63	0.84	3
History	2.40	0.83	2
English	2.30	0.89	2
Physics	2.14	0.89	2
Visual arts	2.12	0.83	2
Crafts	2.08	0.87	2

On average, teachers integrated most often health education into Home Economics (median 4). Consumer Science, Mathematics and science subjects, such as Chemistry, Biology, and Microbiology were integrated on average now and then (median 3). Other disciplines, such as History, English, Physics, Arts and crafts, were integrated on average seldom (median 2).

Also, teachers' self-assessed competence to integrate Science and Mathematics was asked by using a five-point scale (1 = no competence, 5 = excellent competence). Teachers assessed their competence being good (4) or excellent (5) as follow: Microbiology (25%), Mathematics (26%), Biology (18%), Chemistry (15%), Physics (4%). Sixty-two percentage of the teachers assessed that they are not at all competent (1) or they have a weak competence (2) to integrate Physics. Also the Physics curriculum was known poorly. Only 18% of the teachers had familiarized themselves with the Physics curriculum.

Integration frequency (1 = never, 5 = all the time) correlated positively with the amount of science education in pre-service education ($r = 0.39$, $p < .001$), teachers' self-assessed competence to integrate ($r = 0.55$, $p < .001$) and participation to in-service training ($t = -3.764$, $p < .001$). No connection was found between the integration frequency and the teachers' age, degree and science learning experiences. Reliability of the scale was good (Cronbach's alpha 0.86).

Teachers were asked about the context of integration science subjects and Mathematics using a five-point scale (1 = never, 5 = all the time). Integration took place most often when explaining phenomena and causal relations (mean = 3.6). Common contexts for integration were situations where Mathematical skills were needed (mean = 3.4) and where the teacher answered questions (mean = 3.4) or guided in practice (mean = 3.1). The rarest integration forms were teacher's demonstrations (mean = 2.9) and experimental cooking tests (mean = 2.3).

About half of the teachers co-operated with science teachers. Most often this happened with a Biology teacher (62 mentions), a Chemistry teacher (52 mentions), a Mathematics teacher (33 mentions) or a Physics teacher (15 mentions). The most general co-operation form was discussion, but teachers also had common courses and projects and they planned their teaching so that certain topics were taught simultaneously, in Chemistry and Home Economics, for example.

Teachers' reasons (ten alternative claims) for Science and Mathematics integration (See Table 3) were asked by using a five-point scale (1 = not at all, 5 = very much). Three most important reasons cited were: natural phenomena and laws help to understand everyday life (mean = 4.2), integration furthers illustration of matters and the wholeness of students' knowledge base (mean = 3.9).

Table 3
Factors Influencing on Integration (scale 1 – 5)

	Mean	SD	Median
a. The reasons for the ways of action are found from natural phenomena and laws (e.g., why yeast is added in lukewarm water when baking)	4.24	0.76	4
b. Integration furthers illustration of matters	3.86	0.74	4
c. Integration develops thinking and logical reasoning	3.83	0.79	4
d. Integration furthers the wholeness of students' knowledge base	3.83	0.87	4
e. Teacher's personal interest in the matter	3.81	0.86	4
f. Integration furthers the understanding of the phenomena related to Home Economics, which makes application of the knowledge into new situations possible	3.80	0.89	4
g. Teacher's personal depth of knowledge of Science and Math	3.62	0.94	4
h. Belief that integration increases pupils' motivation in learning	3.47	0.77	3
i. Belief that pupils are interested in Science	2.82	0.75	3
j. The national curriculum promotes the idea of integration	2.47	0.91	2.5

Principal components analysis with an orthogonal rotation (Varimax) was used to explore the factor structure of the items. Three principal components explaining 63% of the variance was extracted. The first principal component collected together *"Learning psychological reasons"* and explained 32% of the shared variance (Cronbach's alpha 0.84). This component was constructed of claims that described the usefulness of integration in fostering pupils' learning and cognitive skills (Table 4, items a, b, c, d, f and h). Teachers who emphasized learning psychological reasons assessed their ability to integrate being significantly better than that assessed by the teachers with lower integration ability ($r = 0.26$, $p < .001$).

The second principal component comprising claims e and g (See Table 3) was named *"Personal interests and capability"*. This principal component explained 16% of the shared variance (Cronbach's alpha 0.68). Teachers who were personally interested in integration were significantly younger than other teachers ($r = -0.26$, $p < .001$). They also had studied more Mathematics ($r = 0.28$, $p < .001$), had a better self-assessed ability to integrate Science and Mathematics ($r = 0.27$, $p < .001$) and had familiarized themselves significantly better with national curriculum of Science and Mathematics ($r = 0.17$, $p < .001$).

The third principal component included claims i and j (See Table 3) and was named *"Curricular reasons"*. It explained 15 % of the shared variance (Cronbach's alpha 0.49). Among teachers there were also those who integrated mainly because it was urged in the national curriculum.

Integration Inhibitors and Promoters

Among the factors limiting the use of integration as a teaching method were lack of material that supports integration (mean = 4.0), lack of time (mean = 3.9), insufficient content knowledge about Science and Mathematics (mean = 3.3), and experienced uncertainty (mean = 3.3) (See Table 4). Teachers' experienced uncertainty correlated inversely with the amount of Natural Sciences ($r = -0.28$, $p < .001$) and Mathematics ($r = -0.22$, $p < .01$) in the university curriculum, teachers' self-assessed ability to integrate Science ($r = -0.57$, $p < .001$) and their familiarization with Home Economics national curriculum ($r = -0.31$, $p < .001$). Also teachers who had not taken part in-service education were more uncertain about their ability (mean = 3.6) as compared to their counterparts (mean = 3.2) who had been active in it ($z = -2.359$, $p < .05$).

Table 4
Obstacles of Integration (scale 1–5)

Obstacle	Mean	SD	Median
a. Home Economics books for pupils and teachers lack material supporting integration	3.95	0.92	4
b. Lack of time in lessons	3.91	1.07	4
c. I feel uncertainty, because I think that I don't master the basics of Science and Math well enough	3.34	1.10	4
d. I do not have sufficient knowledge of subjects such as Science and Math, and of the connections among the subjects	3.32	1.18	4
e. Pupils are usually not interested in the scientific explanations of phenomena	2.30	0.98	2
f. I find it more meaningful to integrate other subjects than Science and Math into Home Economics	2.23	1.03	2
g. I do not think that the integration of Science and Math into Home Economics is important	1.91	0.92	2

Cluster analysis was used to figure out the characteristics of teachers who are more prone to use integration on their lessons. Two teacher groups were identified by using *K-Means* clustering (Dillon & Goldstein, 1984). A two cluster solution was chosen as the optimum solution based upon an adequate number of members in both cluster and the interpretability of the result. Table 5 illustrates the mean differences between the groups on the variables (standardized values) used in the cluster analysis. However, the observed significance levels are not exact and thus cannot automatically be interpreted as tests of the hypothesis that the cluster means are equal (Dillon & Goldstein, 1984).

Table 5
Final Cluster Centres (Z-scores) in Different Teacher Groups (n = 144)

Variables	Cluster 1 (n = 80)	Cluster 2 (n = 64)	F-value	p
Frequency of integration of Science and Math	0.31	-0.45	25.130	.000
The degree of studies in Science	0.30	-0.36	18.053	.000
The degree of studies in Math	0.35	-0.38	20.788	.000
Self-rated ability to integrate Science & Math	0.42	-0.51	36.874	.000
Familiarisation with curriculum of Science & Math	0.41	-0.47	35.603	.000
Teaching methods				
Modern student-centred methods	0.21	-0.33	11.626	.000
Ordinary student-centred methods	0.06	-0.07	0.586	.445
Teacher-centred methods	0.06	-0.11	0.863	.354
Factors Guiding Teaching				
The national curriculum	0.46	-0.78	80.762	.001
School's curriculum	0.27	-0.38	15.929	.001
Text books of HE	-0.18	0.28	7.748	.006
Teacher's own opinion of adequate HE content areas	-0.33	0.58	40.847	.001
HE content areas	-0.35	0.54	32.630	.001

Cluster 1 is comprised of teachers who favor integration as one of their teaching methods ("integration favors"). These teachers integrated Science and Mathematics more often (mean = 0.31) than the teachers in cluster 2 ("integration disfavors") who were not so prone to use this teaching method (mean = -0.45). The teachers in cluster 1 had also taken higher degrees of studies in Science and Mathematics and they considered their ability to integrate Science and Mathematics being better than their counterparts did in cluster 2. They also used more modern student-centered teaching methods (mean = 0.21) than those used by the teachers in cluster 2 (mean = -0.33). In addition, these teachers' teaching was guided more often by the national (mean = 0.46) and local curriculum (mean = 0.27) than that of the teachers in cluster 2 (mean = -0.78, and -0.38, respectively). Teachers in cluster 2 based their teaching more on textbooks (mean = 0.28) and on their own opinion of the importance of certain content areas of Home Economics teaching (mean = 0.58) as well as on the prevailing trends of Home Economics teaching (mean = 0.54).

Discussion

Results of the survey support the findings observed in the pilot study (Rauma & Väisänen, 2003). Despite the fact that Home Economics teachers sometimes integrate Science and Mathematics into Home Economics, the forms of integration in most cases are not developed or well planned beforehand. There are presumably several reasons for this practice. The number of Natural Science classes in the curriculum of Home Economics teacher education is minimal, which makes teachers uncertain about their ability to integrate. Finnish Home Economics textbooks do not contain experimental cooking and hence do not support the integration.

Teachers also complained about the science teaching methods used in their pre-service teacher training at university. This supports the ideas of Vermunt & Verloop (1999) about the inertness of knowledge. This means that knowledge domains acquired through education are often studied in isolation from one another and from the context of knowledge use and are therefore difficult to access. More than one third of Home Economics teachers were worried about high quality learning among their own pupils and as a consequence they favored Science integration in their teaching.

Despite the fact that there is little empirical research that supports the usefulness of integration (Czerniak, Weber, Sandman & Ahern, 1999; Pang & Good, 2000; Venville, Wallace, Rennie, & Malone, 1998), the results produced by general educational research and the contemporary interpretations of brain research support the integration of curriculum (Westbrook, 1998). Powerful knowledge base is constructed on the base of mutual relationships, learner's previous knowledge, misconceptions, meta-cognitive skills and emphasizing the connections between subjects (Biggs, 1999). Integration in science teaching experiments has also shown that integration increases motivation and interest towards Science and Mathematics as well as learning in general, and improves abilities of understanding, solving of problems and applying of knowledge (Meier, 1998).

This study also revealed that teachers who were more prone to integrate had studied Science more and consequently were more self-confident about their teaching. They also used more pupil-centered working methods and based their teaching more on both national and local curriculum. This result reflects the importance of pre-service training and gives us a reason to further develop university pedagogy. We should also use integration as a teaching method in university teaching. Teachers should also be provided with Home Economics textbooks with information on kitchen chemistry experiments. This would probably increase both teacher's motivation to integrate and pupil's motivation to learn (Land & Hannafin, 2000).

How well can these results be generalized to all Finnish Home Economics teachers at comprehensive schools? The response rate (41%) was not good, but the typical one for a postal survey. Non-response bias was not found with respect to age or province of residence. Selection bias is naturally possible, however, there were respondents (12%) who didn't integrate either Science or Mathematics into Home Economics. In addition, 20% of respondents said they did not see Science integration necessary. The respective amount for Mathematics was 54%.

Since Home Economics is such a multidisciplinary subject and since students choose their minor subjects according to their own preferences, any recommendations on students' preference to specialize can't be given in general. However, we can encourage Home Economics teachers to use different teaching methods including the integration method.

References

Adey, P., & Shayer, M. (1994). *Really raising standards: Cognitive interventions and academic achievement*. London: Routledge.

Biggs, J. (1999). *Teaching for quality learning at university. What the student does*. Buckingham: The Society for Research into Higher Education and Open University Press.

Darling, C. A. (1995). An evolving historical paradigm: from "home economics" to "family and consumer sciences". *Journal of Consumer Studies and Home Economics, 19,* 367-379.

Davis, M. L. (1993). Perspectives on home economics: Unity and identity. *Journal of Home Economics, 85,* 27-32.

Czerniak, C. M., Weber, W. B. Jr., Sandmann, A., & Ahern, J. (1999). A literature review of science and mathematics integration [Electronic Version]. *School Science and Mathematics 99,* 421-431.

Dillon, W. R., & Goldstein, M. (1984). *Multivariate analysis. Methods and applications*. New York: Wiley & Sons.

Gallagher, J. J. (2000). Teaching for understanding and application of Science knowledge [Electronic Version]. *School Science & Mathematics 10, 310 -318*.

Kivilehto, S. (2002). *"Miksi aina pitää ajatella?" Formaalista ajattelua kehittävät tehtävät kotitalouden leivonnan opetuksessa.* Helsingin yliopisto. Kotitalous- ja käsityötieteiden laitos. Licentiate's dissertation.

Land, S., & Hannafin, M. (2000). Student-centered learning environments. In D. Jonassen & S. Land (Eds.), *Theoretical foundations of learning environments* (pp 1-23). New Jersey: Lawrence Erblaum Associates, Inc.

Lederman, N. G., & Niess, M. L. (1997). Integrated, interdisciplinary, or thematic instruction? Is this a question or is it questionable semantics [Electronic Version]? *School Science and Mathematics, 97,* 57-59.

LUMA Support Group. (2002). *Finnish knowledge in mathematics and sciences in 2002: Final report of LUMA programme.* Retrieved February 21, 2006, from http://www.minedu.fi/minefu/education/luma/finn_knowhow.htm

Meier, S. L. (1998). Potential benefits and barriers to integration [Electronic Version]. *School Science and Mathematics, 98,* 438-447.

National Core Curriculum for Basic Education (2004). *National core curriculum for basic education intended for pupils subject to compulsory education*. Finnish National Board of Education. Vammalan Kirjapaino Oy, Vammala.

Pang, J. S., & Good, R. (2000). A review of the integration of science and mathematics: implications for further research [Electronic Version]. *School Science and Mathematics, 100,* 73-82.

Peterat, L., & DeZwart, M. L. (1991). Meaning of practical in home economics. *Research Forum* S*pring,* 57-59.

Rauma, A. L., & Väisänen, P. (2003). Encouraging a science orientation in home economics, *American Journal of Family and Consumer Sciences, 94,* 73-74.

Richards, M.V. (2000). The postmodern perspective on home economics history. *Journal of Family and Consumer Studies, 92*, 81-84.

Venville, G., Wallace, J., Rennie, L. J., & Malone, J. (1998). The integration of science, mathematics, and technology in a discipline-based culture [Electronic Version]. *School Science and Mathematics, 98*, 294-303.

Vermunt, J. D. & Verloop, N. (1999). Congruence and friction between learning and teaching. *Learning and Instruction, 9,* 257-280.

Westbrook, S. L. (1998). Examining the conceptual organization of students in an integrated algebra and physical science class [Electronic Version]. *School Science and Mathematics, 98,* 84-93.

Yoo, T. M. (1999). Critical examination of human ecology paradigm and critical Science paradigm as appropriate paradigms of home economics. *Journal of Asian regional Association for Home Economics, 6*, 1-9.

About the Authors

Dr. Anna-Liisa Rauma has a PhD in Clinical Nutrition from University of Kuopio, Finland. She is a Professor at University of Joensuu in Finland. Mrs. Riikka Himanen has a MEd in Home Economics from University of Joensuu, Finland, and she is a doctoral student at University of Joensuu. Dr. Pertti Väisänen has a PhD in Education from University of Joensuu, and he is a Professor at University of Joensuu in Finland.