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Niemelä, Mikko

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Subject matter specific curriculum integration: a quantitative study of finnish student teachers' integrative content knowledge

Mikko Niemelä

Faculty of Educational Sciences, University of Helsinki, Helsinki, Finland

ABSTRACT

Curriculum integration has recently stirred growing interest in educational discourses. New Finnish core curricula for basic education and for general upper secondary schools encourage and even obligate schools to integrate the curriculum. Integration has been deemed to be important, as the boundaries between school subjects have remained unnecessarily rigid. Integration is needed to construct a coherent structure for educational knowledge allowing for the study of broad-ranging topics crossing the subject boundaries. This paper is a piece of quantitative research based on a questionnaire completed by Finnish student teachers (N = 243) studying to teach a range of subjects in secondary schools (age groups 13–18). The questionnaire explored student teachers' readiness to generate integrative topics between subjects. Variables such as teaching experience or expertise in several subjects did not correlate with the readiness and the subject matter was found to be the main correlating variable. The results outlined in this paper indicate that subject specific differences exist in the potentiality of subjects to be integrated.

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Curriculum integration; subject teaching; pedagogical content knowledge; subject didactics

Introduction

Integration of the school curriculum has been an enduring topic in school development and education, and it has again received widespread international attention (see McPhail 2019). Generally, curriculum integration (CI) means bridge building between different school subjects or building an interdisciplinary curriculum with the objective of making learning more holistic and/or to increase curricular coherence. In the latest (2016) Finnish core curriculum for basic education (age groups 7–15) CI was made a compulsory part of curriculum enactment. The curriculum introduced multidisciplinary learning modules as a new element that integrates perspectives from school subjects (Finnish National Agency of Education 2016). Further, the new core curriculum for general upper secondary schools (age groups 16–18) encourages schools to design courses that integrate content from a range of subjects (Finnish National Agency of Education 2019).

CONTACT Mikko Niemelä mikko.a.niemela@helsinki.fi

At the same time, Finnish curricula are relatively subject divided in international comparison (Dussel 2020). Thus, the Finnish curricula are simultaneously strongly differentiated according to subject boundaries, and they address the need to integrate the subjects. This dichotomy reflects the long debate in Finnish curriculum development whether the curricula should be more subject oriented or integrated (Vitikka, Krokfors, and Rikabi 2016).

This paper is a study of Finnish student teachers' views on the potentiality of integrating the content of various school subjects. With multidisciplinary learning modules and integrated courses in mind, it is important to know if some subjects are more open to integration than others are and if certain subjects have more potential for being integrated with some subjects rather than others. Previous research has given cause to search for subject-specific differences (McPhail 2018). The research question for this study is:

- What content-specific differences do student teachers identify in the suitability of subjects to be integrated with other subjects?

The content of school subjects can be divided into topics. Many subjects share topics that can serve as integrative bridges allowing cognitive advancement for students (McPhail 2018). For example, technology is a topic that can be approached differently from the perspectives of the natural sciences, social studies or crafts. If cognitive advancement is expected, it would be hard to imagine how integration of various subjects could take place without some shared topic, which can be conceptual, contextual, or problem-based (Nikitina 2006). The research question here has been answered by studying student teachers' perceptions of topics connecting various school subjects.

Theoretically, CI is commonly presented as a continuum with isolated subjects at one end, and complete abandonment of subject boundaries at the other end. In between, several forms of collaboration between subjects can be found (Gresnigt et al. 2014). It is not necessary to see CI and school subjects as opposites. A subject-based curriculum both differentiates and integrates knowledge (Niemelä 2021). First, subjects are formed by drawing subject boundaries that differentiate one field of knowledge from others. This enables integrating the content of a subject within its boundaries. However, topics such as global pandemics or climate change remain shared between subjects. To enhance the study of wide-ranging topics, integration between subjects is needed, as well as enhancing the coherency of the curriculum as a whole and supporting the cognitive advancement across subject boundaries.

Most research on CI has focused on integrative projects searching for suitable pedagogical alternatives (McPhail 2018). The role of content in CI has received only marginal attention. Maton and Howard (2018) point to the knowledge blindness that has largely framed the research on CI. To address the lack of research on integrative knowledge in the framework of subject-based curriculum, this study developed a novel quantitative approach to investigate CI. This paper provides an overview of the integrative potential of wide range of subjects present in the core curricula of Finnish secondary schools. In general, the use of quantitative methodology in researching CI has been rare. As the methodological choices always allow specific findings (Shulman 2004), the focus on qualitative research has steered the attention of the studies to certain direction.

In the Finnish system, pupils in age groups 7 to 12 are taught by class teachers, who are teaching the majority of the subjects. In turn, age groups 13 to 18 are taught by subject teachers specialised in one or a few subjects. The focus of this study is on student teachers preparing to become subject teachers. Studies have shown that CI provides subject teachers with specific challenges (McPhail 2019; Niemelä and Tirri 2018). Researching student teachers provides a pre-service viewpoint on CI that will be valuable in teacher education. Further, this approach unfolds the views of future teachers educated at university following the curriculum reforms that placed new emphasis on CI. In addition, this study serves as an explorative pilot that can be further developed and expanded to investigate in-service teachers.

Integrating subject matter

Many theories of teaching acknowledge teachers' content knowledge as the foundation for successful teaching (see Gitomer and Zisk 2015). Two widely referred theories underline the role of content knowledge for professional subject teachers: Lee Shulman's (1987) theory of pedagogical content knowledge and Continental European subject didactics (Kansanen and Meri 1999). However, the function of teachers' content knowledge has been overlooked in the recent research into CI that has focused primarily on students' learning and the role of the teacher has mostly been seen as a facilitator of learning (McPhail 2019).

A common principle for these two theories is that teachers' subject matter knowledge is essential for successful teaching, but not sufficient in itself without pedagogical knowledge. This is the basic idea shared by both theories (Kansanen 2009). Having enough content knowledge enables flexible teaching with various groups of students and development of topic-specific pedagogical practices such as examples, metaphors, analogies, exercises, and activities. With Shulman's (1987) conceptualisation, successful teaching cannot be based solely on general pedagogical knowledge nor on content knowledge of subject matter. They need to be synthesised as pedagogical content knowledge. In turn, the core concept for subject didactics is the didactic relationship. It addresses how a teacher relates to the relationship between the student and the content. The latter relationship is manifested as studying. Thus, the didactic relationship refers to the diverse ways how the teacher steers the studying process, i.e. the students' relation to the content (Kansanen and Meri 1999).

Shulman's (1987) concept of pedagogical content knowledge is composed of seven major categories of a teacher's knowledge: 1) general pedagogical knowledge, 2) knowledge of learners, 3) knowledge of educational contexts, 4) knowledge of educational ends, purposes and values, 5) content knowledge, 6) curriculum knowledge, and 7) pedagogical content knowledge (see Ball, Thames, and Phelps 2008). Niemelä and Tirri (2018) expanded Shulman's conceptualisation to study CI and developed the concept of a teacher's integrative pedagogical knowledge to study the knowledge requirements CI brings for teachers. Here, the focus is on integrative content knowledge, which is a part of integrative pedagogical knowledge and refers to teacher's knowledge of the topics suitable for integration in various subjects.

CI is challenging for subject teachers because they have specialised in one or a few subjects. If a teacher does not have adequate content knowledge of the subjects to be integrated, teaching will be based on everyday knowledge and good quality pedagogy is unlikely to result. Therefore, student teachers' views of integrative topics was chosen as the area of interest for this study. However, integration of various subjects also requires many other aspects from teachers, such as collaboration skills, comprehensive understanding of the curriculum and awareness of the purpose of CI (Niemelä and Tirri 2018).

Further, the content of subjects consists of divergent forms of knowledge. Bernstein (2000) has divided educational knowledge into hierarchical and horizontal forms. The hierarchical form refers to the form of knowledge that builds cumulatively. To acquire hierarchical knowledge, it is necessary to begin from the elementary elements for understanding the higher levels. For example, one needs to know the concept of mass in physics before understanding gravitation. Hierarchical knowledge has a rigid structure and it aims at making generalisations. This form of knowledge is typical in the natural sciences. In turn, horizontal knowledge includes several specialised parallel languages. Learning a piece of a horizontal language does not presuppose deep preliminary knowledge. For example, one can understand the meaning of the fall of the Berlin Wall in history without deep knowledge of the Franco-Prussian War. The horizontal knowledge does not advance cumulatively, but via expansion.

Data and methods

A sample of the views of 243 student teachers studying in subject teacher education programmes at the University of x was collected twice, in February 2019 and February 2020 after a general lecture on CI. Participation in the study was voluntary and all participants remained anonymous. The study was not part of the official teacher education programme and it did not have an effect on students' academic success. According to the guidelines of the ethical committee of University of x, research design used in this study did not require an approval from the committee.

Scheduling the data collection after the lecture ensured that all respondents were aware of the meaning of CI. Each student teacher had studied certain disciplines as a major subject and then entered a subject teacher education programme to earn the formal teaching qualification for the major subject and for possible minor subjects (for an explanation of teacher education in Finland see e.g. Lavonen 2018). As 95% of the participating student teachers were in at least their fourth year of studying at university, they could be considered to be specialists well aware of the content of the subjects to be taught. Saloviita (2019) found that in general, Finnish student teachers in subject teacher education programmes are satisfied with the level of content knowledge for teaching that they achieved at university.

The major subjects of the participants are listed in Table 1. Some subjects taught at Finnish schools are missing, because it was not possible to study all the subjects as majors at the University of x. Some subjects, such as health education and ethics, are not usually major subjects. Furthermore, crafts and home economics have their own programmes and their student teachers do not participate in the general lectures. Some participants reported having information technology as a subject to be taught, but the study included only subjects that are mentioned in the two national curricula.

A questionnaire was designed to collect the data for this study. First, in addition to other background variables, the respondents selected the major and possible minor subjects they will teach. Then, they were asked to select how easy or difficult it was to

Table 1. Student teachers' readiness to generate integrative topics: divided by major subjects.

Major subject	n	M (SD)
Geography	7	3.4 (0.4)
History	13	3.2 (0.5)
Biology	12	3.1 (0.6)
Religion	34	3.0 (0.4)
Swedish	10	2.9 (0.4)
English	27	2.8 (0.3)
Chemistry	12	2.8 (0.4)
Other foreign languages	35	2.8 (0.6)
Mother tongue and literature	34	2.8 (0.4)
Physics	11	2.7 (0.5)
Mathematics	42	2.5 (0.5)
Total	243[a]	2.8 (0.5)

[a]Includes also a small number of psychology, philosophy, social studies and visual arts majors, which were deleted from the list for guaranteeing anonymity.

come up with topics that integrated their major subject with each of the 21 other subjects. The questionnaire comprised 22 subject-specific items on a four-point Likert scale (1 = 'Very difficult to generate', 2 = 'Difficult . . . ', 3 = 'Easy . . . ', 4 = 'Very easy . . . '). The item concerning students' own major subject was omitted in each case. The result was conceptualised as student teachers' readiness to generate integrative topics. It refers to how easy or difficult student teachers perceive it is to generate integrative topics between subjects. In this way, student teachers approximated the integrative content shared by the subjects.

Statistical analysis was undertaken in three stages. In the first stage, means and standard deviations were calculated for each subject. First, student teachers were placed in separate subject groups according to their majors (Table 1). Then, student teachers evaluated the integrative potential of subjects other than their major (Table 2). In addition, subjects were compared pairwise to reveal more specifically how easy or difficult it is to generate topics integrating certain subjects (Table 3). In the second stage, one-way analysis of variance was used to investigate the correlations of the background variables with student teachers' readiness to generate integrative topics. In the last stage, correlations between subjects were studied using exploratory factor analysis (Table 4).

Results

In the first stage, the integrative potential of subjects was studied from two directions: 1) student teachers' views on the integrative potential of other than their major subject, and 2) student teachers' views on the integrative potential of their major subject.

Table 1 mentions Swedish as a subject. In Table 2 it is referred to as the 'second national language'. Table 2 lists the means of how easy or difficult student teachers saw it as being to generate integrative topics between their major subjects with all other subjects.

Table 2. Student teachers' readiness to develop integrative topics between their major subjects with other subjects.

Non-major subject	*n*	*M* (SD)
History	230	3.2 (0.9)
Social studies	242	3.2 (0.8)
Geography	236	3.2 (0.7)
Visual arts	242	3.1 (0.8)
Mother tongue and literature	209	3.1 (0.8)
English	216	3.0 (0.7)
Home economics	243	3.0 (0.9)
Music	243	2.9 (0.9)
Health education	243	2.9 (0.8)
Ethics	243	2.9 (1.0)
Biology	231	2.8 (0.8)
Philosophy	241	2.8 (0.9)
Second national language	233	2.8 (0.9)
Religion	209	2.7 (0.9)
Other foreign languages	208	2.7 (0.9)
Psychology	241	2.6 (0.9)
Physics	232	2.6 (1.0)
Physical education	243	2.6 (0.9)
Chemistry	231	2.5 (1.0)
Crafts	243	2.5 (0.9)
Guidance counselling	243	2.4 (0.9)
Mathematics	201	2.4 (1.0)

To continue the analysis, a sum variable was formed by counting the mean of subject specific items for each respondent. The new variable shows the mean of 21 items measuring student teachers' readiness to generate integrative topics between their major subject and all other subjects. Thus, each respondent received a mean describing their general readiness to generate integrative topics.

Then, applying the sum variable, subject teachers' readiness to generate integrative topics were grouped according to their majors and listed in Table 1. The statistical significances of the differences between the means are discussed in the next section. Especially noteworthy for the analysis below is the low general readiness of students with mathematics majors and the high general readiness of students with geography, history, biology and religion majors.

Table 3 unpacks the results presented in Table 1. It shows subject-wise comparisons of student teachers' readiness to generate integrative topics connecting their majors with each other subject. Table 3 acts as a preliminary map revealing potential grounds for integrative bridges between specific subjects.

Subjects to be taught correlate strongly with student teachers' readiness to integrate

One-way analysis of variation was used to study the correlation of general readiness to integrate with background variables: 1) age, 2) gender, 3) teaching experience, 4) number of subjects to be taught, 5) study year, 6) major subject, and 7) second subject to be taught. Before conducting the analysis, the normal distribution of the sum variable was investigated. The Kolmogorov-Smirnov test ($p = .003$) disproved the hypothesis of the normal distribution. However, when the skewness and kurtosis were examined in more

Table 3. Student teachers' readiness to integrate their major subjects with each other subject: M (SD).

Major subjects											
Subjects to be integrated with	Geography	History	Biology	Religion	Swedish	English	Chemistry	Other foreign languages	Mother tongue and literature	Physics	Mathematics
History	3.7 (0.5)	–	3.2 (0.7)	3.8 (0.5)	3.2 (0.6)	3.3 (0.7)	3.3 (0.7)	3.3 (0.8)	3.6 (0.6)	3.4 (0.7)	2.2 (0.8)
Social studies	3.7 (0.5)	4.0 (0.0)	3.2 (0.7)	3.6 (0.5)	3.3 (0.7)	3.2 (0.6)	2.9 (0.7)	3.1 (0.9)	3.4 (0.7)	2.9 (1.0)	2.6 (0.8)
Geography	–	3.6 (0.7)	3.7 (0.7)	3.4 (0.7)	3.2 (0.6)	3.0 (0.7)	3.2 (0.8)	3.3 (0.7)	2.9 (0.6)	3.4 (0.7)	3.0 (0.6)
Visual arts	3.6 (0.5)	3.5 (0.5)	3.2 (0.6)	3.7 (0.5)	3.3 (0.7)	2.6 (0.8)	2.9 (0.8)	3.1 (0.8)	3.3 (0.7)	2.1 (0.8)	3.1 (0.7)
Mother tongue and literature	3.6 (0.5)	3.9 (0.4)	3.3 (0.8)	3.3 (0.6)	3.4 (0.5)	3.5 (0.6)	3.1 (0.7)	3.1 (0.7)	–	3.0 (0.8)	2.2 (0.8)
English	3.3 (0.5)	3.6 (0.7)	3.3 (0.7)	3.0 (0.7)	3.6 (0.5)	–	2.9 (0.7)	3.3 (0.6)	3.1 (0.5)	3.1 (0.7)	2.4 (0.8)
Home economics	3.4 (1.1)	2.8 (0.8)	3.2 (0.7)	3.1 (1.0)	3.5 (0.5)	2.9 (0.8)	3.8 (0.4)	3.3 (0.8)	2.5 (0.8)	2.4 (1.1)	2.8 (0.8)
Music	3.4 (0.8)	3.2 (0.6)	2.3 (0.8)	3.4 (0.6)	3.5 (0.7)	3.1 (0.8)	1.8 (0.8)	3.2 (0.8)	2.8 (0.9)	3.3 (0.6)	2.5 (0.8)
Health education	3.6 (0.8)	2.7 (0.9)	3.8 (0.6)	2.9 (0.7)	2.7 (0.7)	2.9 (0.7)	3.3 (0.5)	2.7 (0.9)	3.0 (0.6)	2.7 (0.9)	2.5 (0.8)
Ethics	3.3 (1.0)	3.9 (0.4)	2.8 (0.8)	3.8 (0.4)	2.8 (0.9)	3.0 (0.6)	1.8 (0.7)	2.8 (0.9)	3.2 (0.4)	2.0 (0.8)	1.8 (0.6)
Biology	3.9 (0.4)	2.7 (0.9)	–	2.8 (0.8)	2.6 (0.7)	2.7 (0.7)	3.8 (0.4)	2.4 (0.8)	2.6 (0.6)	3.1 (0.7)	3.0 (0.6)
Philosophy	3.1 (0.7)	3.5 (0.7)	2.7 (1.1)	3.6 (0.5)	2.4 (0.8)	2.9 (0.8)	2.6 (1.0)	2.6 (1.0)	3.1 (0.7)	2.2 (0.9)	2.2 (0.9)
Second national language	2.7 (0.7)	3.5 (0.5)	3.1 (0.8)	2.7 (0.9)	–	3.3 (0.7)	2.6 (0.7)	3.1 (0.7)	3.1 (0.6)	2.0 (1.1)	2.1 (0.8)
Religion	3.4 (0.8)	3.9 (0.4)	2.5 (0.7)	–	2.9 (0.9)	3.0 (0.6)	1.8 (0.9)	3.0 (0.8)	3.3 (0.4)	2.1 (1.0)	1.8 (0.7)
Other foreign languages	3.0 (0.6)	3.1 (1.0)	2.8 (0.9)	2.6 (0.9)	3.5 (0.5)	3.4 (0.6)	2.2 (0.6)	–	3.1 (0.6)	2.1 (1.1)	2.1 (0.8)
Psychology	3.0 (0.6)	2.9 (0.9)	3.2 (0.7)	3.3 (0.6)	2.5 (0.9)	2.6 (0.6)	2.0 (1.0)	2.1 (0.9)	3.0 (0.7)	1.7 (0.5)	2.1 (0.8)
Physics	3.6 (0.5)	2.9 (0.9)	3.3 (0.7)	1.8 (0.6)	2.0 (0.5)	2.3 (0.5)	3.7 (0.5)	2.1 (0.8)	1.9 (0.8)	–	3.6 (0.5)
Physical education	3.6 (0.5)	2.5 (1.1)	3.0 (1.0)	2.3 (0.9)	3.1 (0.9)	2.6 (0.8)	2.2 (0.7)	2.8 (0.9)	2.2 (0.9)	2.7 (0.8)	2.6 (0.9)
Chemistry	3.4 (0.8)	2.6 (1.0)	3.7 (0.7)	1.7 (0.6)	2.0 (0.5)	2.3 (0.6)	–	2.1 (0.8)	1.9 (0.8)	3.7 (0.5)	3.5 (0.7)
Crafts	2.7 (0.8)	2.9 (1.0)	2.7 (1.0)	2.8 (0.9)	2.8 (0.9)	2.1 (0.7)	2.6 (1.0)	2.4 (0.9)	2.1 (0.9)	2.6 (0.8)	2.6 (0.9)
Guidance counselling	3.0 (0.6)	2.5 (1.0)	2.8 (0.9)	2.4 (0.9)	2.5 (0.7)	2.5 (0.6)	2.9 (0.7)	2.2 (0.8)	2.6 (0.9)	2.6 (1.1)	1.9 (0.8)
Mathematics	3.1 (0.7)	2.6 (0.8)	3.2 (0.8)	1.9 (0.8)	2.3 (0.5)	2.3 (0.7)	3.8 (0.5)	2.1 (0.9)	1.8 (0.7)	3.9 (0.3)	–
n	7	13	12	34	10	27	12	35	34	11	42

Table 4. Factor loadings and extraction communalities.

	1 Human sciences	2 Mathematics and natural sciences	3 Languages	4 Artistic and practical subjects	h^2
Ethics	**.913**	−.163	.021	−.041	.833
Psychology	**.820**	.177	−.064	−.113	.557
Philosophy	**.799**	.071	−.073	.000	.586
Social studies	**.726**	.024	−.057	.119	.588
History	**.709**	−.127	.025	.128	.634
Religion	**.629**	−.141	.196	−.052	.548
Health education	**.431**	.382	.071	.067	.443
Chemistry	−.111	**.857**	−.046	.010	.750
Physics	−.110	**.856**	−.100	.025	.762
Mathematics	−.061	**.710**	.136	−.018	.520
Biology	.268	**.637**	−.093	.058	.505
Guidance counselling	.319	**.367**	.217	−.012	.369
Second national language	−.099	−.070	**.885**	.063	.727
English	−0.28	−.011	**.812**	.080	.686
Other foreign languages	−.039	.028	**.808**	−.016	.615
Mother tongue and literature	.336	.012	**.610**	−.142	.616
Home economics	−.138	.045	.100	**.742**	.544
Crafts	.035	.144	−.077	**.671**	.542
Visual arts	.300	−.127	−.161	**.636**	.538
Physical education	−.146	.206	.089	**.630**	.513
Music	.248	−.214	.016	**.544**	.452
Geography	.135	.136	.154	**.425**	.430

detail, they did not have values more than 3.29 times their standard error, which allows for the null hypothesis of sufficient normal distribution with medium-sized samples to be sustained (Kim 2013). Therefore, parametric analysis methods were used.

The analysis revealed that teaching experience or the number of subjects to be taught did not correlate statistically significantly with the readiness to generate integrative topics. The result is counter-intuitive, as one could expect more teaching experience to provide more ideas about shared topics. Similarly, expertise on a wider group of subjects would be a reason to expect one to see more linkages between them. Neither study year nor gender had a statistically significant correlation. However, major subject, second subject and age did have statistically significant correlations. Next, analysis of these three variables is examined more closely.

First, one-way analysis of variance was used to examine subject-wise differences in readiness to integrate students' *major subject* with other subjects. Students perceived significant differences between subjects ($F(10, 226) = 4.416$, $p < .001$, $\eta^2 = .163$). According to Cohen's (1988) parameters, the effect size was found to be large, thus showing that readiness to generate integrative topics correlates strongly with the major subjects. Equality of variances was assured with Levene's test ($p = .545$). Then, Bonferroni's post hoc test was used to study the differences in variance between subject groups in more detail. It showed that statistically significant differences can be found between student teachers majoring in mathematics and four other groups, which are student teachers majoring in geography ($p = .001$), biology ($p = .015$), history ($p < .001$) and religion ($p = .003$).

Second, student teachers' readiness to integrate was studied from the perspective of their *second subject* to be taught. One-way analysis of variance showed that also the second subject correlated in a statistically significant way with the readiness to generate integrative topics ($F(16, 145) = 1.779$, $p < .039$, $\eta^2 = .164$), however post hoc tests did not reveal any statistically significant subject specific differences. Again, the effect size was large.

Third, one-way analysis of variance between *age groups* shows that there are significant differences ($F(3, 238) = 4.402$, $p = .005$, $\eta^2 = .053$). However, when the composition of the age groups was studied, it revealed that the division of major subjects between age groups is not equal. Younger age groups include more mathematics student teachers who were previously revealed as being a group having a significant effect on the results. When mathematics student teachers were eliminated from the analysis, the result was no longer statistically significant. Therefore, it can be assumed that in this study, the differences in readiness to integrate between age groups were largely due to their different major subjects.

Four subject groups

Finally, an exploratory factor analysis was conducted to study how the integrative potential of various subjects is correlated according to the student teachers. The latent factor dimensions reveal if student teachers' readiness to integrate their major subject with some subject correlates with readiness to integrate the major subject with other subjects i.e. if there are groups of subjects that integrate in the same direction. For example, when chemistry is integrated with another subject, the result enables it to be reasoned that there are many topics touching physics as well. Overall, the factors describe the groups of subjects sharing integrative topics. The factor model creates a generalised picture of the results presented in Table 3.

The exploratory factor analysis included all 22 subject items used in the survey. Communalities visible in Table 4 were found to be above .3 for all items. The Kaiser-Meyer-Olkin test result was .856 and the result of Bartlett's test of sphericity was that it was significant ($p < .001$). Therefore, the factor matrix was proved to be acceptable. The analysis was conducted with Principal Axis Factoring extraction, because not all items were normally distributed. Promax rotation was used to allow for correlations between groups of subjects. The analysis revealed four underlying factors exceeding Eigenvalue 1, explaining 65% of the variance cumulatively. The factors and their loadings are presented in Table 4. All four factors had high values for Cronbach's Alpha presented in Table 5. No significant increase in the Alpha values would have been achieved by dropping some items, nor it would have been theoretically sound to leave out some subjects. Table 5 also shows the correlations between factors.

Table 5. Alpha loadings and correlations among the factors.

Factors	α	1	2	3	4
1 Human sciences	.90	–			
2 Mathematics and natural sciences	.86	.02	–		
3 Languages	.90	.55	.08	–	
4 Artistic and practical subjects	.82	.53	.43	.38	–

The four factors were labelled as 1) Human sciences, 2) Mathematics and natural sciences, 3) Languages, and 4) Artistic and practical subjects. The four-factor model corresponds well with the common way to group subjects in the Finnish curricula (Saloviita 2019). This result confirms the categorisation as having internal rationale or reflects how students are well socialised to think through these categories.

Three subjects require distinctive attention: heath education, guidance counselling, and geography. Health education loaded relatively equally to two factors and guidance counselling to three factors. These two subjects do not fall easily into any subject group. Health education is an integrative subject sharing perspectives from human and natural sciences. In the factor model, health education had loadings for both dimensions. In turn, guidance counselling is a special type of subject with a focus on general study skills and career planning. The role of geography will be discussed in the next section.

Discussion

The main conclusion of this paper is that according to the student teachers, CI is subject matter specific. The variance of student teachers' readiness to generate integrative topics did not correlate in a statistically significant way with any variables other than with the subjects the student teachers were going to teach. Therefore, when curriculum is integrated, it is essential to pay attention to what content is being integrated. The conclusion corresponds well with the frameworks of pedagogical content knowledge and subject didactics that point to the important role of content knowledge in teaching.

The most obvious subject specific result indicates that mathematics is a challenging subject from the perspective of CI. However, it is noteworthy to acknowledge that low perceived integrative potential does not mean that mathematics would in any sense be worse than other subjects. Instead, the results show that in the case of mathematics, particular attention must be paid to the subjects it is integrated with. The factor analysis grouped mathematics with the natural sciences with which mathematics shares many boundary crossing opportunities.

Table 5 shows that mathematics and the natural sciences do not really correlate with any other factor except with artistic and practical subjects. This result gives support for integration within the so-called STEAM subjects (Science, Technology, Engineering, Art, and Mathematics), which has recently been a popular grouping of subjects (Perignat and Katz-Buonincontro 2019). However, as Table 3 shows, student teachers undertaking biology, chemistry, and physics majors located many shared topics with history. Although students undertaking history majors did not see these connections as strongly, adding history to a STEAM collaboration could provide an opportunity to overcome the traditional dichotomy between the human sciences and the natural sciences.

Another subject that needs to be discussed is geography, which is the only subject that had positive loadings with all factors. Thus, as also Table 3 shows, geography was found to be a subject that has high potential to be integrated with almost all other subjects. This can explain geography's unexpected place in the factor model. These results provide a reason to consider if geography as a subject could serve a special integrative role. Geography, which includes perspectives from natural and cultural geography, has been traditionally close to biology in Finnish schools (Tani 2014). However, in the factor model, biology is grouped with mathematics and the natural sciences. As shown in Table 3, student teachers undertaking biology majors located as many shared topics with chemistry as with geography. Thus, it is worth asking if biology should be more directly connected with chemistry in addition to its traditional partnership with geography.

Overall, the variation between the subjects can be explained by: 1) students' socialisation to different disciplinary cultures, and 2) differences in the forms of knowledge. Ylijoki (2000) has studied the territories of the academic tribes in Finnish university life. Students can be seen as novices in the academic disciplines internalising what are seen as the vices and virtues in the tribe. The tribal culture may direct the students to see appropriate opportunities for integration with some subjects rather than others. In addition, student teachers are socialised into the various teaching traditions, which set their boundary conditions to integrative collaboration (Sund, Gericke, and Bladh 2020).

Further, the variations between the subjects can also be explained with the differences in the forms of knowledge present in the subject matter. The factor model adheres well with Bernstein's (2000) division between hierarchical and horizontal forms of knowledge. The factor titled 'mathematics and natural sciences' collects disciplines organised in accordance with the hierarchical form of knowledge. Bernstein breaks horizontal knowledge further into two sub-forms: knowledge with strong and weak grammars. Knowledge with a strong grammar refers to fields able to produce precise descriptions and formal modelling. In the factor model, the 'languages' group includes subjects following the strongest grammar, 'human sciences' grammar with medium strength, and 'artistic and practical subjects' the weakest grammar. The weaker the grammar is, the more context dependent and subjective the form of knowledge is. A tendency in the results is that subjects with a horizontal knowledge structure and especially with medium or weak grammar, such as geography, history, visual arts and home economics, are perceived as having high integrative potential, although exceptions can also be seen. In some cases, the context specificity of a weak grammar subject, such as crafts and physical education, may make the content less relevant outside its own sphere, thus limiting its integrative potential.

This research focused on investigating student teachers' integrative content knowledge. It is important to acknowledge the difference between disciplinary knowledge and teachers' content knowledge for teaching (Ball, Thames, and Phelps 2008). It is beyond the scope of this study to examine what potential for integration the subjects might have in themselves as abstract entities. For teaching, how the teachers experience the subjects and their potential for integration is essential, although student teachers' assumptions about subjects' integrative potential can change after they have implemented integrative teaching (Kallunki, Karppinen, and Komulainen 2017).

As noted above, researching CI using quantitative methods has been rare. Therefore, certain perspectives of CI have remain understudied, as different methodological choices allow different sides of a phenomenon to be examined (Shulman 2004). In this study, the methodological approach allowed for an overview of integrative potential to be established of a wide range of subjects in the two Finnish secondary core curricula. What this study gains in its breadth, it loses in depth. The results remain indicative, and they need to be reflected on with caution. However, what the results indicate is worth noting, as this study has grasped the whole subject structure of Finnish secondary schools and the effect sizes of the results are large.

Qualitative studies have focused in more detail on attempts to integrate a few subjects (see e.g. Kallunki, Karppinen, and Komulainen 2017). They can reveal special characteristics of what certain subjects bring to integration and what potential specific pedagogical solutions have. The results of this study can be used to design further studies to test if certain subjects have more potential to be integrated with each other than with some other subjects. One way to bring this study further forward would be to investigate what topics the subjects are sharing. Starr and Krajcik (1990) have proposed the creation of concept maps as instruments for differentiating and integrating conceptual content knowledge and arranging it as a hierarchic curricular structure. In addition, mapping the topics shared by subjects could be used as a tool in teacher education and in curriculum design for integrating subject matter both within and between the subjects.

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References

Ball, Deborah Loewenberg, Mark Hoover Thames, and Geoffrey Phelps. 2008. "Content Knowledge for Teaching: What Makes It Special?" *Journal of Teacher Education* 59 (5): 389–407. doi:10.1177/0022487108324554.

Bernstein, Basil. 2000. *Pedagogy, Symbolic Control and Identity: Theory, Research, Critique*. 2nd ed. Lanham: Rowman & Littlefield.

Cohen, Jacob. 1988. *Statistical Power Analysis for the Behavioral Sciences*. 2nd ed. Hillsdale: Lawrence Erlbaum.

Dussel, Inés. 2020. "The Shifting Boundaries of School Subjects in Contemporary Curriculum Reforms." *Zeitschrift Für Pädagogik* 66 (5): 666–689.

Finnish National Agency of Education. 2016. *National Core Curriculum for Basic Education*. Helsinki: Finnish National Agency of Education.

Finnish National Agency of Education. 2019. *Lukion Opetussuunnitelman Perusteet [National Core Curriculum for General Upper Secondary Schools]*. Helsinki: Finnish National Agency of Education.

Gitomer, Drew H., and Robert C. Zisk. 2015. "Knowing What Teachers Know." *Review of Research in Education* 39 (1): 1–53. doi:10.3102/0091732X14557001.

Gresnigt, Rens, Ruurd Taconis, Hanno van Keulen, Koeno Gravemeijer, and Liesbeth Baartman. 2014. "Promoting Science and Technology in Primary Education: A Review of Integrated Curricula." *Studies in Science Education* 50 (1): 47–84. doi:10.1080/03057267.2013.877694.

Kallunki, Veera, Seija Karppinen, and Kauko Komulainen. 2017. "Becoming Animated When Teaching Physics, Crafts and Drama Together: A Multidisciplinary Course for Student-Teachers." *Journal of Education for Teaching* 43 (1): 32–47. doi:10.1080/02607476.2016.1182373.

Kansanen, Pertti. 2009. "Subject-Matter Didactics as a Central Knowledge Base for Teachers, or Should It Be Called Pedagogical Content Knowledge?" *Pedagogy, Culture and Society* 17 (1): 29–39. doi:10.1080/14681360902742845.

Kansanen, Pertti, and Matti Meri. 1999. "The Didactic Relation in the Teaching-Studying-Learning Process." In *Didaktik/Fachdidaktik as the Science(-s) of the Teaching Profession?* edited by Brian Hudson, Friedrich Buchberger, Pertti Kansanen, and Helmut Seel, 107–16. Umeå: Thematic Network of Teacher Education in Europe.

Kim, Hae-Young. 2013. "Statistical Notes for Clinical Researchers: Assessing Normal Distribution (2) Using Skewness and Kurtosis." *Restorative Dentistry & Endodontics* 38 (1): 52–54. doi:10.5395/rde.2013.38.1.52.

Lavonen, Jari. 2018. "Educating Professional Teachers in Finland through the Continuous Improvement of Teacher Education Programmes." In *Contemporary Pedagogies in Teacher Education and Development*, edited by Yehudith Weinberger and Zipora Libman, 3–22. London: IntechOpen. doi:10.5772/intechopen.77979.

Maton, Karl, and Sarah K. Howard. 2018. "Taking Autonomy Tours: A Key to Integrative Knowledge-Building." *LCT Centre Occasional Paper* 1 (June): 1–35.

McPhail, Graham. 2018. "Curriculum Integration in the Senior Secondary School: A Case Study in A National Assessment Context." *Journal of Curriculum Studies* 50 (1): 1–21. doi:10.1080/00220272.2017.1386234.

McPhail, Graham. 2019. "Curriculum Integration in Flexible Learning Environments, Challenges for Teachers, and Teacher Education." In *Encyclopedia of Teacher Education*, edited by Michael A. Peters. Singapore: Springer https://link.springer.com/referenceworkentry/10.1007/978-981-13-1179-6_369-1#howtocite. doi:10.1007/978-981-13-1179-6_369-1.

Niemelä, Mikko A., and Kirsi Tirri. 2018. "Teachers' Knowledge of Curriculum Integration: A Current Challenge for Finnish Subject Teachers." In *Contemporary Pedagogies in Teacher Education and Development*, edited by Yehudith Weinberger and Zipora Libman, 119–132. London: IntechOpen. doi:10.5772/intechopen.75870.

Niemelä, Mikko A. 2021. "Crossing Curricular Boundaries for Powerful Knowledge." *Curriculum Journal* 32 (2): 359–375. doi:10.1002/curj.77.

Nikitina, Svetlana. 2006. "Three Strategies for Interdisciplinary Teaching: Contextualizing, Conceptualizing, and Problem-Centring." *Journal of Curriculum Studies* 38 (3): 251–271. doi:10.1080/00220270500422632.

Perignat, Elaine, and Jen Katz-Buonincontro. 2019. "STEAM in Practice and Research: An Integrative Literature Review." *Thinking Skills and Creativity* 31: 31–43. doi:10.1016/j.tsc.2018.10.002.

Saloviita, Timo. 2019. "Outcomes of Teacher Education in Finland: Subject Teachers Compared with Primary Teachers." *Journal of Education for Teaching* 45 (3): 322–334. doi:10.1080/09589236.2019.1599504.

Shulman, Lee S. 1987. "Knowledge and Teaching: Foundations of the New Reform." *Harvard Educational Review* 57 (1): 1–23. doi:10.17763/haer.57.1.j463w79r56455411.

Shulman, Lee S. 2004. "Disciplines of Inquiry in Education: A New Overview." In *The Wisdom of Practice*, edited by Suzanne M Wilson, 276–307. San Francisco: Jossey-Bass.

Starr, Mary L., and Joseph S. Krajcik. 1990. "Concept Maps as a Heuristic for Science Curriculum Development: Toward Improvement in Process and Product." *Journal of Research in Science Teaching* 27 (10): 987–1000. doi:10.1002/tea.3660271007.

Sund, Per, Niklas Gericke, and Gabriel Bladh. 2020. "Educational Content in Cross-Curricular ESE Teaching and A Model to Discern Teacher's Teaching Traditions." *Journal of Education for Sustainable Development* 14 (1): 78–97. doi:10.1177/0973408220930706.

Tani, Sirpa. 2014. "Geography in the Finnish School Curriculum: Part of the Success Story?" *International Research in Geographical and Environmental Education* 23 (1): 90–101. doi:10.1080/10382046.2013.858457.

Vitikka, Erja, Leena Krokfors, and Leila Rikabi. 2016. "The Finnish National Core Curriculum: Design and Development." In *Miracle of Education: The Principles and Practices of Teaching and Learning in Finnish Schools*, edited by Hannele Niemi, Auli Toom, and Arto Kallioniemi, 83–90. 2nd ed. Rotterdam: Sense Publishers.

Ylijoki, Oili-Helena. 2000. "Disciplinary Cultures and the Moral Order of Studying - A Case-Study of Four Finnish University Departments." *Higher Education* 39 (3): 339–362. doi:10.1023/A:1003920230873.