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Analysis of TPACK Self-Efficacy Perception Levels of Social Studies Teachers and Pre-Service Teachers

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Abstract

The purpose of this research is to examine the self-efficacy technological pedagogical and content knowledge (TPACK) of the social studies teachers and pre-service teachers. TPACK scale which is developed by the researcher in this respect is applied to 113 social studies teachers and 919 social studies pre-service teachers. The method of the research has been patterned by the monitoring method. In accordance with the obtained data, the consistency index values are found by calculation of structural equity path coefficients (path analysis). The data has been classified with SPSS program and has been analyzed with AMOS (Analyses of Moment Structures) program. In the study, while the relation level between other components and the technological knowledge teachers and pre-service teachers are seen in low and middle level, the relation level between the content knowledge and pedagogical knowledge has been found in higher level. Consequently, the necessity has occurred for the integration of the technological pedagogical and content knowledge of the social studies teachers and pre-service teachers with each other.

Key words: TPACK, Social Studies, Technology, Pedagogy

Introduction

The rapid changes and developments in the knowledge and communication technologies in our day which we named as knowledge area reflect on the education. The individual has to use the technology efficiently for keeping up with this change and development (Kurt, 2013). Turkey which is not indifferent to this issue has started Increasing Opportunities in Education and Technology Reformation Movement (FATİH) project with the cooperation of Ministry of National Education and Ministry of Communication. The technological pedagogical and content knowledge perception which is presented by Mishra and Koehler (2006) in this respect has been united with technology and education has been tried to be more efficient by being integrated within education processes.

Theoretical Framework: TPACK

The components of technological, pedagogical and content knowledge consists of seven components as technological knowledge, pedagogical knowledge, content knowledge, technological pedagogical knowledge, technological content knowledge, content pedagogical knowledge and technological pedagogical content knowledge.

Technology Knowledge (TK): Technology with the widest meaning has been identified as the changes made by the humans on the nature for their needs (Pearson & Young, 2002). When consider the technology in terms of education, Kurt (2013) has showed the efficient usage of the software tools like operating system, computer hardware, word processors, spreadsheet programs, web browser and e-mail in addition to book, chalk and blackboard. The technologies which are developed in present oblige the technology usage skills of the teachers (Koehler & Mishra, 2009). The constant change of the technology causes the changing of the nature of the technology (Mishra & Koehler, 2005; Yigit, 2014).

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Content Knowledge (CK): Mishra and Koehler (2006) have explained the content knowledge as expressing the knowledge which takes part in this content and the knowledge to be taught in this content. The content knowledge is the knowledge which is given to the student through courses. The knowledge content of the course which is taught shall be known in outstanding level in this respect (Kurt et al., 2013).

Pedagogical Knowledge (PK): Harris et al. (2009) has identified the pedagogical knowledge as the knowledge of the method of teaching a subject. Yelken et al. (2013) have explained the pedagogical knowledge as the subjects like learning, evaluation of learning, development practices, course planning, class management, regulation the class environment and intramural communication. Saltan (2013), identifies this subject as the course designs which are in conformity with the cognitive levels, development level, learning types and interest of the student groups during the course process. Incekapı (2013) considers pedagogical knowledge as knowing how to teach a course

Pedagogical content knowledge (PCK): PCK idea was first presented by Shulman (1986). Pedagogical content knowledge is related with the teaching method of a specific content, the types of the education strategies. PCK, is the education with different strategies, method and techniques for each subject (Mishra & Koehler, 2006). PCK is the combination of the pedagogy and content and the implementation of them. PCK is the knowledge of, showing how to teach any subject to the student in a specific discipline (Cox & Graham, 2009; Jimoiannis, 2010; Yigit, 2014). There is strong relation between the pedagogy and content knowledge. This relation shows us to teach each subject with different teaching strategies (Sahin, 2011).

Technological and Content Knowledge (TCK): TCK is the knowledge about the integration of technology with content. The teachers need to know the new technological applications as well as the subjects to be taught (Mishra & Koehler, 2006). Kılıç (2013), defines the technological content knowledge as a knowledge type which is associated with each other. The technological content knowledge is to know the conformity of the new technology to the teaching at the same time. We have to know which subject is in conformity with which technology (Kurt et al., 2013). The teacher must know to select the appropriate technology for enriching the content of the course because a technology which does not conform to its purpose is ineffective in reintegrating the terminal behavior.

Technological and Pedagogical Knowledge (TPK): TPK occur from the integration of the technology and formation knowledge (Mishra & Koehler, 2006). Kılıç (2013), expresses that there are different technologies used in teaching and learning environment and to know their specialities. This knowledge can also be expressed as the usage method of the technology in teaching environment (Yurdakul & Odabası, 2013). A teacher can have technological knowledge but we cannot consider education efficiency in efficient level when he cannot integrate this with the pedagogical knowledge in education environment. One of the reasons of the failure of many educations given with technology does not know how to give technology with pedagogy (Bozkurt et al., 2013).

Technological, Pedagogical and Content Knowledge (TPACK): TPACK is the knowledge which consists of the components of technology, pedagogy and content knowledge. This knowledge is different from the general pedagogical knowledge which is used by the teacher, from the technology which needs a specific expertise, discipline. TPACK establishes the base of a good teaching with technology (Mishra & Koehler, 2006). As mentioned in Figure 1, TPACK is an integration which is formed by the technology pedagogy and content knowledge. However TPACK shall be considered as a situation which is used in the education environment at the same time. In other words, to teach a subject, a course by using technology, does mean that the teacher uses TPACK (Kurt, 2013). Technology pedagogy and content knowledge shall not be given as independent from each other but shall be given as integration (Sahin, 2011).

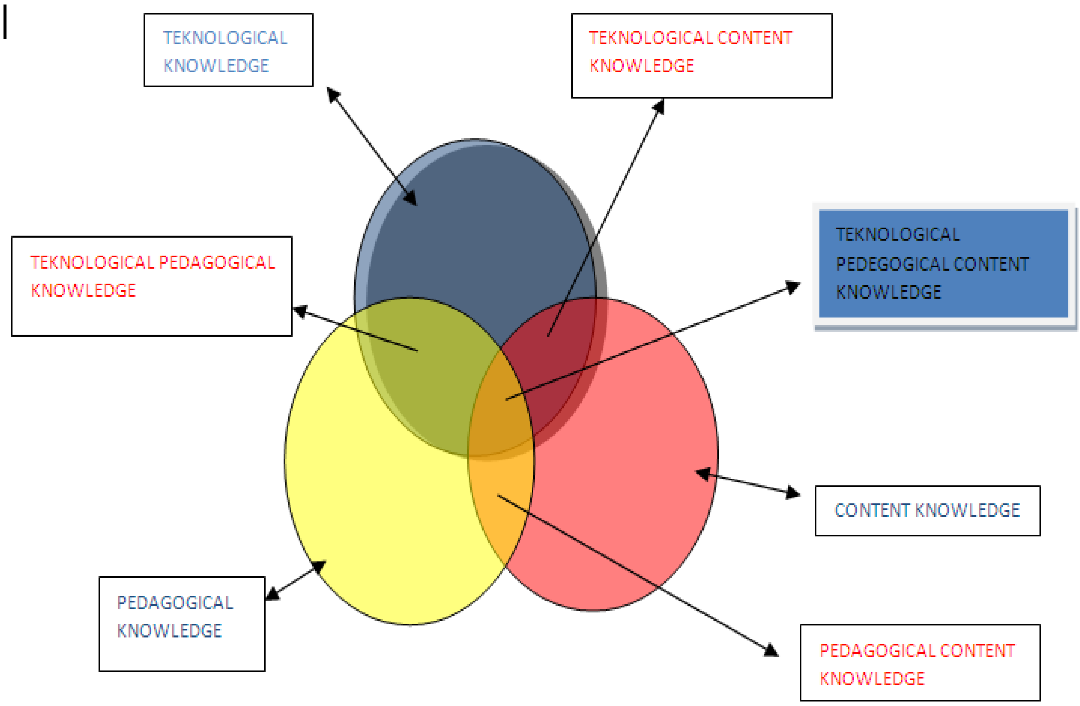

Figure 1. Technological, Pedagogical and Content Knowledge Components

This study is made for determining TPAB levels of teachers and pre-service teachers of social studies. As different from other studies, it is a study which is specific for social sciences content. The scale which is developed by the researcher is prepared only for determining the TPACK level of the teachers and pre-service teachers of social studies. Answers are searched for the below questions in this respect.

1. What kind of a relation are there between the perception of the social studies teachers to technological, pedagogical and content knowledge components?
2. What kind of a relation are there between the perception of the social studies pre-service teachers to technological, pedagogical and content knowledge components?

Method

This section of the research mentions the model of the research, nature/sample, sampling type, data collection tools, analysis and commenting the data.

Model of the research

By using TPACK model in this research, it is aimed to examine the technological pedagogical and content knowledge level of the pre-service teachers of social studies in faculty of education and social studies teachers working in secondary schools. This study is patterned by using monitoring model.

Participants

Sampling.1 (Application 1 – pre-service teachers): This study is carried out in all regions of our country. The nature of the pre-service teachers is formed by the fourth grade students in social studies education in whole faculty of education in our country. Our sampling group consists of 919 pre-service teachers in total who are selected by the nature based sampling method.

Sampling.2 (Application 2 - teachers): the nature of the teacher consists of the social studies teachers working within the body of Konya Provincial National Education Directorate. The sampling of the research is carried out by 113 teachers who are selected from this nature.

Data Collection Tools

Accordingly, seven sizes have been determined in the scale which is issued by the researcher (Akman, 2014; Akman & Guven, 2015). These are; size of technological knowledge (TK), pedagogical knowledge size (PK), size of content knowledge (CK), size of pedagogical and content knowledge (PCK), size of technological and pedagogical knowledge (TPK), size of technological and content knowledge (TCK), size of technological, pedagogical and content knowledge (TPACK).

The scale which is issued has been formed in the type of five points Likert scale. 1-2-3-4-5 numbers are located across the articles of the scales. Respectively the numbers are given the meaning as; I do not know, I know in low level, I know in middle level, I know in good level, I know in very good level. Validity and reliability studies are made for the obtained data. According to the reliability studies made, the reliability coefficient of Alpha Cronbach of the scale has been found as 0.977. Affirmative factor analyses are made on the obtained data.

Data Collection and Application: The data of the study is collected from the teachers and pre-service teachers. The scale which is distributed for being applied to the teachers is 230 and the collected scale is 120. However, some teachers have marked the scale without reading so seven of them are deducted and the data collected from 113 teachers is taken as a basis. The feedback rate in pre-service teachers is seventy percent (distributed scale: 1450; collected: 1113). However, some teachers have marked the scale without reading so 919 of them are taken to evaluation.

Data Analysis

According to results, the consistency index values are found by calculation of structural equity path coefficients (path analysis). The data has been classified with SPSS program and has been analysed with AMOS (Analyses of Moment Structures) program. In this study, structural equity model is used in order to determine factors and their relations and it is found how those relations are conformed with real data.

There are some index types which are confronted regularly in literature. These are: X^2/df, CFI, RMSEA, GFI, AGFI, NFI, NNFI, SRMR indexes (Karademir & Erten, 2013; Karademir & Erten, 2014).

Table 1.Criterion references for fit indices of linear factor analysis

Index Types	χ^2 / df	*RMR*	*GFI*	*CFI*	*RMSEA*
Index Values	1,398	0,038	0,853	0,918	0,050
Perfect fit	< 3	0 ≤ RMR ≤ 0,05	0,95≤GFI≤1	0,97≤ CFI ≤ 1	0≤ RMSEA ≤ 0,05
Acceptable fit	< 5	0,05 ≤ RMR ≤ 0,10	0,90≤GFI≤0,95 veya 0,80≤GFI≤0,89	0,90≤CFI≤0,95 veya 0,80≤GFI≤0,89	0,05≤ RMSEA ≤ 0,10

Results

In this section of the research, structural equity model outputs are mentioned for understanding the relation level between teachers and pre-service teachers and TPACK components.

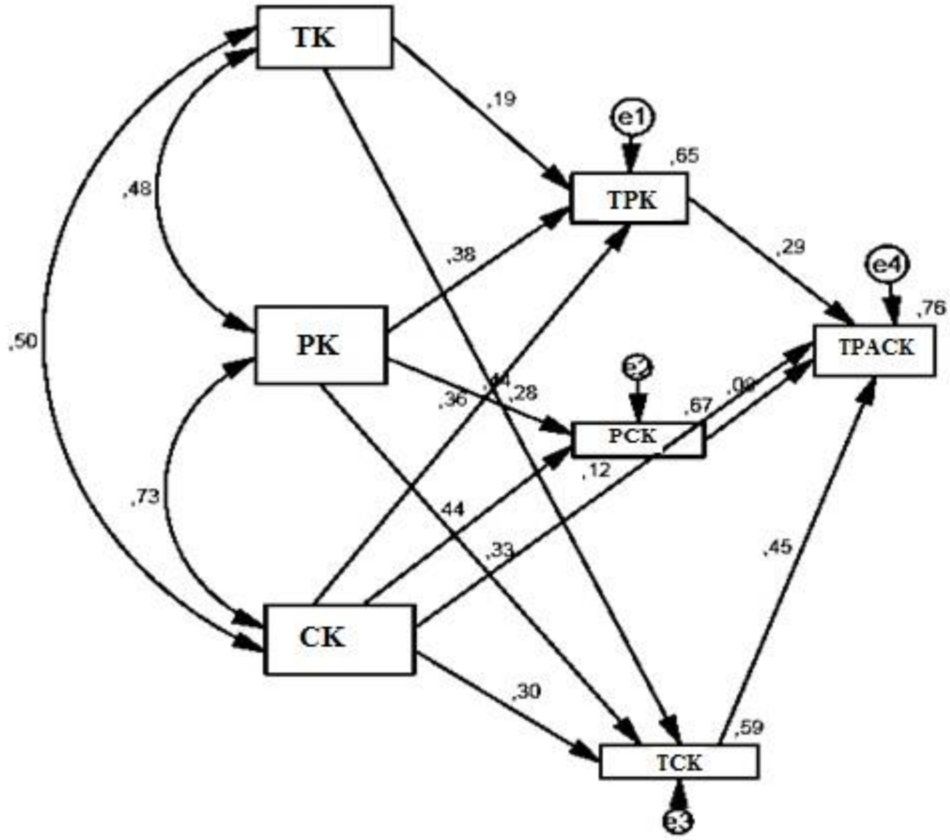

Figure 1. Findings showing the relation between the structural equity model and technological pedagogical content knowledge of the teachers

Fit Index Values: X2/df: 0.249, N: 113, RMSEA: 0.056, RMR: 0.149, GFI: 0.997, AGFI: 0.982, NFI: 0.998

The structural equation model outputs made with the teacher data related with TPACK are mentioned in Figure 1. Accordingly; it is determined that the adaptive value is in the acceptable level. Accordingly; there is medium level relation between the TK and CK (r=0.50), a medium level relation between TK and PK (r=0.48), there is high level relation between PK and CK (r=0.73). There is no direct relation between TPK and CK but there is low level direct relation between TPK and CK (β=0.33). There is very low relation between TK and TPK (β=0.19), low level relation between PK and TPK (β=0.38). The explanation percentage of TPK relation between these two factors is R^2=0.65. So 65 % of the TPK perception is explained by the TK and PK. There is a low level relation between PK and PCK (β=0.28). A medium level relation is detected between CK and PCK (β=0.44). The explanation percentage of PCK between these two factors is R^2= 0.67. So 67 % of the PCK perception is explained by the PK and CK. There is a low level relation between the TK and TCK (β=0.30) and a higher relation is detected between TK and TCK (β=0.44). The explanation percentage of TCK between these two factors is R^2=0.59. So 59 % of the TCK perception is explained by the TK and CK. There is a low level relation between TPK and CK (β=0.29), there is a very low relation between PCK and TPACK (β=0.08) and there is medium relation between TCK and TPACK (β=0.45). The explanation percentage of TPACK between these three factors is R^2=0.76. So 76 % of the TPACK perception is explained by these three factors. In figure 2, structural equity model and findings related with the pre-service teachers are mentioned.

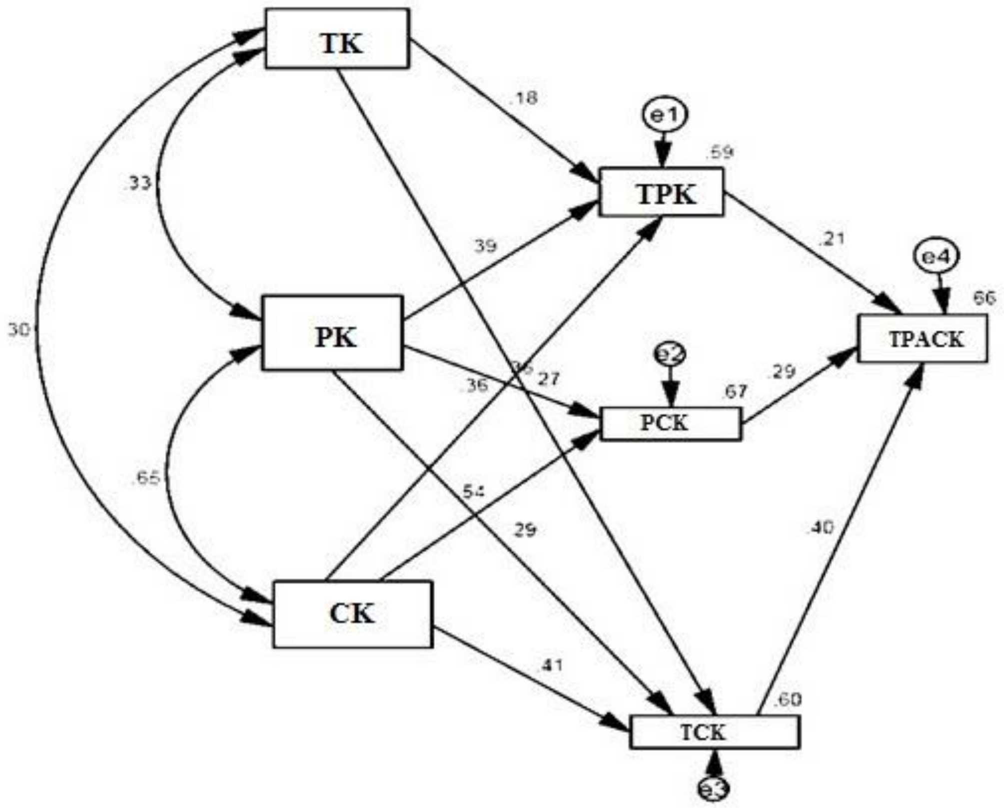

Figure 2. Findings showing the relation between the components of technological pedagogical content knowledge of pre-service teachers with structural equity model.

Fit Index Values: X2/df: 0.922, N: 919, RMSEA: 0.054, RMR: 0.84, GFI: 0.999, AGFI: 0.992, NFI: 1.00

The structural equation modelling outputs made with pre-service teachers related with TPACK are mentioned in figure 2. Accordingly it is detected that the adaptive values are in the acceptable level. Accordingly there is low level relation between TK and CK (r=0.30), there is higher relation between TK and PK (r=0.33) and there is a higher relation between PK and CK (r=0.65) No direct relation is seen between TK, PK, CK and TPACK. There is very low relation between TK and TPK (β=0.18), there is a higher relation between PK and TPK (β=0.39). The explanation percentage of TPK relation between these two factors is R^2=0.59. So 59 % of the TPK perception is explained by the TK and PK. There is a low level relation between PK and PCK is (β=0.27). A higher relation is detected between CK and PCK (β=0.54). The explanation percentage of PCK between these two factors is detected as R^2=0.67. So 67 % of the PCK perception is explained by the PCK. There is a medium relation between CK and TCK (β=0.41) and there is a lower relation between TK and TCK (β=0.36). The explanation percentage of TCK of these two factors are R^2=0.60. So 60 % of the TCK perception is explained by the TCK. There is a lower relation between TPK and TPACK (β=0.21), there is a higher relation between PCK and TPACK (β=0.29) and there is a medium level relation between TCK and TPACK (β=0.40). The explanation percentage of TPACK of these three factors are R^2=0.66. So 66 % of the TPACK perception is explained by these three factors.

Discussion and Conclusion

Results related with pre-service teachers

In the structural equity model analysis of the pre-service teachers, the relation level of technology with other components of TPACK is low with pedagogy and content knowledge. However, it is so challenging that the pre-service teachers, who will start working in Ministry of National Education, should have these types of skills during their bachelor education but they do not have these skills. Similar result to this situation shows parallelism to a study made by Celik et al. (2014). The technology which the teachers need for integrating the technology in parallel with the development of technology from past to present has been built on the knowledge (Hofer & Swan, 2008; Koehler, Mishra & Yahya, 2007; Landry, 2010). Likewise, it has been mentioned that the technological knowledge of the teachers shall be strengthened for providing the efficiency and persistency of the learning environment with technology (Sahin, 2011; Selim, Tatar & Oz, 2009; Schmidt et al., 2009; Kabakci Yurdakul et al., 2012). The relation level between the TK and PK of the pre-service teachers in structural equity modelling is low (r=0.33) while the relation level between CK and PK is higher (r=0.65). When we consider the results, we can see that the relation level between the TK and PK is low. Accordingly the technology must be supported together with the pedagogical perceptions in education (Hughes, 2005; Koehler, Mishra & Yahya, 2007; Erdogan & Sahin, 2010; Lux, Bangert, & Whittier, 2011). There is low relation between the CK and TK (r=0.30) and the relation level between CK and PK is higher (r=0.65). There is no direct relation with the CK and TPACK but there is a relation between PCK, TPK and PCK. It is mentioned in the results of various studies that the CK of the pre-service teachers shall be supported with the educations they take and the following skills they gain (Koehler & Mishra, 2005; Koehler & Mishra, 2008; Koehler & Mishra, 2009; Mishra & Koehler, 2006; Mishra & Koehler, 2008; Schmidt et al., 2009). The relation level between PCK and TPACK is lower (β=0.27). The situation includes contrast in the research made by Celik et al. (2014). Accordingly the relation level between PCK and PK is higher and the relation level between PCK and CK is lower. There is a direct relation between the PK and CK on PCK. When the researches made on the teacher education is examined, the PK is ignored although the PCK which the teachers and pre-service teachers should have must be within an in dissociable structure (Shulman, 1986). However many studies in the last years are built on the PCK (Shulman, 1986). It has been discussed that the PK and CK shall be integrated with each other (Mishra and Koehler, 2006), and the learning strategies shall be learned for being a better teacher (Shulman, 1986). The level of the relation between TPK and TK is lower (β=0.18). The level of relation between TPK and PK has medium level (β=0.39). The relation level between TPK and TPACK is (β=0.21). The results of the study made by Celik et al. (2014) show parallelism. However there is no direct relation between TPK and TPACK in this study. In the different studies, there is also no direct relation between TPK and TPACK (Lux, 2010).

There is medium level between TCK and TK (β=0.36), there is a medium relation between TCK and CK (β=0.41), there is a medium relation between TCK and TPACK (β=0.49). There is a low relation between TCK and TK, the relation between TCK and CK is very low in the study made by Celik et al. (2014). The relation between TCK and TPACK shows parallelism with our study. The usage of content and technology together, is more important than using the technology by itself (Kuşkaya-Mumcu, Haslaman, & Usluel, 2008; Mishra & Koehler, 2008; Sahin, 2011).There is no direct relation between TPACK and TK, PK and CK. There is a low level relation with TPK (β=0.21), low relation with PCK (β=0.29), medium relation level with TCK. In the study developed by Schmidt et al. (2009), the measurement of TPACK is aimed and similar results have been achieved. In another study made by Kim et al. (2009) on pre-service teachers, it is observed that TK, PK and CK which are the components of TPACK are not efficient adequately.

Results related with teachers

According to the structural equity model, the relation between TK and PK is in medium level (r=0.48), the relation with CK is in medium level (r=0.50), the relation with TCK is in medium level (β= 0.44) and the relation with TPK is in low level (β=0.19). In the study made by Archambault and Crippen (2009) for measuring the competence of the teachers in terms of TPACK, it is seen that the TK of the teachers is in medium level however their TCK is in low level. In the study of Schmidt et al. (2009), aimed at the course experiences of the teachers, it is observed that their TPACK increases when the courses are organized with technologies approaches for teachers. There is a medium level between PK and TK of the teachers (r=0.48) and there is a high relation between PK and CK (r=0.73). There is low relation between PK and TPK (β=0.38) and there is a medium level relation between PCK (β=0.44). There is no direct relation between TPACK. In the study made by Archambault and Crippen (2009), there is weak relation between TK and PK forming TPACK however the relation between PK and CK is high.

This study shows parallelism with our study. According to the results of the structural equity modelling; there is a medium relation between CK and TK (r=0.50), a high level between PK (r=0.73). There is a low level relation between CK and TPK (β=0.28), a medium level relation between PCK (β=0.44), low level relation between TCK (β=0.30), there is a direct relation between TPACK (β=0.12). When other researchers are examined, it is observed that in case the CK is low, the other content types shall be affected negatively and therefore the teachers shall have a healthy CK level (Cavanagh & Koehler, 2013; Kuşkaya-Mumcu, Haşlaman, & Usluel, 2008; Demir & Bozkurt, 2011). It is seen that TPACK has a direct relation with CK, PCK, TPK and TCK, TK and PK has no direct relation. In the researches made in the different education field, same results have been achieved (Bilgin, Tatar, & Ay, 2012). Schmidt et al. (2009) have concluded that the in service courses provided to the teachers increase TPACK skills of the teachers.

Suggestions

The developments in science and technology have changed the education technologies as well as the communal life. Therefore the pre-service teachers, who shall be appointed to this sacred profession in the future, shall adopt and comprehend this change. They shall not limit themselves only with the bachelor courses in the faculty in terms of professional development but also; they shall follow the academic and scientific activities for improving themselves.
The teachers shall keep their pedagogical and technological knowledge updated during learning and teaching process. They shall guide the students in accessing the right information in digital sources (internet, CD, etc) they shall develop themselves in technology integration by using their expertise's in social sciences.

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Appendix 1: The Scale of TPACK

Dear Social Studies Teacher and Pre-Service Teacher

This survey is issued for examining the relation between technology, pedagogy and content knowledge of the social studies teacher and pre-service teachers. Your answers in the Survey shall be used for research and your identification and answers shall be definitely kept secret. For this reason, do not hesitate to answer intimately. The numbers at the right side of the page express these: (1) I do not know, (2) I know in low level, (3) I know in middle level, (4) I know in good level, (5) I know in very good level

ITEMS OF TPACK SURVEY

1	Using Office programs (Like *Word*, *Excel*, and *Powerpoint*) …	1	2	3	4	5
2	Communicating through Internet (*E-mail*, *Skype*) …	1	2	3	4	5
3	Using data (*saving to Flash Memory, CD, DVD*) …	1	2	3	4	5
4	*Using printer, digital camera and Scanner* …	1	2	3	4	5
5	Using the programs of concept maps, drawing graphics (*Inspration*, *Excel* etc.) …	1	2	3	4	5
6	Developing daily, annual and unit plan…	1	2	3	4	5
7	Developing classic (multiple choice test, True-False Test, open ended Question etc) and complementary (Control List, Valuation Scale, Gradational Grading Key, Self-Efficacy Form, Peer Assessment Form etc) measurement tools …	1	2	3	4	5
8	*Evaluating the performance of the teacher with classic and alternative (complementary) measuring tools. …*	1	2	3	4	5
9	Implementing the different teaching strategies (Presentation Strategy, *Invention Strategy, Research-Analysing Strategy etc*.) …	1	2	3	4	5
10	*Implementing different methods (Plain Expression, Case Study, Problem Based Learning, Project based Learning etc*.) …	1	2	3	4	5
11	*Implementing different teaching techniques* (*Brain Storming, Six Thinking Hats, Demonstration, Metaphor etc*.) …	1	2	3	4	5
12	Learning theory and hypothesis (Structuralist *Learning, Multiple Intelligence Theory, Project Based Education etc.*)…	1	2	3	4	5
13	*How the class management shall be organized and continued in Social Sciences course* …	1	2	3	4	5
14	*Content Knowledge related with Individual and Society learning domain*	1	2	3	4	5
15	*Content Knowledge related with Culture and Heritage learning domain* …	1	2	3	4	5
16	*Content Knowledge related with Humans, Places and Environment learning domain*	1	2	3	4	5
17	*Content Knowledge related with Production, Distribution, Consumption learning domain*	1	2	3	4	5
18	*Content Knowledge related with Time, Consistency and Alteration learning domain*	1	2	3	4	5
19	*Content Knowledge related with Science, Technology and Society learning domain*	1	2	3	4	5
20	*Content Knowledge related with Groups, Institutions and Social Organizations learning domain*	1	2	3	4	5
21	*Content Knowledge related with Power, Management and Society learning domain*	1	2	3	4	5
22	*Content Knowledge related with Global Connections learning domain*	1	2	3	4	5
23	Current releases in Social Sciences field (Releases and books)…	1	2	3	4	5
24	*Selecting teaching strategies which are convenient to achievements related with Social Studies* …	1	2	3	4	5
25	*Selecting education models which are convenient to achievements related with Social Studies* …	1	2	3	4	5
26	*Selecting education techniques* which are convenient for teaching achievements related with Social Studies …	1	2	3	4	5
27	*Selecting education methods which are* convenient for teaching achievements related with Social Studies ……	1	2	3	4	5
28	*Selecting alternative /complementary and evaluation tools for evaluating achievements related with Social Studies.* …	1	2	3	4	5
29	*Preparing* daily, annual and unit plan *which is convenient to achievements*	1	2	3	4	5

	related with Social Studies courses …					
30	*Preparing a course plan including the class/ intramural activities for Social Studies courses …*	1	2	3	4	5
31	Technologies which are convenient to teaching approaches/ strategies …	1	2	3	4	5
32	Providing class management while using different education technologies. …	1	2	3	4	5
33	Using technologies which are convenient to different education model and theories …	1	2	3	4	5
34	Using technologies which are convenient to different education strategies….	1	2	3	4	5
35	Using technologies convenient to different education methods …	1	2	3	4	5
36	Using technologies convenient to different education techniques …	1	2	3	4	5
37	Using technologies which shall affect the education in positive manner …	1	2	3	4	5
38	Using technologies which are convenient to classic-alternative measurement and evaluation approaches …	1	2	3	4	5
39	Benefiting from technology by considering the individual differences of the students …	1	2	3	4	5
40	Preparing daily, annual and unit annual plans in computer …	1	2	3	4	5
41	Evaluating the conformance of a new technology to the education …	1	2	3	4	5
42	*Education technologies which are convenient to different learning content of the social studies courses …*	1	2	3	4	5
43	*Selecting technologies which are convenient for enriching the content of social studies course …*	1	2	3	4	5
44	*Using technologies which are developed by Course Tools Construction Centre while teaching achievements of Social Studies course …*	1	2	3	4	5
45	*Technologies which shall provide easier access to the targets/ achievements mentioned in the social studies course teaching plan …*	1	2	3	4	5
46	*Using computer aided technologies which are convenient to different learning content of social studies course …*	1	2	3	4	5
47	*Using tablet computer and smart board while teaching the different learning content of social studies courses*	1	2	3	4	5
48	*Developing projects and class activities including the education technologies in social studies course …*	1	2	3	4	5
49	*Integrating the social studies course content with appropriate technology and formation information …*	1	2	3	4	5
50	*Selecting appropriate education approaches and contemporary education technologies which shall provide better teaching of social studies course content …*	1	2	3	4	5
51	*Teaching courses by integrating the social studies learning content with my formation and technological knowledge …*	1	2	3	4	5
52	To take the leading to my colleagues about integrating the social studies contend and formation and technological knowledge …	1	2	3	4	5
53	Teaching a social studies subject by using appropriate technologies according to different education theories …	1	2	3	4	5
54	*To increase the value of the learning of my students through my formation and technological knowledge while teaching social studies subjects …*	1	2	3	4	5
55	*To integrate my content, technology and formation knowledge related with social studies course …*	1	2	3	4	5

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Analysis of TPACK Self-Efficacy Perception Levels of Social Studies Teachers and Pre-Service Teachers

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Abstract

The purpose of this research is to examine the self-efficacy technological pedagogical and content knowledge (TPACK) of the social studies teachers and pre-service teachers. TPACK scale which is developed by the researcher in this respect is applied to 113 social studies teachers and 919 social studies pre-service teachers. The method of the research has been patterned by the monitoring method. In accordance with the obtained data, the consistency index values are found by calculation of structural equity path coefficients (path analysis). The data has been classified with SPSS program and has been analyzed with AMOS (Analyses of Moment Structures) program. In the study, while the relation level between other components and the technological knowledge teachers and pre-service teachers are seen in low and middle level, the relation level between the content knowledge and pedagogical knowledge has been found in higher level. Consequently, the necessity has occurred for the integration of the technological pedagogical and content knowledge of the social studies teachers and pre-service teachers with each other.

Key words: TPACK, Social Studies, Technology, Pedagogy

Introduction

The rapid changes and developments in the knowledge and communication technologies in our day which we named as knowledge area reflect on the education. The individual has to use the technology efficiently for keeping up with this change and development (Kurt, 2013). Turkey which is not indifferent to this issue has started Increasing Opportunities in Education and Technology Reformation Movement (FATİH) project with the cooperation of Ministry of National Education and Ministry of Communication. The technological pedagogical and content knowledge perception which is presented by Mishra and Koehler (2006) in this respect has been united with technology and education has been tried to be more efficient by being integrated within education processes.

Theoretical Framework: TPACK

The components of technological, pedagogical and content knowledge consists of seven components as technological knowledge, pedagogical knowledge, content knowledge, technological pedagogical knowledge, technological content knowledge, content pedagogical knowledge and technological pedagogical content knowledge.

Technology Knowledge (TK): Technology with the widest meaning has been identified as the changes made by the humans on the nature for their needs (Pearson & Young, 2002). When consider the technology in terms of education, Kurt (2013) has showed the efficient usage of the software tools like operating system, computer hardware, word processors, spreadsheet programs, web browser and e-mail in addition to book, chalk and blackboard. The technologies which are developed in present oblige the technology usage skills of the teachers (Koehler & Mishra, 2009). The constant change of the technology causes the changing of the nature of the technology (Mishra & Koehler, 2005; Yigit, 2014).

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Content Knowledge (CK): Mishra and Koehler (2006) have explained the content knowledge as expressing the knowledge which takes part in this content and the knowledge to be taught in this content. The content knowledge is the knowledge which is given to the student through courses. The knowledge content of the course which is taught shall be known in outstanding level in this respect (Kurt et al., 2013).

Pedagogical Knowledge (PK): Harris et al. (2009) has identified the pedagogical knowledge as the knowledge of the method of teaching a subject. Yelken et al. (2013) have explained the pedagogical knowledge as the subjects like learning, evaluation of learning, development practices, course planning, class management, regulation the class environment and intramural communication. Saltan (2013), identifies this subject as the course designs which are in conformity with the cognitive levels, development level, learning types and interest of the student groups during the course process. Incekapı (2013) considers pedagogical knowledge as knowing how to teach a course

Pedagogical content knowledge (PCK): PCK idea was first presented by Shulman (1986). Pedagogical content knowledge is related with the teaching method of a specific content, the types of the education strategies. PCK, is the education with different strategies, method and techniques for each subject (Mishra & Koehler, 2006). PCK is the combination of the pedagogy and content and the implementation of them. PCK is the knowledge of, showing how to teach any subject to the student in a specific discipline (Cox & Graham, 2009; Jimoiannis, 2010; Yigit, 2014). There is strong relation between the pedagogy and content knowledge. This relation shows us to teach each subject with different teaching strategies (Sahin, 2011).

Technological and Content Knowledge (TCK): TCK is the knowledge about the integration of technology with content. The teachers need to know the new technological applications as well as the subjects to be taught (Mishra & Koehler, 2006). Kılıç (2013), defines the technological content knowledge as a knowledge type which is associated with each other. The technological content knowledge is to know the conformity of the new technology to the teaching at the same time. We have to know which subject is in conformity with which technology (Kurt et al., 2013). The teacher must know to select the appropriate technology for enriching the content of the course because a technology which does not conform to its purpose is ineffective in reintegrating the terminal behavior.

Technological and Pedagogical Knowledge (TPK): TPK occur from the integration of the technology and formation knowledge (Mishra & Koehler, 2006). Kılıç (2013), expresses that there are different technologies used in teaching and learning environment and to know their specialities. This knowledge can also be expressed as the usage method of the technology in teaching environment (Yurdakul & Odabası, 2013). A teacher can have technological knowledge but we cannot consider education efficiency in efficient level when he cannot integrate this with the pedagogical knowledge in education environment. One of the reasons of the failure of many educations given with technology does not know how to give technology with pedagogy (Bozkurt et al., 2013).

Technological, Pedagogical and Content Knowledge (TPACK): TPACK is the knowledge which consists of the components of technology, pedagogy and content knowledge. This knowledge is different from the general pedagogical knowledge which is used by the teacher, from the technology which needs a specific expertise, discipline. TPACK establishes the base of a good teaching with technology (Mishra & Koehler, 2006). As mentioned in Figure 1, TPACK is an integration which is formed by the technology pedagogy and content knowledge. However TPACK shall be considered as a situation which is used in the education environment at the same time. In other words, to teach a subject, a course by using technology, does mean that the teacher uses TPACK (Kurt, 2013). Technology pedagogy and content knowledge shall not be given as independent from each other but shall be given as integration (Sahin, 2011).

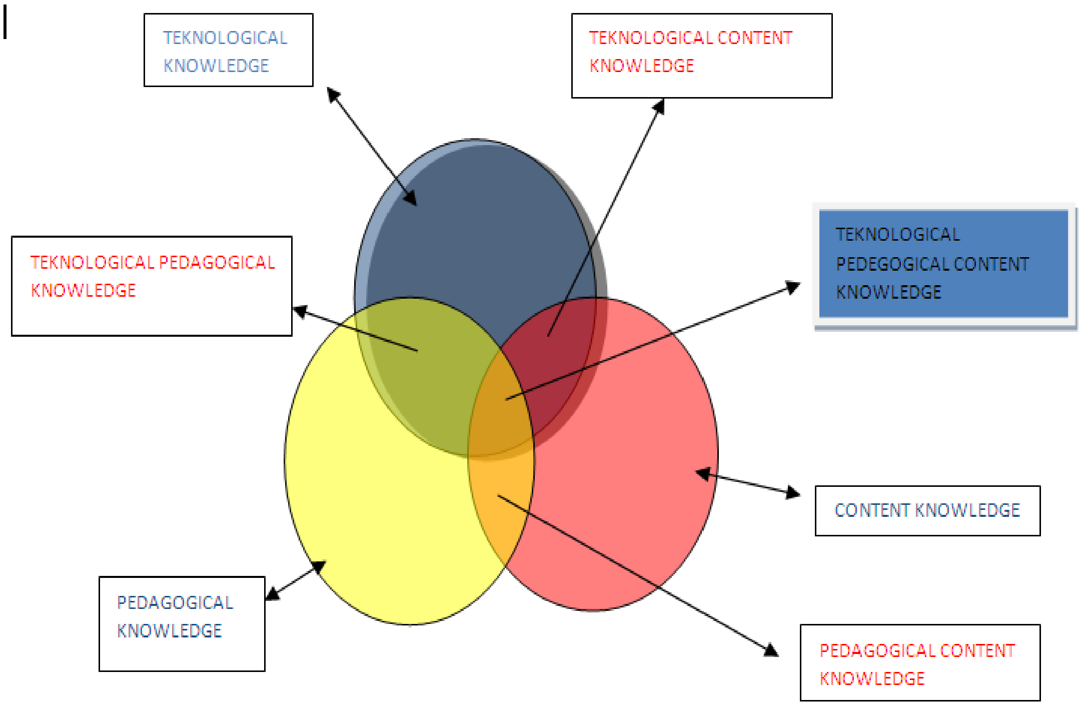

Figure 1. Technological, Pedagogical and Content Knowledge Components

This study is made for determining TPAB levels of teachers and pre-service teachers of social studies. As different from other studies, it is a study which is specific for social sciences content. The scale which is developed by the researcher is prepared only for determining the TPACK level of the teachers and pre-service teachers of social studies. Answers are searched for the below questions in this respect.

1. What kind of a relation are there between the perception of the social studies teachers to technological, pedagogical and content knowledge components?
2. What kind of a relation are there between the perception of the social studies pre-service teachers to technological, pedagogical and content knowledge components?

Method

This section of the research mentions the model of the research, nature/sample, sampling type, data collection tools, analysis and commenting the data.

Model of the research

By using TPACK model in this research, it is aimed to examine the technological pedagogical and content knowledge level of the pre-service teachers of social studies in faculty of education and social studies teachers working in secondary schools. This study is patterned by using monitoring model.

Participants

Sampling.1 (Application 1 – pre-service teachers): This study is carried out in all regions of our country. The nature of the pre-service teachers is formed by the fourth grade students in social studies education in whole faculty of education in our country. Our sampling group consists of 919 pre-service teachers in total who are selected by the nature based sampling method.

Sampling.2 (Application 2 - teachers): the nature of the teacher consists of the social studies teachers working within the body of Konya Provincial National Education Directorate. The sampling of the research is carried out by 113 teachers who are selected from this nature.

Data Collection Tools

Accordingly, seven sizes have been determined in the scale which is issued by the researcher (Akman, 2014; Akman & Guven, 2015). These are; size of technological knowledge (TK), pedagogical knowledge size (PK), size of content knowledge (CK), size of pedagogical and content knowledge (PCK), size of technological and pedagogical knowledge (TPK), size of technological and content knowledge (TCK), size of technological, pedagogical and content knowledge (TPACK).

The scale which is issued has been formed in the type of five points Likert scale. 1-2-3-4-5 numbers are located across the articles of the scales. Respectively the numbers are given the meaning as; I do not know, I know in low level, I know in middle level, I know in good level, I know in very good level. Validity and reliability studies are made for the obtained data. According to the reliability studies made, the reliability coefficient of Alpha Cronbach of the scale has been found as 0.977. Affirmative factor analyses are made on the obtained data.

Data Collection and Application: The data of the study is collected from the teachers and pre-service teachers. The scale which is distributed for being applied to the teachers is 230 and the collected scale is 120. However, some teachers have marked the scale without reading so seven of them are deducted and the data collected from 113 teachers is taken as a basis. The feedback rate in pre-service teachers is seventy percent (distributed scale: 1450; collected: 1113). However, some teachers have marked the scale without reading so 919 of them are taken to evaluation.

Data Analysis

According to results, the consistency index values are found by calculation of structural equity path coefficients (path analysis). The data has been classified with SPSS program and has been analysed with AMOS (Analyses of Moment Structures) program. In this study, structural equity model is used in order to determine factors and their relations and it is found how those relations are conformed with real data.

There are some index types which are confronted regularly in literature. These are: X^2/df, CFI, RMSEA, GFI, AGFI, NFI, NNFI, SRMR indexes (Karademir & Erten, 2013; Karademir & Erten, 2014).

Table 1.Criterion references for fit indices of linear factor analysis

Index Types	χ^2 / df	*RMR*	*GFI*	*CFI*	*RMSEA*
Index Values	1,398	0,038	0,853	0,918	0,050
Perfect fit	< 3	0 ≤ RMR ≤ 0,05	0,95≤GFI≤1	0,97≤ CFI ≤ 1	0≤ RMSEA ≤ 0,05
Acceptable fit	< 5	0,05 ≤ RMR ≤ 0,10	0,90≤GFI≤0,95 veya 0,80≤GFI≤0,89	0,90≤CFI≤0,95 veya 0,80≤GFI≤0,89	0,05≤ RMSEA ≤ 0,10

Results

In this section of the research, structural equity model outputs are mentioned for understanding the relation level between teachers and pre-service teachers and TPACK components.

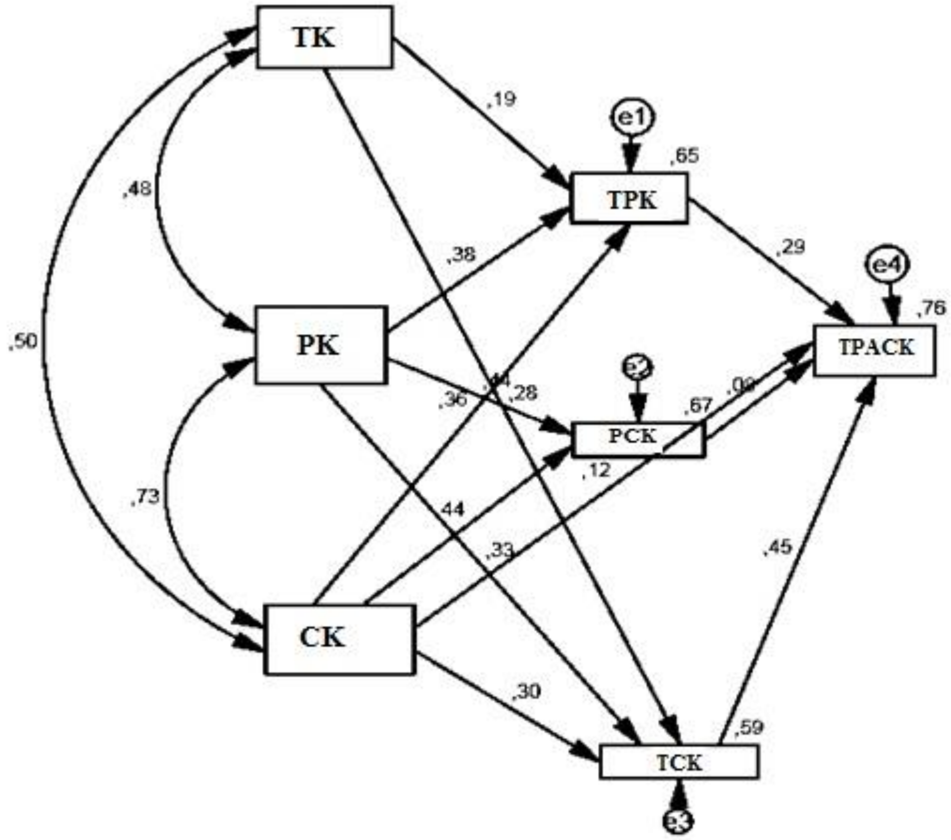

Figure 1. Findings showing the relation between the structural equity model and technological pedagogical content knowledge of the teachers

Fit Index Values: X2/df: 0.249, N: 113, RMSEA: 0.056, RMR: 0.149, GFI: 0.997, AGFI: 0.982, NFI: 0.998

The structural equation model outputs made with the teacher data related with TPACK are mentioned in Figure 1. Accordingly; it is determined that the adaptive value is in the acceptable level. Accordingly; there is medium level relation between the TK and CK (r=0.50), a medium level relation between TK and PK (r=0.48), there is high level relation between PK and CK (r=0.73). There is no direct relation between TPK and CK but there is low level direct relation between TPK and CK (β=0.33). There is very low relation between TK and TPK (β=0.19), low level relation between PK and TPK (β=0.38). The explanation percentage of TPK relation between these two factors is R^2=0.65. So 65 % of the TPK perception is explained by the TK and PK. There is a low level relation between PK and PCK (β=0.28). A medium level relation is detected between CK and PCK (β=0.44). The explanation percentage of PCK between these two factors is R^2= 0.67. So 67 % of the PCK perception is explained by the PK and CK. There is a low level relation between the TK and TCK (β=0.30) and a higher relation is detected between TK and TCK (β=0.44). The explanation percentage of TCK between these two factors is R^2=0.59. So 59 % of the TCK perception is explained by the TK and CK. There is a low level relation between TPK and CK (β=0.29), there is a very low relation between PCK and TPACK (β=0.08) and there is medium relation between TCK and TPACK (β=0.45). The explanation percentage of TPACK between these three factors is R^2=0.76. So 76 % of the TPACK perception is explained by these three factors. In figure 2, structural equity model and findings related with the pre-service teachers are mentioned.

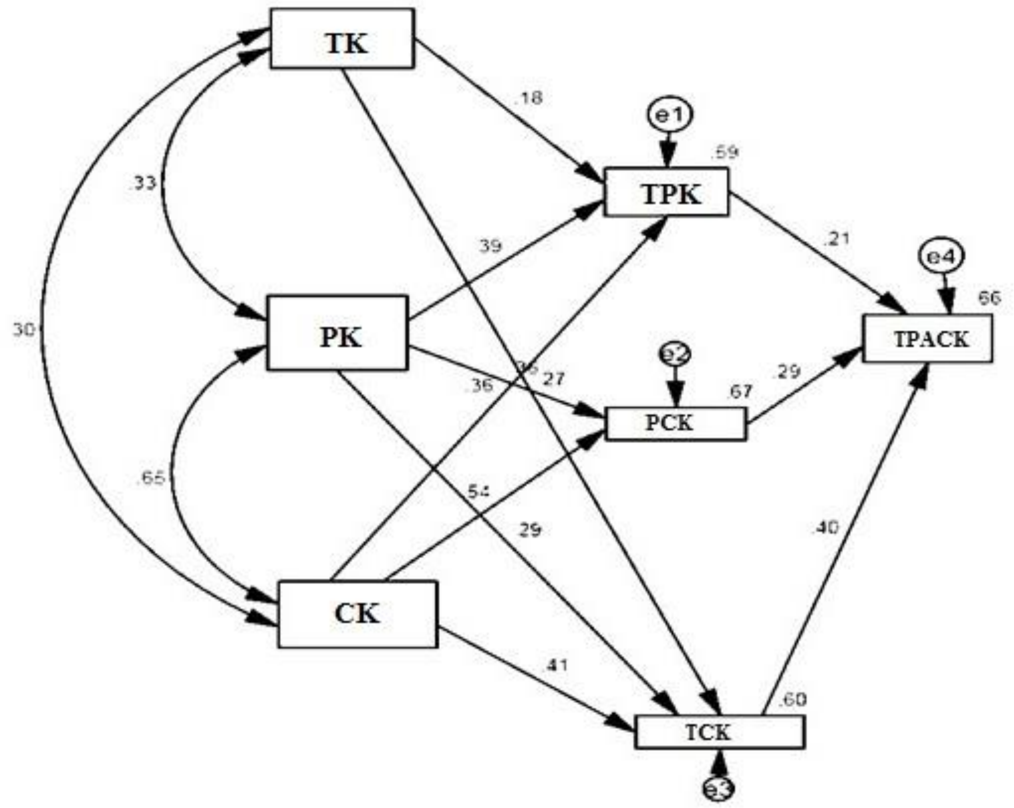

Figure 2. Findings showing the relation between the components of technological pedagogical content knowledge of pre-service teachers with structural equity model.

Fit Index Values: X2/df: 0.922, N: 919, RMSEA: 0.054, RMR: 0.84, GFI: 0.999, AGFI: 0.992, NFI: 1.00

The structural equation modelling outputs made with pre-service teachers related with TPACK are mentioned in figure 2. Accordingly it is detected that the adaptive values are in the acceptable level. Accordingly there is low level relation between TK and CK (r=0.30), there is higher relation between TK and PK (r=0.33) and there is a higher relation between PK and CK (r=0.65) No direct relation is seen between TK, PK, CK and TPACK. There is very low relation between TK and TPK (β=0.18), there is a higher relation between PK and TPK (β=0.39). The explanation percentage of TPK relation between these two factors is R^2=0.59. So 59 % of the TPK perception is explained by the TK and PK. There is a low level relation between PK and PCK is (β=0.27). A higher relation is detected between CK and PCK (β=0.54). The explanation percentage of PCK between these two factors is detected as R^2=0.67. So 67 % of the PCK perception is explained by the PCK. There is a medium relation between CK and TCK (β=0.41) and there is a lower relation between TK and TCK (β=0.36). The explanation percentage of TCK of these two factors are R^2=0.60. So 60 % of the TCK perception is explained by the TCK. There is a lower relation between TPK and TPACK (β=0.21), there is a higher relation between PCK and TPACK (β=0.29) and there is a medium level relation between TCK and TPACK (β=0.40). The explanation percentage of TPACK of these three factors are R^2=0.66. So 66 % of the TPACK perception is explained by these three factors.

Discussion and Conclusion

Results related with pre-service teachers

In the structural equity model analysis of the pre-service teachers, the relation level of technology with other components of TPACK is low with pedagogy and content knowledge. However, it is so challenging that the pre-service teachers, who will start working in Ministry of National Education, should have these types of skills during their bachelor education but they do not have these skills. Similar result to this situation shows parallelism to a study made by Celik et al. (2014). The technology which the teachers need for integrating the technology in parallel with the development of technology from past to present has been built on the knowledge (Hofer & Swan, 2008; Koehler, Mishra & Yahya, 2007; Landry, 2010). Likewise, it has been mentioned that the technological knowledge of the teachers shall be strengthened for providing the efficiency and persistency of the learning environment with technology (Sahin, 2011; Selim, Tatar & Oz, 2009; Schmidt et al., 2009; Kabakci Yurdakul et al., 2012). The relation level between the TK and PK of the pre-service teachers in structural equity modelling is low (r=0.33) while the relation level between CK and PK is higher (r=0.65). When we consider the results, we can see that the relation level between the TK and PK is low. Accordingly the technology must be supported together with the pedagogical perceptions in education (Hughes, 2005; Koehler, Mishra & Yahya, 2007; Erdogan & Sahin, 2010; Lux, Bangert, & Whittier, 2011). There is low relation between the CK and TK (r=0.30) and the relation level between CK and PK is higher (r=0.65). There is no direct relation with the CK and TPACK but there is a relation between PCK, TPK and PCK. It is mentioned in the results of various studies that the CK of the pre-service teachers shall be supported with the educations they take and the following skills they gain (Koehler & Mishra, 2005; Koehler & Mishra, 2008; Koehler & Mishra, 2009; Mishra & Koehler, 2006; Mishra & Koehler, 2008; Schmidt et al., 2009). The relation level between PCK and TPACK is lower (β=0.27). The situation includes contrast in the research made by Celik et al. (2014). Accordingly the relation level between PCK and PK is higher and the relation level between PCK and CK is lower. There is a direct relation between the PK and CK on PCK. When the researches made on the teacher education is examined, the PK is ignored although the PCK which the teachers and pre-service teachers should have must be within an in dissociable structure (Shulman, 1986). However many studies in the last years are built on the PCK (Shulman, 1986). It has been discussed that the PK and CK shall be integrated with each other (Mishra and Koehler, 2006), and the learning strategies shall be learned for being a better teacher (Shulman, 1986). The level of the relation between TPK and TK is lower (β=0.18). The level of relation between TPK and PK has medium level (β=0.39). The relation level between TPK and TPACK is (β=0.21). The results of the study made by Celik et al. (2014) show parallelism. However there is no direct relation between TPK and TPACK in this study. In the different studies, there is also no direct relation between TPK and TPACK (Lux, 2010).

There is medium level between TCK and TK (β=0.36), there is a medium relation between TCK and CK (β=0.41), there is a medium relation between TCK and TPACK (β=0.49). There is a low relation between TCK and TK, the relation between TCK and CK is very low in the study made by Celik et al. (2014). The relation between TCK and TPACK shows parallelism with our study. The usage of content and technology together, is more important than using the technology by itself (Kuşkaya-Mumcu, Haslaman, & Usluel, 2008; Mishra & Koehler, 2008; Sahin, 2011).There is no direct relation between TPACK and TK, PK and CK. There is a low level relation with TPK (β=0.21), low relation with PCK (β=0.29), medium relation level with TCK. In the study developed by Schmidt et al. (2009), the measurement of TPACK is aimed and similar results have been achieved. In another study made by Kim et al. (2009) on pre-service teachers, it is observed that TK, PK and CK which are the components of TPACK are not efficient adequately.

Results related with teachers

According to the structural equity model, the relation between TK and PK is in medium level (r=0.48), the relation with CK is in medium level (r=0.50), the relation with TCK is in medium level (β= 0.44) and the relation with TPK is in low level (β=0.19). In the study made by Archambault and Crippen (2009) for measuring the competence of the teachers in terms of TPACK, it is seen that the TK of the teachers is in medium level however their TCK is in low level. In the study of Schmidt et al. (2009), aimed at the course experiences of the teachers, it is observed that their TPACK increases when the courses are organized with technologies approaches for teachers. There is a medium level between PK and TK of the teachers (r=0.48) and there is a high relation between PK and CK (r=0.73). There is low relation between PK and TPK (β=0.38) and there is a medium level relation between PCK (β=0.44). There is no direct relation between TPACK. In the study made by Archambault and Crippen (2009), there is weak relation between TK and PK forming TPACK however the relation between PK and CK is high.

This study shows parallelism with our study. According to the results of the structural equity modelling; there is a medium relation between CK and TK (r=0.50), a high level between PK (r=0.73). There is a low level relation between CK and TPK (β=0.28), a medium level relation between PCK (β=0.44), low level relation between TCK (β=0.30), there is a direct relation between TPACK (β=0.12). When other researchers are examined, it is observed that in case the CK is low, the other content types shall be affected negatively and therefore the teachers shall have a healthy CK level (Cavanagh & Koehler, 2013; Kuşkaya-Mumcu, Haşlaman, & Usluel, 2008; Demir & Bozkurt, 2011). It is seen that TPACK has a direct relation with CK, PCK, TPK and TCK, TK and PK has no direct relation. In the researches made in the different education field, same results have been achieved (Bilgin, Tatar, & Ay, 2012). Schmidt et al. (2009) have concluded that the in service courses provided to the teachers increase TPACK skills of the teachers.

Suggestions

The developments in science and technology have changed the education technologies as well as the communal life. Therefore the pre-service teachers, who shall be appointed to this sacred profession in the future, shall adopt and comprehend this change. They shall not limit themselves only with the bachelor courses in the faculty in terms of professional development but also; they shall follow the academic and scientific activities for improving themselves.

The teachers shall keep their pedagogical and technological knowledge updated during learning and teaching process. They shall guide the students in accessing the right information in digital sources (internet, CD, etc) they shall develop themselves in technology integration by using their expertise's in social sciences.

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Appendix 1: The Scale of TPACK

Dear Social Studies Teacher and Pre-Service Teacher
This survey is issued for examining the relation between technology, pedagogy and content knowledge of the social studies teacher and pre-service teachers. Your answers in the Survey shall be used for research and your identification and answers shall be definitely kept secret. For this reason, do not hesitate to answer intimately. The numbers at the right side of the page express these: (1) I do not know, (2) I know in low level, (3) I know in middle level, (4) I know in good level, (5) I know in very good level

ITEMS OF TPACK SURVEY

1	Using Office programs (Like *Word*, *Excel*, and *Powerpoint*) …	1	2	3	4	5
2	Communicating through Internet (*E-mail, Skype*) …	1	2	3	4	5
3	Using data (*saving to Flash Memory, CD, DVD*) …	1	2	3	4	5
4	*Using printer, digital camera and Scanner* …	1	2	3	4	5
5	Using the programs of concept maps, drawing graphics (*Inspration, Excel* etc.) …	1	2	3	4	5
6	Developing daily, annual and unit plan…	1	2	3	4	5
7	Developing classic (multiple choice test, True-False Test, open ended Question etc) and complementary (Control List, Valuation Scale, Gradational Grading Key, Self-Efficacy Form, Peer Assessment Form etc) measurement tools …	1	2	3	4	5
8	*Evaluating the performance of the teacher with classic and alternative (complementary) measuring tools. …*	1	2	3	4	5
9	Implementing the different teaching strategies (Presentation Strategy, *Invention Strategy, Research-Analysing Strategy etc*.) …	1	2	3	4	5
10	*Implementing different methods (Plain Expression, Case Study, Problem Based Learning, Project based Learning etc*.) …	1	2	3	4	5
11	*Implementing different teaching techniques* (*Brain Storming, Six Thinking Hats, Demonstration, Metaphor etc*.) …	1	2	3	4	5
12	Learning theory and hypothesis (Structuralist *Learning, Multiple Intelligence Theory, Project Based Education etc.*)…	1	2	3	4	5
13	*How the class management shall be organized and continued in Social Sciences course* …	1	2	3	4	5
14	*Content Knowledge related with Individual and Society learning domain*	1	2	3	4	5
15	*Content Knowledge related with Culture and Heritage learning domain* …	1	2	3	4	5
16	*Content Knowledge related with Humans, Places and Environment learning domain*	1	2	3	4	5
17	*Content Knowledge related with Production, Distribution, Consumption learning domain*	1	2	3	4	5
18	*Content Knowledge related with Time, Consistency and Alteration learning domain*	1	2	3	4	5
19	*Content Knowledge related with Science, Technology and Society learning domain*	1	2	3	4	5
20	*Content Knowledge related with Groups, Institutions and Social Organizations learning domain*	1	2	3	4	5
21	*Content Knowledge related with Power, Management and Society learning domain*	1	2	3	4	5
22	*Content Knowledge related with Global Connections learning domain*	1	2	3	4	5
23	Current releases in Social Sciences field (Releases and books)…	1	2	3	4	5
24	*Selecting teaching strategies which are convenient to achievements related with Social Studies* …	1	2	3	4	5
25	*Selecting education models which are convenient to achievements related with Social Studies* …	1	2	3	4	5
26	*Selecting education techniques* which are convenient for teaching achievements related with Social Studies …	1	2	3	4	5
27	*Selecting education methods which are* convenient for teaching achievements related with Social Studies ……	1	2	3	4	5
28	*Selecting alternative /complementary and evaluation tools for evaluating achievements related with Social Studies.* …	1	2	3	4	5
29	*Preparing* daily, annual and unit plan *which is convenient to achievements*	1	2	3	4	5

	related with Social Studies courses …					
30	*Preparing a course plan including the class/ intramural activities for Social Studies courses …*	1	2	3	4	5
31	Technologies which are convenient to teaching approaches/ strategies …	1	2	3	4	5
32	Providing class management while using different education technologies. …	1	2	3	4	5
33	Using technologies which are convenient to different education model and theories …	1	2	3	4	5
34	Using technologies which are convenient to different education strategies….	1	2	3	4	5
35	Using technologies convenient to different education methods …	1	2	3	4	5
36	Using technologies convenient to different education techniques …	1	2	3	4	5
37	Using technologies which shall affect the education in positive manner …	1	2	3	4	5
38	Using technologies which are convenient to classic-alternative measurement and evaluation approaches …	1	2	3	4	5
39	Benefiting from technology by considering the individual differences of the students …	1	2	3	4	5
40	Preparing daily, annual and unit annual plans in computer …	1	2	3	4	5
41	Evaluating the conformance of a new technology to the education …	1	2	3	4	5
42	*Education technologies which are convenient to different learning content of the social studies courses …*	1	2	3	4	5
43	*Selecting technologies which are convenient for enriching the content of social studies course …*	1	2	3	4	5
44	*Using technologies which are developed by Course Tools Construction Centre while teaching achievements of Social Studies course …*	1	2	3	4	5
45	*Technologies which shall provide easier access to the targets/ achievements mentioned in the social studies course teaching plan …*	1	2	3	4	5
46	*Using computer aided technologies which are convenient to different learning content of social studies course …*	1	2	3	4	5
47	*Using tablet computer and smart board while teaching the different learning content of social studies courses*	1	2	3	4	5
48	*Developing projects and class activities including the education technologies in social studies course …*	1	2	3	4	5
49	*Integrating the social studies course content with appropriate technology and formation information …*	1	2	3	4	5
50	*Selecting appropriate education approaches and contemporary education technologies which shall provide better teaching of social studies course content …*	1	2	3	4	5
51	*Teaching courses by integrating the social studies learning content with my formation and technological knowledge …*	1	2	3	4	5
52	To take the leading to my colleagues about integrating the social studies contend and formation and technological knowledge …	1	2	3	4	5
53	Teaching a social studies subject by using appropriate technologies according to different education theories …	1	2	3	4	5
54	*To increase the value of the learning of my students through my formation and technological knowledge while teaching social studies subjects …*	1	2	3	4	5
55	*To integrate my content, technology and formation knowledge related with social studies course …*	1	2	3	4	5

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The Development of Craft and Technology Education Curriculums and Students' Attitudes towards Technology in Finland, Estonia and Iceland

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Abstract

The research is based on a comparative study of craft and technology education curriculums and students' attitudes towards craft and technology in Finland, Estonia and Iceland. The study was undertaken in the Helsinki University, University of Tallinn and University of Iceland during years 2012-2013. In order to examine and compare the origins of craft education in Finland, Estonia and Iceland a literature review was completed. In addition, a quantitative survey was subsequently distributed to 658 school students in Finland, Estonia and Iceland. It consisted of 14 questions, which aimed to ascertain students' attitudes towards craft and technology. The survey showed substantial differences in students' attitudes towards craft and technology education in the three countries: these differences may be explained by differences in the national curriculums, the different pedagogical traditions and cultural differences in the field of technology. However, for deeper understanding, the qualitative findings need to be examined further with different research methods.

Key words: Technology education, Craft education Attitudes towards technology, National curriculum

Introduction

Compulsory education in Finland is intended for students from 7 to 15 years old. In addition, all 6 year olds are entitled to pre-school education for one year, prior to starting basic education. Primary school teachers teach students aged 7 to 13 years old (grades 1-6), while specialist teachers teach children aged 13 to 15 years old (grades 7-9). Secondary schools educate students aged 16 -19 years and these schools are divided into general education (upper secondary schools) and vocational education (vocational schools). Upper secondary schools prepare students mainly for higher education, while vocational schools instruct students for specialised vocational training (Framework Curriculum Guidelines, 2004).

The general aim of Finnish technology education is to increase students' self-esteem by developing their skills through enjoyable craft activities; it also aims to increase students' understanding of the various manufacturing processes and the use of different materials in craft. Furthermore, the subject aims to encourage students to make their own decisions in designing, allowing them to assess their ideas and products. Students' practical work is product orientated and based on experimentation, in accordance with the development of their personality. The role of the teacher is to guide students' work in a systematic manner. They must encourage pupils' independence, the growth of their creative skills through problem-based learning and the development of technical literacy. In addition, gender issues are important throughout the whole curriculum (Framework Curriculum Guidelines, 2004).

In Estonia, school attendance is mandatory for all children from age 7 until the pupil turns 17. In basic school, the allocated time for covering the curriculum is nine years. The stages of study in basic school are: 1st stage of study – grades 1 to 3; 2nd stage of study – grades 4 to 6; 3rd stage of study – grades 7 to 9. The standard period of study in upper secondary school is three years (Põhikooli- ja gümnaasiumiseadus, 2010). After graduating basic school, students can continue their studies in a vocational school. After obtaining secondary education in a vocational school or in an upper secondary school, students can move on to the higher education level, opting either for an institution of professional higher education or a university (Eesti Vabariigi haridusseadus, 1992).

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Subjects taught in the domain of technology in Estonia enable students to acquire the mentality, ideals, and values inherent to the contemporary society. They learn to understand the options they have in solving tasks or creating new products; find and combine various environmentally sustainable techniques. In lessons, students study and analyse phenomena and situations, as well as use various sources of information, integrate creative thinking and manual activity. As a part of the study process, students generate ideas, plan, model, and prepare objects/products and learn how to present these. Students' initiative, entrepreneurial spirit, and creativity are supported and they learn to appreciate an economic and healthy life style. Learning takes place in a positive environment, where students' diligence and development are recognized in every way. Teaching develops their skills in working and cooperating, as well as their critical thinking and the ability to analyse and evaluate. (Ainevaldkond "Tehnoloogia", 2011)

There are four levels of education in Iceland: playschool, compulsory school, upper secondary school and higher education (this is similar to the educational systems in other Nordic countries). Education in Iceland is mandatory for children aged 6–16 and is organised into a single, structured system; i.e., primary and lower secondary education are both part of the same school level and are generally housed within the same school. Upper secondary education (aged 16-20 years) is not compulsory, but anyone who has completed compulsory education has a right to study at this level. Upper secondary schools offer both general academic studies and vocational training. General academic studies are of four-years' duration, leading to a matriculation examination, while the length of vocational courses varies: they may last from one semester to ten semesters; the four-year courses are most prevalent (The Icelandic Ministry of Education, 2007).

The present national curriculum for the subject of craft and technology in Iceland places an emphasis on individual-based learning. It also gives teachers the freedom to run an independent curriculum in school, which is based on the national curriculum. As in Finland, the subject is product based and students learn via traditional craft activities. Students' work is based on craft tradition rather than technology; however, innovation and idea generation are an important part of the Icelandic curriculum. There are also the aims of developing students' manual skills, instructing them in the manufacturing processes and training them to organise their own work. The national curriculum also incorporates outdoor education, working with green wood and sustainable design (Olafsson & Thorsteinsson, 2010).

Thus, as seen above, there are many similarities between the national curriculums in Finland, Estonia and Iceland; however there are also some differences. In the following sections, the authors will attempt to highlight these differences in the curriculum level and later will try to ascertain whether there are any differences in practical level between the three countries, with regards to students' attitudes towards craft and technology.

Main part of the study was to recognise the origin of craft education in Finland, Estonia and Iceland to identify fundamental changes during the development of the curriculums. This was done by a literature review based on the different curriculums. The quantitative part of the study was, however, to find any differences in students' attitudes towards craft and technology in Finland, Estonia and Iceland. The research questions were:

1. What are the origins of craft education in Finland, Estonia and Iceland and how have the curriculums developed over the years?
2. Are there differences in students' attitudes towards craft and technology in Finland, Estonia and Iceland?

The origin of pedagogical craft and technology education

The Finnish educationalist Gygnaeus (1810-1888) founded public schools in Finland in 1866. At this time, Gygnaeus also introduced craft as a pedagogically-based compulsory subject, in an attempt to improve general education in Finland (Thorarinsson, 1891). In 1866, educational Sloyd (known as craft and technology education today) became a compulsory subject in Finland (Kantola, 1997).

Manual training in Finland was established in two ways: males in rural communities were required to take the programme and teaching centres had to offer related courses (Vaughn & Mays, 1924). With the implementation of this system of universal education for all citizens, Finland became the first nation to make handwork an integral part of a national scheme of elementary education (Bennett, 1926: Kananoja, 1989; Kantola, 1997).

Gygnaeus drew a sharp distinction between handicraft or manual arts as part of the general curriculum and handicraft as part of a technical or specialised education (Kananoja, 1989). Furthermore, he insisted that handicrafts should be taught by regular teachers, rather than specialised craftsmen (Bennett, 1937).

Unfortunately, Gygnaeus' ideas for teaching craft were not adopted. In the Committee Report (1912), the aims of teaching handiwork were based on the ideas of Mikael Soininen, who stated that craft education should be based on the general aims of handicraft training. These aims were in practice the same until the 1970s (Anttila, 1983).

Industrialisation in Finland occurred between the years 1920–1960 and, at the same time, the craft national curriculum began to focus on industrial skills, as such skills were required in society (Kananoja, 1989); little emphasis was placed on the development of students' personalities and the enjoyment of craft work. However, the policy of fulfilling the needs of an industrialised society did not last long. In the Committee Report (1970), it was claimed that craft education was outdated and, influenced by the Norwegian 'Forming' model, the education authorities decided to make craft part of the subject area for art. The Committee Report also emphasised the importance of sexual equality for the first time: it was considered that craft education could develop the important skills needed for everyday life in both sexes. At this time, the name of the subject was changed from craft education to technical craft or textile craft and it was recommended that the number of lessons taught should be considerably decreased. However, these plans never came to full fruition, as the result of a protest by the society of craft teachers. Thus, the impact of the Committee Report, in terms of how the subject was taught in schools, was of little significance.

Technology Education was first introduced in the Framework Curriculum Guidelines (1985), yet its impact on the subject of craft was insignificant. Handicraft skills were still considered of great importance; however, electronics and engineering were incorporated into the subject. The authorities wanted to further develop technology education, but, in practice, this was difficult. They also wanted to preserve the link to the heritage of Finnish craft and support student equality.

In the 1994 Framework Curriculum Guidelines, it was asserted that technology was an important aspect of the development of a modern Finnish society. Sustainability was also introduced into the curriculum. However, technology education was not established as a specific subject and the technological aspect of craft education was not particularly supported. The importance of developing technical literacy in students was emphasised, in order to enable students to adapt to new circumstances and take part in the development of new technologies within a modern Finnish society. It was deemed that students of both sexes should benefit from familiarity with modern technology.

Around 2001, a discussion took place between the authorities and the spokesmen of the craft industry, with regards to the importance of incorporating technology education as an active part of general education in Finland. Unfortunately, these assertions were not taken into account in the Framework Curriculum Guidelines of 2004, with technology merely mentioned in the craft curriculum. Compared to the previous curriculum, few changes were made. The importance of developing students' handicraft skills was underlined, as in the Committee Report of 1970, within the context of the complete process of handiwork. Nevertheless, technology was introduced as part of a specific cross-curricular theme, entitled *The Human Being and Technology*. In the next curriculum 2016, even the name for the subject is expected to be Handicraft. It means that there is a minor emphasis on technology. Instead, the development of students' personalities, the growth of self-esteem and gender issues will be more important.

The development of craft and technology curriculum in Estonia

According to the Schools Act in 1803 and 1804, an upper secondary school was to be established in each provincial town; among other subjects the study program included technology and technical drawing (Andresen, 2003). Schools functioned on the principles of "activity schools" (Arbeitschulen), which were common in the Western Europe and favored maximum application of work education principles at school, which did not mean only craft, but the principle, which should include the whole school and would guide the learner towards independent thinking and activity through work and through physical work, in particular (Põld, 1993).

In the independent Republic of Estonia (1919-1940) consistent work was started with the aim of developing the content and organization of education (Läänemets, 1995). The lessons plans of the seven-year school included the subject of handicraft, which was taught 2 lessons a week in every class (Haridusministeeriumi määrus tunnikava kohta, 1919). In 1940, the Republic of Estonia was incorporated in the Soviet Union. According to the study programs established in schools after WW II, Craft lessons focused on making study aids, including objects for other subjects, as schools lacked means and tools for the subject (ENSV Haridusministeeriumi Koolivalitsus). In the program of the 1954/1955 academic year, the objective of Craft was to develop students' personality, their skills, the ability to handle simpler tools and materials, using accomplishable techniques. In addition, socialist approach to work and collective working was developed in students (Keskkooli programmid 1954/55, 1954).

The directives of the 20th Congress of the Party in 1956 claimed that polytechnic education must be developed in general education schools, guaranteeing that students familiarize themselves with the most important contemporary industrial and agricultural sectors (Štšukin, 1956). At the beginning of the 1960s an innovation in the study plans was students' work for the public good, as well as practical training and practical production practice, at the beginning of the 1980s the trend was towards establishing inter-school production practice plants and the number of Craft lessons per week was increased to four (Rihvk, 1985). At that time various types of tools were made in craft lessons, e.g. surfaced pointers, tin dustpans, which were needed either at school or in the household. Also creative building works were done within decorative wood carving and metal working art. The main aim was to prepare young people, who in the future would mostly become laborers and start working in a public economy sector.

On August 20, 1991 the Supreme Council of the Republic of Estonia passed the decision that Estonia no longer belongs to the Soviet Union and is an independent republic. In 1992 the Ministry of Education established the Craft programs for Grades 5 to 9 in general education schools (Eesti NSV Haridusministeerium, 1992). Classes were divided into two groups (boys and girls) and the program intended for a material-technological system in craft for grades 5 to 9, which meant that teaching various techniques is carried out through producing object of common need, whereas the goal orientation towards the usefulness of the objects for the society was essential. The program for boys had ten different parts: general technical training, woodwork, metal work, decorative wood carving, metal working art, electro-technical work, design and technical modelling, gardening and agriculture, and cording. Four different parts of it were expected to be taught (Eesti NSV Haridusministeerium 1992, pp. 4-5).

The 2002 curriculum established that the craft syllabus for basic schools has four different syllabi: handicraft for grades 1 to 3; handicraft, home economics, and craft and technology education for grades 4 to 9. The main content of craft and technology education was connecting national experience, innovation, and modern technology with students' purposeful creative practical work. **(**Põhikooli ja gümnaasiumi riiklik õppekava**,** 2002).

Later on, the regulation established by the government of the republic in 2011, states that the subjects of technology domain are craft, technology education, and handicraft and home economics. Craft is taught in grades 1 to 3 (girls and boys together). At the 2nd stage of study the students are divided into study groups based on their wishes and interests, selecting either handicraft and home economics or Technology studies. This allows students to study in greater detail the subject that they are interested in. The division into study groups is not gender-based, but in practice Technology education in grades 4 to 9 was mostly chosen by boys and handicraft / home economics in Grades 4 to 9 mostly by girls (Ainevaldkond "Tehnoloogia", 2011)

The teaching focuses largely on pupils' purposeful and creative innovation, where along with the joy of discovery they experience creating a selected object. Students perform interesting and imaginative creative tasks of applied nature, including the planning of a task or a product, designing and producing it, as well as self-evaluation and presentation of the work. Connections and applied outputs between the subject and spheres of life are pointed out, so that pupils get a complete understanding of the task or the product. It is important that students understand how technology works and they can take part in creating technology that corresponds to their abilities. Students' varying abilities and interests are taken into account and their initiative and motivation to learn is supported. The subject stresses the importance of invention and shapes students' professional behaviors and value judgments. The objective is to value ecological attitude and local traditions, as well as attain ethical beliefs. (Ainevaldkond "Tehnoloogia", 2011).

The development of craft and technology curriculum in Iceland

The originators of pedagogical craft education in Iceland introduced the ideology of Scandinavian Sloyd to Icelandic educators around 1900. Consequently, their work provided the basis for the establishment of school laws, in terms of general craft education and curriculum development. The first public school laws were established in Iceland's parliament in 1907 (Log um fraedslu barna, 1907); however, ideas for craft education were not included in this. The possible reasons for this were a lack of school buildings and facilities, a lack of interest on the part of the authorities and the importance of children working in the economy.

The first National Curriculum for the Education of Children was published in 1929 and this outlined seven years of school education for children living in urban areas and four years of education for children residing in rural areas. The craft industry was still not mentioned in the curriculum, although drawing was recommended as a subject (Eliasson, 1944). Despite this, craft was taught in several schools that had the necessary facilities.

Craft was first established as a subject in 1948. Instruction was gender-based, with craft for boys and textiles for girls (Fræðslumálastjórnin, 1948). The first integral national curriculum for compulsory education was published in 1960: this was gender-divided, but emphasised the general pedagogical values of the subject.

Based on the above law, a new national curriculum was established in 1976-1977 (The Icelandic Ministry of Education, 1977). In this curriculum, craft education was incorporated as a new subject area, entitled *Art and Handicraft*; this included art, textiles and craft. For the first time, all these subjects were compulsory for both boys and girls, with the curriculum being slightly revised in 1989.

In 1999, Craft was re-established as a technological subject, under the heading of *Design and Craft* (The Icelandic Ministry of Education, 1999): this new subject was based on a rationale of technological literacy, innovation and design (Thorsteinsson, 2002; Thorsteinsson & Denton, 2003). The curriculum was ambitious and made significant strides towards the education of technology. However, many teachers felt this was a step too far and felt uncomfortable utilising electronics in lessons. They lacked sufficient knowledge, skills and interest, with regards to the teaching of technology (Olafsson, Hilmarsson & Svavarsson, 2005).

When the national curriculum was revised in 2007, the education authority decided to seek suggestions from the Design and Craft Teachers' Association, in terms of the teaching of Design and Craft. Taking the teachers' views into account, it was decided to minimise the technological part of the Design and Craft curriculum and the original Sloyd values were once again included in the curriculum (Olafsson, Hilmarsson & Svavarsson, 2005).The curriculum moved away from the manufacturing process (i.e., mass production) and towards handicraft-based processes. Today, innovation and idea generation are still an important part of the curriculum (Olafsson & Thorsteinsson, 2010), as is encouraging students to organise their work. New aspects of the curriculum are outdoor education, green woodwork, sustainable design and health and safety. Teachers have gained increased freedom, in terms of following the school curriculum and managing their teaching, as there are no longer any aims listed each year. The main changes in the development of the three curriculums are presented in Table 1.

Table 1. The main changes in the national curriculums for Craft and Technology in Finland, Estonia and Iceland

Finland	Estonia	Iceland
1866 Statute of folk school -Craft compulsory school subject	1894 Russian law -Craft was officially a part of the curriculum for general education	The first public school laws in 1907 --Ideas for Craft education were not included.
1952 Committee Report -focus on industrial skills - using industrial machines deemed important	1954 Secondary school programs - focus on polytechnic education - develop students' ability to work with simpler tools and materials	The first National Curriculum for the Education of Children in 1929 -Craft was not mentioned. Despite this, craft was taught in schools that had the necessary facilities.
1970 Committee Report -pedagogical background for Craft education was introduced - large emphasis on gender equity	1961 Secondary school study plans - practical production and inter-school production practice plants -students' work for the public good	Craft was first established as a subject in 1948. Instruction was gender-based, with craft for boys and textiles for girls
1985 Framework Curriculum -concept of technology introduced -cultural heritage in Craft education made important	1992 Programs for general education -Craft separately for boys and girls -teaching various techniques -usefulness of the objects for the society was essential	In 1977 curriculum, Craft education was incorporated as a new subject area, entitled *Art and Handicraft*. -Both subjects were compulsory for both boys and girls.
2004 Framework Curriculum -students' personality development highlighted	2002 National curriculum for basic schools and upper secondary schools	In 1999 Craft was re-established as a technological subject, under the heading of *Design and Craft*

-enjoyment in doing craftwork and self-esteem deemed important	-Craft and Technology Education for grades 4 to 9 (mostly boys) -basic knowledge and practical skills in present-day engineering and technology	-The new subject was based on a rationale of technological literacy,
2016 Framework Curriculum -ideas on the name of the subject are exchanged? -additional lessons are requested for the subject in primary level?	2011 National curriculum for basic school -Technology education for grades 4 to 9 (study groups based on students' wishes and interests) -project works (girls and boys together)	In 2007 national curriculum was revised, the technological part was minimized and the original craft values were once again included in the curriculum. -innovation and idea generation still an important part of Craft education

Empirical research

The aim of the quantitative aspect of the research was to answer the question: *Are there differences in students' attitudes towards craft and technology in Finland, Estonia and Iceland?* Dyrenfurth (1990) and Layton (1994) referred to attitudes in technology education using the concept of 'technological will'. According to these authors, technology is determined and guided by human emotions, motivation, values and personal qualities. Thus, the development of technology is dependent on the students' will to take part in lessons and on the impact of their technological decisions.

In order to evaluate students' attitudes towards craft and technology in Finland, Estonia and Iceland, a questionnaire was devised, consisting of 14 statements. For each Likert-type item, there were five options, from 'Strongly Disagree' (= 1) to 'Strongly Agree' (= 5). The questionnaire also featured some questions about students' backgrounds, in addition to questions that attempted to gauge students' motivation and success, in terms of craft and technology education classes. The questionnaire was based on the PATT standards (Pupils Attitudes Towards Technology), which were designed and validated by Raat & de Vries (1986) and van de Velde (1992). Reliability measured by Cronbach alpha was 0.84. Totally 658 students took part in the survey. The age of the student-respondents was 11-13 years.

According to Autio (1997), de Klerk Wolters (1989), Fensham (1992) and Lauren (1993), we could assume that there would be differences in individuals' attitudes towards technology. Therefore, we tried to find out whether there were any differences between the respondents. This was done by conducting the one tailed t-test, with the same variance, on boys and girls. In the entire Finnish, Estonian and Icelandic groups, we employed the two tailed t-test, as we had no hypothesis based on the previous research.

Results

Several differences in students' attitudes towards craft and technology were found in the three countries. The average response in our Likert-style (1-5) questionnaire to all 14 items was among Finnish girls 3.37, Estonian girls 3.55 and Icelandic girls 3.67. Significant statistical difference was found between boys and girls (p=0.001), whereas the average response of boys was in Finland 3.78, Estonia 4.00 and in Iceland 3.87. Estonian boys had the most positive attitude towards technology, whereas the lowest attitude was found among Finnish girls. The difference between boys and girls was definitely the smallest in Iceland. The averages for all 14 items in each country are presented in Table 2.

Table 2. Average (Mean) values for each statement, with regards to the measurement of students' attitudes towards craft and technology in Finland, Estonia and Iceland

Statement	Gender	Average Finland	Average Estonia	Average Iceland
1. Is interested in engineering and the phenomena related to it	girls	3.45	3.32	3.55
	boys	4.30	4.40	4.40
2. Spends a lot of time with engineering-related hobby activities	girls	<u>2.71</u>	<u>2.02</u>	<u>2.82</u>
	boys	3.06	3.44	3.58

3. Newspapers, magazines, and articles from the field of engineering are interesting	girls	2.35	2.87	2.82
	boys	2.83	3.50	3.00
4. Understanding engineering-related phenomena will be beneficial in the future	girls	3.45	3.59	3.59
	boys	3.95	4.43	3.95
5. Understanding engineering-related phenomena requires a special wit	girls	3.55	3.50	3.16
	boys	3.60	4.16	3.70
6. Both boys and girls may understand engineering-related phenomena	girls	4.62	4.42	4.82
	boys	4.29	4.22	4.60
7. The mankind has rather benefited than sustained damage from the development of engineering	girls	3.85	3.89	3.98
	boys	4.25	4.29	4.23
8. In the future would like to choose a specialty or a profession related to engineering	girls	2.40	2.40	2.55
	boys	3.25	3.39	3.25
9. Parents have a lot of engineering-related hobbies	girls	2.98	2.61	3.07
	boys	3.09	2.96	2.88
10. The atmosphere in the Technology Education / Craft lessons is pleasant and inspiring	girls	3.56	4.32	4.07
	boys	4.24	4.11	4.03
11. Technology Education / Craft lessons considerably contribute to the development of manual skills	girls	3.85	4.56	4.66
	boys	4.25	4.56	4.50
12. Technology Education / Craft lessons develop logical thinking	girls	3.60	4.12	3.89
	boys	3.84	4.24	3.93
13. Has been successful in Technology Education / Craft lessons	girls	3.49	3.99	4.55
	boys	3.80	3.93	4.25
14. Technology Education / Craft lessons will be beneficial in the future	girls	3.51	4.09	3.82
	boys	3.90	4.39	3.88
All 14 items	girls	3.37	3.55	3.67
	boys	3.78	4.00	3.87

The highest average values in the whole questionnaire were found in statement 7: Both boys and girls may understand engineering-related phenomena. The highest average responses were among Icelandic girls 4.82, Finnish girls 4.62 and Icelandic boys 4.60. No significant statistical differences (p=0.21) were found between boys and girls. This is a clear sign that gender issues in technology education are adopted by both boys and girls. The averages for statement: Both boys and girls may understand engineering-related phenomena are shown in Figure 1.

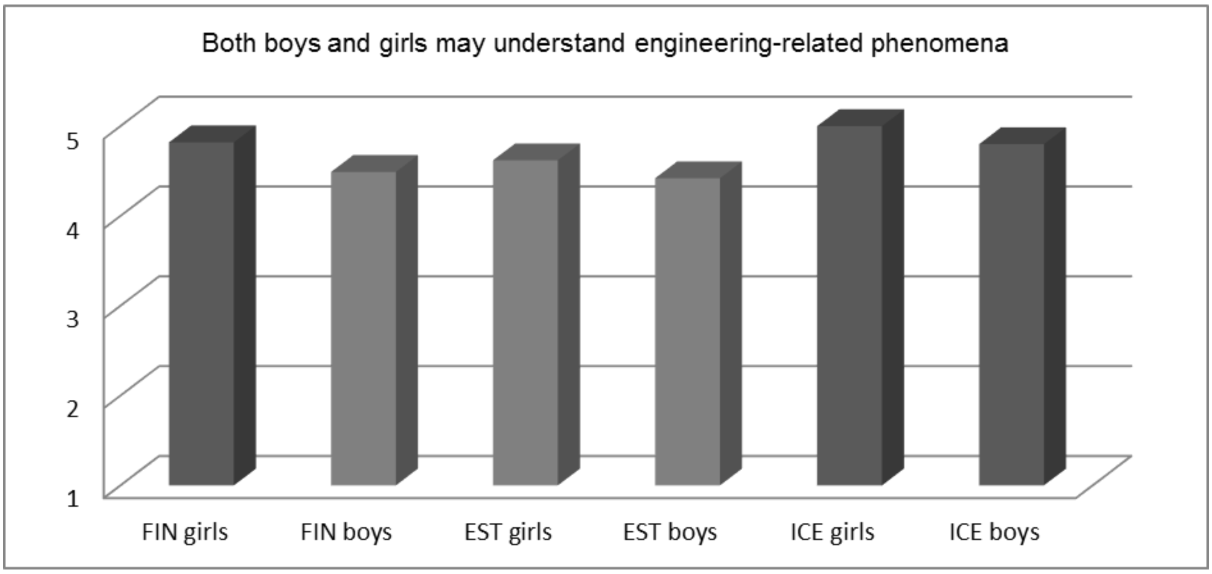

Figure 1: Shows the average values in statement: Both boys and girls may understand engineering-related phenomena

Another statement with high loadings was number 11: Technology education / craft lessons considerably contribute to the development of manual skills. The highest average responses were among Icelandic girls 4.66, Estonian boys and girls 4.56 and Icelandic boys 4.50. Interestingly there was a significant statistical difference (p=0.001) when compared with Finnish girls 3.85. In general, it seems that it is not surprising that both boys and girls are attracted to craft and technology education because they enjoy working with their hands and like the independence and chance for creativity provided by these classes (Silverman & Pritchard, 1996). It is obvious that several other school subjects have more motivational problems than technology education (Shernoff, Csikszentmiahlyi, Schneider & Shernoff, 2003). The averages for statement: Technology education / handicraft lessons considerably contribute to the development of manual skills are shown in Figure 2.

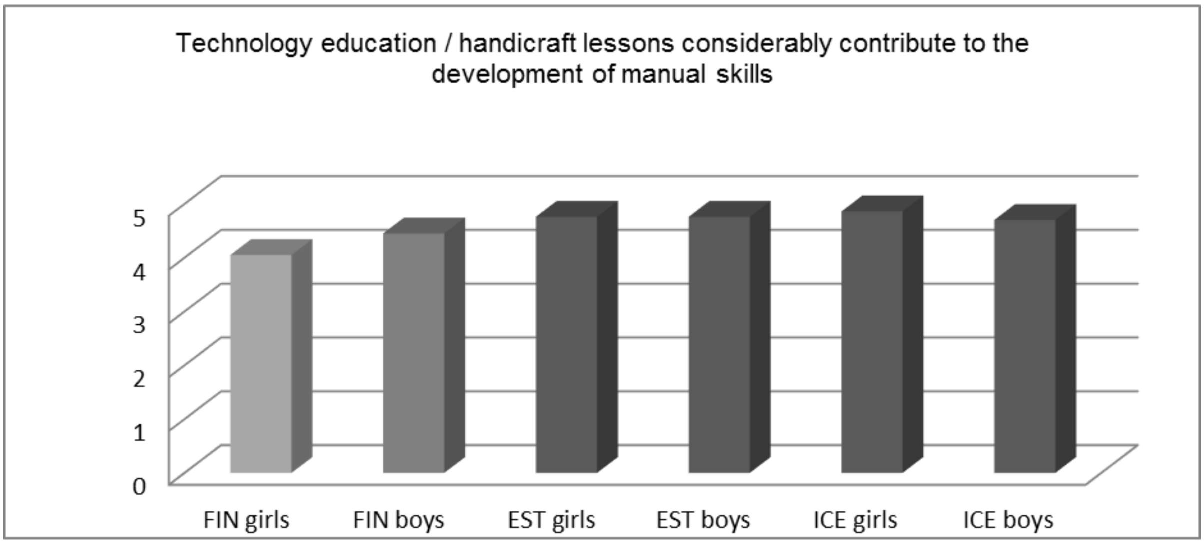

Figure 2: Shows the average values in statement: Technology education / handicraft lessons considerable contribute to the development of manual skills

The lowest value was found in statement 2: Spends a lot of time with engineering-related hobby activities. The average response among Estonian girls was 2.02 followed by Finnish girls 2.71 and Icelandic girls 2.82. Difference between boys and girls was statistically very significant ($p<0.001$) whereas Icelandic boys scored 3.58 and Estonian boys 3.44. The averages for statement: Spends a lot of time with engineering-related hobby activities are presented in Figure 3.

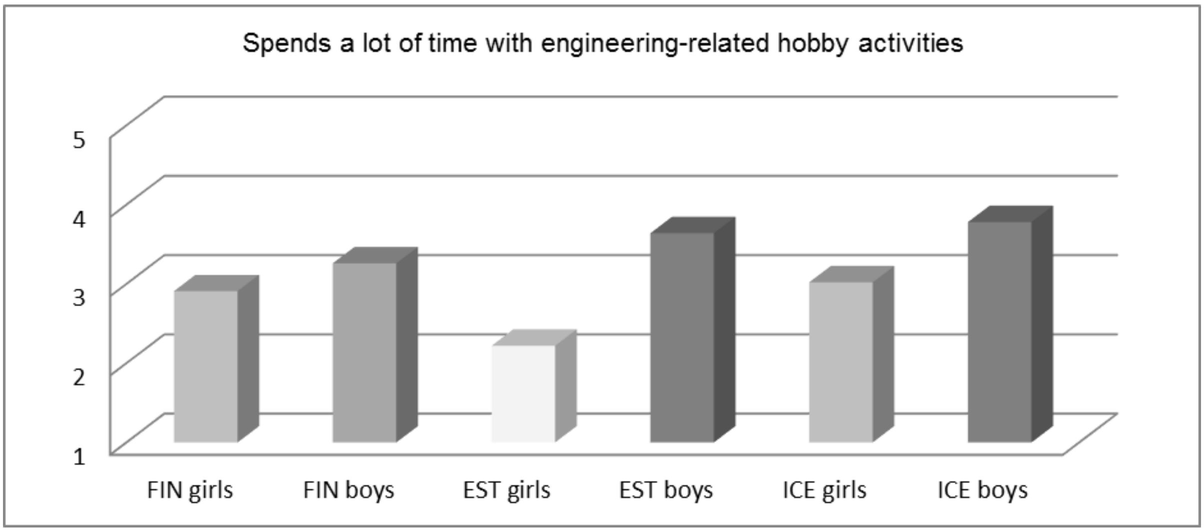

Figure 3: Shows the average value in statement: Spends a lot of time with engineering related hobby activities

Another statement with low values was number 3: In the future would like to choose a speciality or a profession related to engineering The lowest average responses were among Finnish and Estonian girls 2.40 followed by Icelandic girls 2.55. Again, statistically very significant difference ($p<0.001$) was found whereas Estonian boys scored 3.39 followed by and Icelandic and Finnish boys 3.25. This is consistent with Eccles (2007) who states that males will receive more support for developing a strong interest in physical science and engineering from their parents, teachers and peers than females. In addition, it is absolutely the case that all young people will see more examples of males engaged in these occupations than females. The averages for statement: In the future would like to choose a speciality or a profession related to engineering are presented in Figure 4.

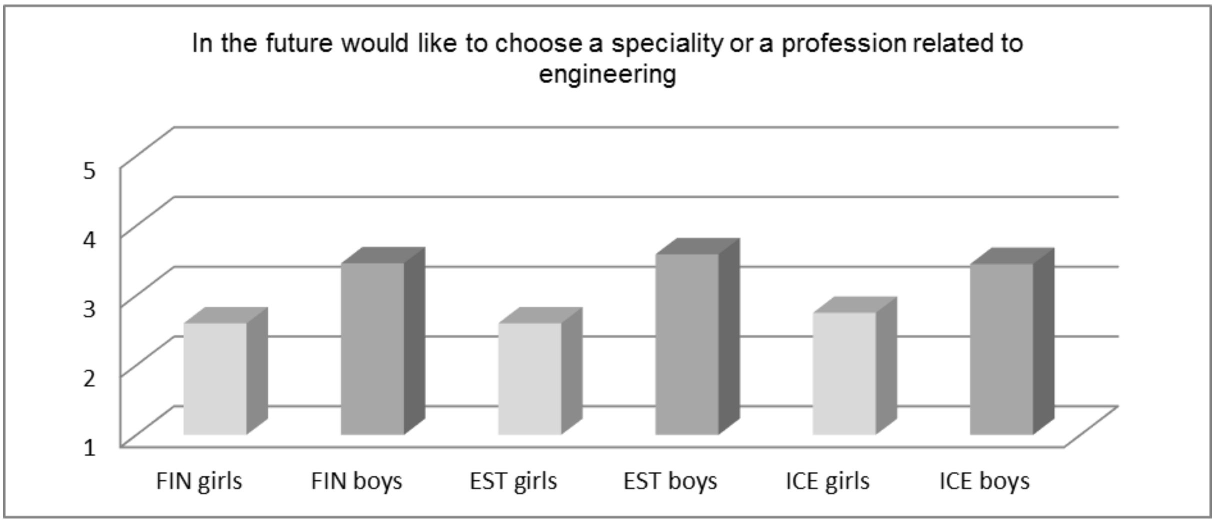

Figure 4*:* Shows the average values in statement: In the future would like to choose a speciality or a profession related to engineering

The highest correlation (0.76, $p<0.001$) to the average of other statements was found in statement 1: Is interested in engineering and the phenomena related to it. The statistical difference ($p<0.001$) between boys and girls was also the highest in this statement. Highest value was found among Estonian and Icelandic boys 4.40 followed by Finnish boys 4.30. Lowest value was scored by Estonian girls 3.32. The difference between boys and girls interest areas can be seen in practice, at least in Finland, where boys still want to choose technical craft studies and the girls' textiles (Autio, 1997; Autio 2013). The averages for statement: In the future would like to choose a speciality or a profession related to engineering are presented in Figure 5.

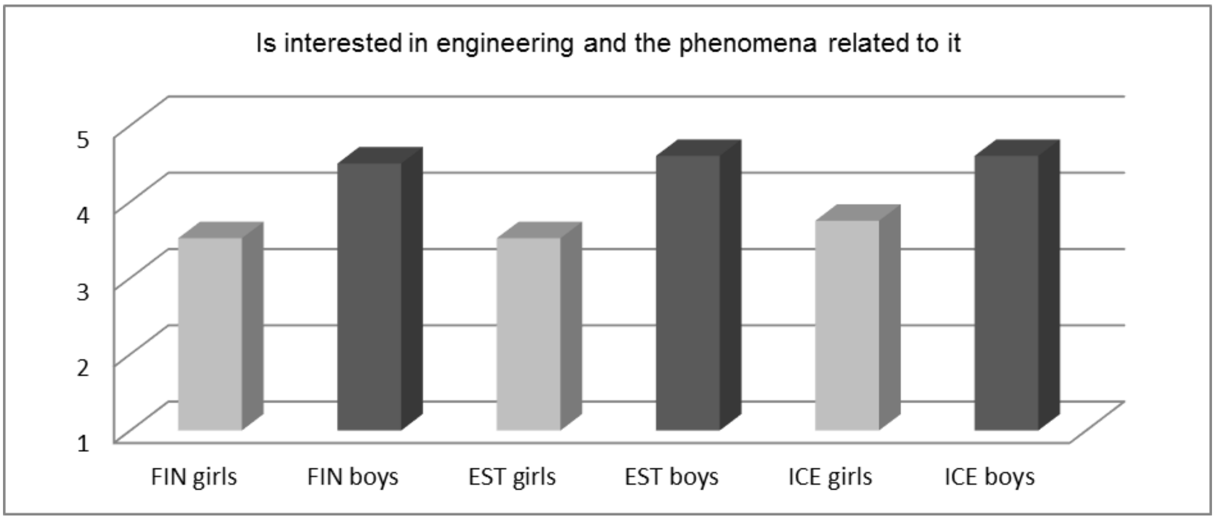

Figure 5: Shows the average value in statement: Is interested in engineering and the phenomena related to it

Conclusions and Discussion

Craft education in Finland, Estonia and Iceland originated over 140 years ago and was influenced by the Scandinavian sloyd pedagogy. In the beginning, the subjects largely focused on students copying artefacts, using a variety of handicraft tools: the purpose of this was to improve their' manual skills, rather than their thinking skills. At that time various types of artifacts were made in craft lessons, e.g. surfaced pointers, tin dustpans, which were needed either at school or in the household. In 1960's especially in Estonia an important aim was to guarantee that students familiarize themselves with the most important contemporary industrial and agricultural sectors and ensuring a tight connection between teaching and public work, as well as to cultivate communistic approach to work in the young generation. Also in Finland one of the main aims was to prepare young people, who in the future would mostly become laborers and start working in a public economy sector. However, to day the focus is much more on developing students' thinking skills, which enables them to work through various handicraft processes (from initial ideas to the final products). This work is based on the idea generation of students and is thus expected to increase their self-esteem and ingenuity.

The literature review also highlighted that during the past twenty years the understanding of technology and its relationship to society has been emphasized. The technical development of society makes it necessary for all citizens to be prepared to use technical adaptations and to be able to exert an influence on the direction of technical development. Furthermore, students regardless of gender must have the opportunity to acquaint themselves with technology and to learn to understand and avail themselves of its uses.

Despite the origins of craft education in Finland, Estonia and Iceland being similar, nowadays the Estonian and Icelandic national curriculum place greater emphasis on technological aspects, design and innovation, whereas the Finnish national curriculum focused on the development of students' personalities and gender issues. What's more, in Finland there is just on subject - Craft education, but it is in practice further divided into technical work and textile work, whereas in Estonia and Iceland the curriculum allows more flexibility. In Iceland art based textile education and innovation based technology education, compulsory for both sexes, seem to be relatively good setup for gender equity as the difference in attitudes was the smallest in Iceland. In Estonia technologically based 'technology' and 'handicraft / home economics' gives students an opportunity to choose study groups based on their wishes and interests, and allows students to study in greater detail the subject that they are interested in.

In the quantitative part of the research, several differences in students' attitudes towards craft and technology were found in the three countries. Definitely, the smallest difference between boys and girls was found in Iceland. This finding corroborates with comparable results from Autio, Soobik (2013) and Autio, Thorsteinsson and Olafsson (2012) which shows that Icelandic girls performed better attitudes than both Estonian and Finnish girls. This is an interesting finding as the Finnish curriculum has put large emphasis on gender equity since 1970, but still Finnish girls had the most negative attitude towards technology. Finnish girls seemed to be aware of the gender equity and their highly agree with the statement: both boys and girls may understand engineering-related phenomena. However, only a few girls are willing to challenge stereotypes about non-traditional careers for women, as it could be conducted from responses to the statement: in the future would like to choose a speciality or a profession related to engineering. This phenomenon seems to be true in Estonia and Iceland as well. Gender-based segregation and falling recruitment for scientific and technological studies are common phenomena in all the Nordic countries (Sjøberg, 2002). However, it is a paradox that the inequity is noticeable in Finland where for decades gender equality has been a prime educational goal.

In addition, only few girls seemed to have technological hobbies or had interest in technological articles. What's more, in Finland the boys still want to choose technical craft studies and the girls' textiles (Autio, 1997; Autio 2013). A practical solution to get both sexes to choose both subjects has not been found, although it is obvious that boys and girls have different interest areas as seen in responses to the statement: Is interested in engineering and the phenomena related to it. Finnish and Estonian craft and technology education curriculum could benefit from Icelandic system with two different subjects: art based textile education and innovation based technology education, compulsory for both boys and girls.

The Estonian boys' attitudes towards craft and technology were most positive. It indicates that the Estonian curriculum that includes two different craft subjects: the technologically based 'technology' and 'handicraft / home economics' is still a relatively motivated setup especially for boys, because they can concentrate in greater detail to the subject that they are really interested in. In addition, the innovation and technology part: technology in everyday life, design and technical drawing, materials and processing with exchanged study groups works fine for both boys and girls. On the other hand, motivation in technology education can be significantly improved by developing special programs (Mammes, 2004), where teachers are aware of the differing interests of both genders and consider ways of making the environment and the subject attractive to all (Silverman & Pritchard, 1996).

The critical side of the study is that the study group consisted only from 11-13 year-old students and in Estonia only 11-year-olds. This concentration only in the younger students may have had a small effect in the results. Although students' attitudes are assumed to be rather stable during the school years (Arffman & Brunell, 1983; Bjerrum Nielsen & Rudberg, 1989); Autio, Thorsteinsson and Olafsson (2012) found that there was significant statistical difference between 11 and 13 year old Finnish girls in attitudes towards technology. Furthermore, no statistical difference was found between younger and older Finnish and Icelandic boys or between Icelandic younger and older girls.

Another critical point of the quantitative part was the use of a relatively small sample of students compared to whole population. In addition, the amount of students varied a little bit between countries. However, 658 students seemed to be enough as the results are consistent with previous studies (Autio, 1997; Autio, Thorsteinsson & Olafsson, 2012; Autio & Soobik, 2013). As the whole technological culture is different in these three countries, we must notice that, the questionnaire measures only students' attitude, not their absolute technological will which is shaped and guided by the whole society, human emotions, motivation, values and personal qualities. The concept attitude is just a single one part of a larger concept, which is 'technological competence'. However, attitude is a crucial part of the competence as it has a remarkable effect on technological knowledge and technological skills in real life situations.

The reasons behind the dissimilarities found between the three countries may be due to differences in the curriculums and in different pedagogical traditions. Besides, in Estonia there was still some influence from Tsarist Russia with a tight connection between teaching and public work, as well as to cultivate ideological approach to work in the young generation. On the other hand, the political situation has considerably changed in Estonia and the motivation for further development seems to be ambitious also in education, including the syllabi of craft and technology education. However, further research is needed before the authors can reach their final conclusions. We are continuing our efforts in several related projects.

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General High School Students' Opinions on the Use of Project FATIH (Sample of Muratpaşa District of Antalya Province)*

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Abstract

The purpose of this study was to determine the opinions of general high school students regarding the usage level of project FATIH started to be implemented in the academic year 2012 – 2013. In this study, survey method was used and the sample of research consisted of the 375 students studying in 16 high schools in which the project FATIH was being implemented in Muratpaşa district of Antalya. For the statistical analysis, by the help software SPSS 18.00 and LISREL 8.54, frequency, percentage, mean, standard deviation, t-Test, LSD, and One-way ANOVA tests were used. According to the results obtained from the study, regarding the usage level of Project FATIH, students had "medium" level positive opinion in terms of the factors "Use of e-content", "Training requirement", and "Institution adequacy" while they had "high" level of positive opinion on the factors "Teaching processes" and "Self-adequacy and project yields". In addition, for the findings it can be said that students studying in the branch of social sciences had lower positive opinion on the usage of e-content during courses. Finally, it is understood that 9th grade students had very high level of opinion in terms of all dimensions with respect to their friends in higher education levels..
Keywords: Project FATIH, Student Opinions

Introduction

Technology originating from the word "technic" in Greek and the science related to technic in its grammatical meaning can be defined as the artefact of the science (Işık, 1981:159, Alkan, Deryakulu, & Şimşek, 1995:81). In other words, technology can also be defined as "the applied information source for improving the efficiency of the production and marketing of available goods and services and for producing new goods and services" (Dunning, 1993:10).

20th century is a more productive century in which the relationship between the technology and the science is exactly expressed and in which there are too many discoveries for the other social development issues. Technological developments revealed some irreversible improvements in many areas such as communication, transportation, production, battle, medicine and also are the trigger for important debates. After the benefits provided by the systemic relationship between practice and academic assumptions, technological progress has been carried out by the specialized researchers in the research and development laboratories funded by industrial companies and governments (McNeill, 2003:651).

Without a doubt, the most intensive application of technological developments is in the field of education. Therefore, education processes are directly affected by the technological developments. Orhan and Akkoyunlu (2003) revealed that technological developments affect the progress of the education, not only in only one aspect but also in many aspects. According to many authorities, an integration between technology and education will make the whole processes, which include everything from the learning environment to the learning materials, more efficient, and as a result, more qualified individuals will be grown up (İnel, Evrekli, & Balım, 2011:129).

According to Aggarwal (2000), 21st century have the features below:

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- Independent of space and time
- Directed to the aim and the result,
- Student-centred,
- Focused on active team-work,
- Directed to get “learning” as output,
- Including differences in between ability and language (Yılmaz & Horzum, 2005:110).

At this point, in the light of the reasons mentioned above, it would be appropriate to talk about the concept of educational technology. Rıza (1997) described the educational technology as "a discipline that plans the learning systems, determines all possible methods, sources, and communication tools of that learning system, complements creative instructional techniques available for providing the most efficient and positive learning" (Rıza, 1997:27). In addition to this definition, Alkan (1997) explained the relationship between process, learning stage, and the environment in the context of educational technology with the expression: "it is related with the execution of education and activities for setting up the stage and adjusting the environment about determining the behaviours, educational status, and actions for giving roles.” Moreover, Çilenti (1998) described the educational technology as "a discipline studying on making individuals reach to the special aims of education by evaluating the results and by using accessible sources about the educational data of behavioural sciences' communication and learning, manpower and non-manpower sources brilliantly and skilfully".

As it is known, there are three main elements of education: teacher, student, and environment. If communication between these elements is to be healthy, this is the duty of educational technology. In order to achieve the desired quality of education, achieving the goals of education by using the technology is a requirement for our century. Similarly, to avoid keeping away from developments in science and technology, developing the educational system and getting the standards of the current age are obligatory. Society, individuals within a society and knowledge are renewing themselves and therefore education must also be updated. In this update process, answering the questions on what the specific environments and technologies of education are and in which ways the objectives of education and training will be carried out are in the scope of educational technology. (Numanoğlu, 1995:67).

In the learning process, one of the factors that encourages students to focus on is the use of technology. By this way, while the student's self-confidence and motivation levels are increasing, their cognitive skills are also improved (Heafner, 2004:47). Of course, to provide these benefits, there are some important duties for teachers. Roblyer and Edwards (2005) focused on the teachers about the use of technology and studied on the reasons of why teachers used technological materials in their classrooms. According to this research, teachers' and therefore students' reasons for using technology are as follows:

a. Motivation,
b. Educational skill,
c. Increased productivity of the teacher,
d. Required skills in the information age,
e. Supporting new instructional methods.

In the literature, there are researches that are focusing on how and how much integration between technology and educational processes is provided. Hew and Brush (2007) emphasized the necessity of this integration but also they argued that for the schools, there would not be an exact definition of this integration. Ajjan and Hartshorne (2008) agree that usage of internet and desktop software like word processors and spreadsheets installed on desktop and laptop computers in schools, if they are used for educational purposes, is the indicator of the integration of technology. Cuban, Kirkpatrick, and Pack (2001) showed that this integration can be a high-level or a low-level integration. According to their study, low-level integration is only the simple usage like making researches on internet in schools, while high-level integration is doing some more complex duties like preparing multimedia presentations, collecting data and explaining data for the projects.

As a result of the improvements in the electronic world, computers occupied a big place in our lives and therefore it is assumed that today's technology and computers are synonyms. In this regard, when educational technology is mentioned, it is inevitable that the education should get the support of computers. Examined in the context of educational technology, the usage of computers as a teaching-learning tool is more important than its usage on other fields. Because, the main function of educational technology is to ensure the teaching-learning process more efficient and effective. There are different classifications of computers in terms of their services and type of their usage in education. According to a classification made by Taylor, computers in teaching process are used (Taylor, 1980:7):

- "As a tool to process words, information and numbers,
- As a learner in a case in which a student uses computer to perform a task, in the simulation environment under the control of the user, and in a case which was created by expert systems and by programming languages,
- As a tutoring media that enables to teach a subject through a computer software."

In the view of Akpınar et al (2005), education is performed under a strict control of teachers for years and the teacher is only the person who gives information. After the students took the primary place in the process of information construction, teachers' role also changed and mainly they became a guide in this process. Although students are in the centre of learning, this process became more obvious by the gains of the computer aided instruction (Bayturan, 2008:11). Computer aided instruction is the use of computers in teaching process not as an option but as an element making the system more powerful (Uşun, 2004:40)

The pioneer ideas on computer aided instruction had been put forward in the 1980s and the first attempts had been in 1987. In 1988 - 1989 academic year, the first project titled "Project of Computer Aided Instruction" began to be carried out. Nowadays, the project carried out by the Ministry of National Education and titled "The Project of FATIH (The Movement of Increasing the Opportunities and Making Technology Better) in Education" is a popular subject in the context of a reform on educational technology.

The Project FATIH announced by the Ministry of National Education in December in 2010 has the purpose of supplying broadband internet access in all classrooms and providing the necessary hardware in the context of improving the school's technological infrastructure. In addition, creating educational electronic contents (e-content) and integrating these e-contents with the teaching processes are the objectives of the project (Perkmen & Tezci, 2011:6). To perform these objectives, smart boards and auxiliary technological equipment will be provided for primary and secondary schools in the whole country, teachers and students will be given tablet pcs, tablet pcs will have the whole related textbooks, and many of the educational materials will be reached over the Internet. For teachers, an in-service training that aims to adapt teachers for the new technological instruments is also planned (Öncü, 2013:394; MEB, 2013). Some of these applications has been carried out and some of them are still waiting to be carried out since the project is still at the stage of supply.

A research conducted by Dinçer, Şenkal, and Sezgin (2013) points out that although students computer literacy is very low, their attitudes towards the project is very high. In addition, in Sünkür, Arabacı, and Şanlı's (2012) study that investigated the usage of smart boards it was expressed that students have positive attitudes towards using smart boards during courses. In another study that was examining the usage of smart boards during lectures again, Kırbağ-Zengin, Kırılmazkaya, and Keçeci (2011) had a conclusion that, similar with the Sünkür and et al.'s work, students had positive feelings with using smart boards but this positive feelings might arise due to curiosity and as time goes by another study had to be performed. In a qualitative research studied by Pamuk, Çakır, Ergun, and Yılmaz (2013), there were noted very interesting results in terms of the usage of smart boards by teachers and the tablet-pc's by students. According to results of that study, teacher's regard a smart board is a new type of projection tool, and all students and teachers suffer from the disconnection between smart boards and tablet pc's. When the literature on the project FATIH, it can be seen that there are so many researches on different aspects of the topic, however, it is hard to see studies investigating the attitudes for different variables like gender, educational level and branch.

In the light of the information above, the aim of this study is to determine the opinions of general high school students on the use of the Project FATIH. For this purpose, answers for the questions below are sought:

1. What are the opinions of general high school students on the use of the Project FATIH?
2. Do the opinions of general high school students differentiate significantly in terms of students' gender, branch, and education level?

Method

Research Pattern

In this study, which is aimed to determine the opinions of general high school students in the Ministry of National Education in Muratpaşa District of Antalya, individual survey model was used.

Population and Sampling

Population of the study consists of 14.185 students studying in 16 different high schools where the Project FATIH is carried out in Muratpaşa district of Antalya Province in 2012 - 2013 academic year. While considering the Alpha level as .05, the sampling calculation is performed by the formula below (Özdamar, 2003:116-118). (N: Number of units of population, n: Sampling size, Z_α : α= (for 0.05) 1.96, d= Sampling error, σ= Standard deviation of the population)

$$n= \frac{N.\sigma^2.Z_\alpha}{(N-1).d^2}$$

As a result of this calculation, a random sampling that has 375 (3%) students in 16 different high schools in which the Project FATIH was being carried out was used.

Data Collection Tool

While trying to determine the opinions of general high school students on the use of the Project FATIH, a literature review was carried out and the questionnaires in the literature were investigated. The survey titled "Survey for the Project FATIH" which was prepared by the team of the Project FATIH working for the Ministry of National Education was redesigned and survey's items were adapted for students. Items obtained after literature review were also added to the survey and so a survey that has a total of 40 items was obtained. This survey was necessary to be used because opinions of students could be revealed by the points it deals. To perform the analysis on the opinions, the survey played a key role to gather data from participants. Since the validity and the reliability of the survey redesigned would be implemented, for that pre-analyze process, there was no need to work on the survey prepared by the Ministry of National Education. After taking the experts' opinions for the redesigned survey's items, the survey in a format of 5-point Likert type that has the options "Strongly agree, agree, neutral, disagree, strongly disagree" was delivered to general high school students. The analysis of the quantitative data was made by considering the range analysis of 5-point Likert Scale: (1,00 - 1,80) Very low, (1,81 - 2,60) : Low, (2,61 - 3,40) : Medium, (3,41 - 4,20) : High, (4,21 - 5,00) : Very high

Analysis

For the overall objective of the study, data collected in order to find answers for the sub-problems was entered directly into the computer and to perform the statistically analysis on data SPSS 13.0 and LISREL 8.54 software packages were used. To determine the opinions on the use of the Project FATIH, by the help of the software package SPSS, frequency (f), percentage (%), mean, standard deviation, t-Test, LSD and one-way ANOVA analysis tests were used. In the study, for the evaluation of all statistical analysis, 0.05 was accepted as the significance level.

According to the exploratory analysis, the value of Kaiser-Meyer-Olkin (KMO) test result was .822 and Bartlett's Sphericity test result was 5375 ($p > .000$). This test measures the adequacy of the sampling size and deals with the size of the sampling. To do that, the size of correlation coefficients and partial correlation coefficients are compared. If the value found by KMO test is below 0.50, it can be said that the value is out of the accepted level, if the value is 0.60, average acceptance; if it is 0.70, good; if it is 0.80, very good; and if it is 0.90, the acceptance level is perfect (Karagöz & Kösterelioğlu, 2008:86-87). In this study, it was seen that KMO test value was higher than 0.60 and Bartlett Sphericity test was meaningful; so factor analysis was be able to be applied for the data.

As a result of factor analysis, to determine under how many factors the survey items were grouped and the compliance of the items' weight, the result of the principal components were investigated. When looked at "Total Variance Explained", it was seen that survey's items were grouped under 10 factors. After offering 5 factors, the Eigen values were 23,370%, 13,525%, 9,892%, 6,647%, and 5,736%; by the way the rate of the total variance explained was also 59,170%.

After the calculations for the validity of the survey above, Cronbach Alpha coefficients were calculated for each of factors separately and for the whole of the survey for reliability. The total reliability level of all factors was .8500. Five factors were also named as "The use of E-content", "Training Requirement", "Teaching Processes", "Self-Adequacy and Project Yields", and "Institution Adequacy" and they had the reliability levels .7990, .8770, .8680, .8010, and .7440 respectively.

After performing the exploratory factor analysis, to verify the factoring structure, a confirmatory factor analysis was applied. As a result of confirmatory factor analysis (Figure 1), fit indexes were ($\chi 2$/df) = 2.441, RMSEA=0,075, GFI=0,88, and AGFI=0,83. Analysed fit indexes, it was seen that the value of $\chi 2$/df was in the range of acceptance and the values of RMSEA, GFI, and AGFI were very close to acceptance range. As a result, the 5-factor structure of the survey was strengthened by the confirmatory factor analysis. Fit indexes of the model and the range of acceptance are given in Table 1.

Table 1. Values of Confirmatory Factor Analysis and Fit Indexes of the Survey about the Opinions of Students on the Use of the Project FATIH

Values	χ^2/df	RMSEA	GFI	AGFI
Model	2,441	0,075	0,88	0,83
Criteria	2-3 *	0,05 - 0,08 *	0,90 - 0,95 *	0,85 - 0,90 *

* Accepted ranges (Schermelleh-Engel, Moosbrugger ve Müler, 2003:52)

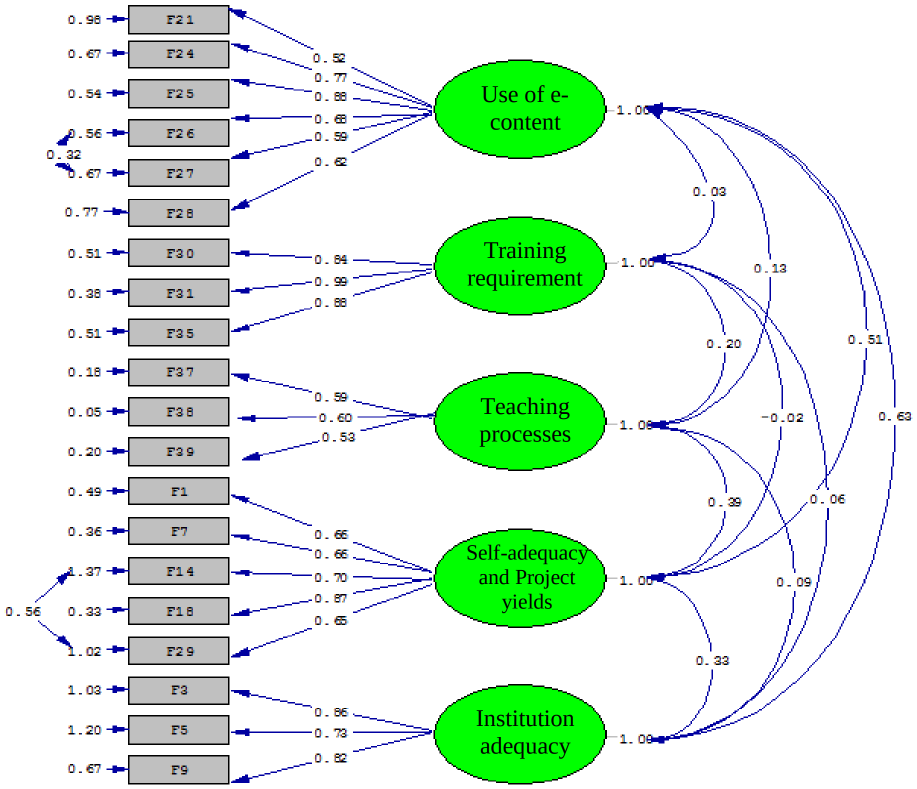

Figure 1: *Model of Confirmatory Factor Analysis of the Survey about the Opinions of Students on the Use of the Project FATIH*

Findings and Interpretations

This section consists of the findings and interpretations obtained by analysing the data of problem statement and sub-problems' statement.

Demographic Characteristics of Students

370 students who were studying in general high schools participated in this research. 193 (52,2%) of students were female and 177 (49,1%) were male. 156 (42,2%) of the students were studying in the branch of Science while 110 (29,7%) of them were studying in Turkish-Math and 13 (4,3%) of them were studying in social science. If we look at the education level of the students, it is seen that 89 (24,1%) of the students are in 9th

grade level, 120 (32,4%) of them are in 10th grade level, 90 (24,3%) of them are in 11th grade level, and 71 (19,2%) of them are in 12th grade level.

Opinions of General High School Students on the Use of the Project FATIH in General

Findings related to general high schools students' use of the project FATIH are given in Table 2.

Table 2. General High School Students' Opinions on the Use of the Project FATIH in General

Factor	$\bar{X}$	SD
Use of E-Content	3,1650	,82455
Training Requirement	2,8422	1,22812
Teaching Processes	3,5724	,84235
Self-Adequacy and Project Yields	3,7591	,85966
Institution Adequacy	2,7419	1,01576

General high school students' use of the Project FATIH had an average value in terms of the factors "use of e-content" ($\bar{X}$ =3,17), "training requirement"($\bar{X}$ =2,84), and "institution adequacy"($\bar{X}$ =2,74); and it had a high value in terms of the factors titled "teaching processes"($\bar{X}$ =3,57) and "self-adequacy and project yields"($\bar{X}$ =3,76).

Looking at the averages above, it can be said that general high school students considered themselves as enough for the use of the project and they had a high level of positive opinion on the yields of the project; however, for the stage of the project implementation, the students did not consider their institution as sufficient.

General High School Students' Opinions on the Use of the Project FATIH According to Gender Variable

Examining the data in Table 3, it was seen that there was no difference in the opinions of the students in terms of the factors "use of e-content" [$t_{(368)}$ = 0,59; p>,05], "training requirement" [$t_{(368)}$ = -0,30; p>,05], "teaching processes" [$t_{(368)}$ = -0,42; p>,05], "self-adequacy and project yields" [$t_{(368)}$ = 0,13; p>,05], and "adequacy of institution" [$t_{(368)}$ = -0,06; p>,05] according to gender variable.

Table 3. t-Test Results for General High School Students' Opinions on the Use of the Project FATIH According to Gender Variable

Factor	Gender	N	$\bar{X}$	S	df	t	p
Use of e-content	Man	177	3,19	,84	368	,59	,553
	Woman	193	3,14	,80			
Training requirement	Man	177	2,82	1,26	368	-,30	,760
	Woman	193	2,86	1,19			
Teaching processes	Man	177	3,55	,84	368	-,42	,671
	Woman	193	3,59	,83			
Self-adequacy and Project yields	Man	177	3,76	,85	368	,13	,890
	Woman	193	3,75	,86			
Institution adequacy	Man	177	2,73	1,01	368	-,06	,949
	Woman	193	2,74	1,02			
	*p<.05, **p<.01, ***p<.001						

Male ($\bar{X}$ =3,19) and female ($\bar{X}$ =3,14) students mentioned that the use of e-content in the lessons had an average level and likewise male ($\bar{X}$ =2,82) and female ($\bar{X}$ =2,86) students had an average level of opinion on whether they needed an education for the use of the project or not. The reason for these results may be the fact that students get familiar with the technology so earlier that they have a high level of ability to use technological devices. In respect to the factor "teaching processes" male ($\overline{X}$ =3,55) and female ($\overline{X}$ =3,59) students agreed that the curriculum and the project had a high level of integration. Both men ($\overline{X}$ =3,76) and women ($\overline{X}$ =3,75) students' average scores showed that they had a high level of self-adequacy on the use of the project and also they had a high level of opinion on the yields of the project.Examined the results obtained for the factor "institution adequacy", it can be said that both male ($\overline{X}$ =2,73) and female ($\overline{X}$ =2,74) students had an average level of opinion. By this result, it can be thought that both genders did not consider their institution as enough for the use of the project FATIH.

General High School Students' Opinions on the Use of the Project FATIH According to Branch Variable

Examining Table 4, it was seen that there was no meaningful difference between students grouped by their branches in terms of the factors "use of e-content" [$F_{(2-276)}$= 0,819 , p<.05], "training requirement" [$F_{(2-276)}$= 0,476, p<.05], "teaching processes" [$F_{(2-276)}$= 0,912, p<.05], "self-adequacy and project yields" [$F_{(2-276)}$= 0,962, p<.05], and "institution adequacy" [$F_{(2-276)}$= 2,792 , p<.05].

Table 4. One-Way ANOVA and LSD Tests Results for General High School Students' Opinions on the Use of the Project FATIH According to Branch Variable

Factor	Source of variance	Sum of squares	Degree of freedom	Mean square	F	p	Meaningful difference
Use of e-content	Between groups	1,044	2	,522	,819	,442	None
	Within groups	175,914	276	,637			
	Total	183,738	278				
	1. Science (3,09, S:0,82) 2. Turkish-Math (3,08, S:0,76) 3. Social Sciences (2,80, S:0,79)						
Training requirement	Between groups	1,365	2	,683	,476	,622	None
	Within groups	395,518	276	1,433			
	Total	396,884	278				
	1. Science (2,82, S:1,16) 2. Turkish-Math (2,94, S:1,24) 3. Social Sciences (2,67, S:1,25)						
Teaching processes	Between groups	1,374	2	,687	,912	,403	None
	Within groups	207,835	276	,753			
	Total	209,209	278				
	1. Science (3,45, S:0,90) 2. Turkish-Math (3,55, S:0,81) 3. Social Sciences (3,26, S:0,99)						
Self-adequacy and Project yields	Between groups	,059	2	,029	,039	,962	None
	Within groups	209,893	276	,760			
	Total	209,952	278				
	1. Science (3,64, S:0,95) 2. Turkish-Math (3,62, S:0,72) 3. Social Sciences (3,58, S:1,05)						
Institution adequacy	Between groups	5,289	2	2,644	2,792	,063	None
	Within groups	261,375	276	,947			
	Total	266,664	278				
	1. Science (2,66, S:0,96) 2. Turkish-Math (2,73, S:1,02) 3. Social Sciences (2,55, S:0,68)						
	*p<.05, **p<.01, ***p<.001						

Although there was no statistically significant difference between students in respect to their branches, it was obvious that students studying on social sciences had a lower positive opinion on the factors "teaching processes" ($\overline{X}$ =3,26 and "institution adequacy" ($\overline{X}$ =2,05) than students studying on other branches. While students studying on the branches science and Turkish-Math had a high level of positive opinion on teaching processes and the integration of the project, students studying on social sciences had an average level of positive opinion. Moreover, while students in science and Turkish-Math branches considered their institutions as moderate enough for the implementation of the project, students in social sciences branch thought that their institution was not enough for the use of the project.

General High School Students' Opinions on the Use of the Project FATIH According to Education Level Variable

As seen in Table 5, in respect to education level variable, there was a meaningful difference between student groups in terms of the factor "use of e-content" [$F_{(3\text{-}366)}$= 4,367 , p<.05]. According to the LSD test which dealt with determining in which groups this difference occured, it was obvious that there was a difference between 9th grade students ($\bar{X}$ =3,4204) and the others (10th grade ($\bar{X}$ =3,1685), 11th grade ($\bar{X}$ =3,0054), 12th grade($\bar{X}$ =3,0412)). Examined the averages, it can be said that 9th grade students thought that there was a high level of e-content usage in their lessons while the rest grade level of students thought that there was a moderate level of usage.

Analysed "training requirements" factor [$F_{(3\text{-}366)}$= 1,021 , p<.05], there was no difference between student groups 9th grade ($\bar{X}$ =2,7621), 10th grade ($\bar{X}$ =2,8754), 11th grade ($\bar{X}$ =2,9992), and 12th grade ($\bar{X}$ =2,6876). According to the averages, students in all grade levels needed training related with the use of the project's elements at a medium level.

Table 5. One-Way ANOVA and LSD Tests Results for General High School Students' Opinions on the Use of the Project FATIH According to Education Level Variable

Factor	Source of variance	Sum of squares	Degree of freedom	Mean square	F	p	Meaningful difference
Use of e-content	Between groups	9,186	3	3,062	4,637**	,003	1-2, 1-3, 1-4
	Within groups	241,688	366	,660			
	Total	250,874	369				
	1.9th grade (3,42, S:0,82) 2. 10th grade (3,17, S:0,77) 3. 11th grade (3,01, S:0,83) 4. 12th grade (3,04, S:0,85)						
Training requirement	Between groups	4,620	3	1,540	1,021	,383	None
	Within groups	551,933	366	1,508			
	Total	556,553	369				
	1.9th grade (2,76, S:1,30) 2. 10th grade (2,88, S:1,22) 3. 11th grade (3,00, S:1,16) 4. 12th grade (2,69, S:1,25)						
Teaching processes	Between groups	10,162	3	3,387	4,926**	,002	1-2, 1-3, 1-4
	Within groups	251,663	366	,688			
	Total	261,825	369				
	1.9th grade (3,86, S:0,69) 2. 10th grade (3,52, S:0,80) 3. 11th grade (3,41, S:0,95) 4. 12th grade (3,52, S:0,87)						
Self-adequacy and Project yields	Between groups	26,630	3	8,877	13,203 ***	,000	1-2, 1-3, 1-4, 2-3,
	Within groups	246,066	366	,672			
	Total	272,696	369				
	1.9th grade (4,13, S:0,71) 2. 10th grade (3,86, S:0,78) 3. 11th grade (3,55, S:0,79) 4. 12th grade (3,40, S:1,02)						
Institution adequacy	Between groups	10,246	3	3,415	3,374**	,019	1-4
	Within groups	370,477	366	1,012			
	Total	380,723	369				
	1.9th grade (2,97, S:1,07) 2. 10th grade (2,76, S:0,96) 3. 11th grade (2,70, S:1,00) 4. 12th grade (2,47, S:1,00)						
	*p<.05, **p<.01, ***p<.001						

There was a meaningful difference between student group in terms of the factor "teaching processes" [$F_{(3\text{-}366)}$= 4,926 , p<.05]. Based on the LSD test detecting this difference and the averages, it can be said that 9th grade ($\bar{X}$ =3,8562) students thought there was a higher level of integration with respect to 10th grade ($\bar{X}$ =3,5187), 11th

grade ($\bar{X}$ =3,4086), and 12th grade ($\bar{X}$ =3,5151) students. Therefore, it was understood that 9th grade students were satisfied with the integration between the present teaching processes and the project at a higher level.

There was also a meaningful difference between the student groups in terms of the factor "Self-adequacy and project yields". According to LSD test results, this difference occured between 9th grade ($\bar{X}$ =4,1284) students and students in all other grades; 10th grade ($\bar{X}$ =3,8581), 11th grade ($\bar{X}$ =3,5468), and 12th grade ($\bar{X}$ =3,3979). Averages indicated that 9th grade students thought they were more sufficient for the application of the project than other grades. In addition they also thought that materials offered by the project would make a considerable contribution to the education processes.

In addition to those differences above, there was also a difference between student groups in the factor "institution adequacy" [$F_{(3\text{-}366)}$= 3,374 , p<.05]. According to LSD test, it was seen that this difference occured between 9th grade ($\bar{X}$ =2,9745) and 12th grade ($\bar{X}$ =3,2408) students. Analysed the means, although both groups believed that their institution was moderate enough for the application of the project, 12th grade students had more positive opinion on this factor than 9th grade students.

Conclusion and Suggestions

Among students, analysed their opinions on the use of the Project FATIH, there was no meaningful difference in respect of all factors. Within the factors "use of e-content", "training requirement", and "institution adequacy", without being dependent from gender variable, students had a moderate level of positive view while they had a high level of positive view in terms of the factors "teaching processes" and "self-adequacy and project yields". Although there was no meaningful difference in the opinions of students according to gender variable, when we analysed the mean values, it was seen that women students had more positive views than men students. This result is also consistent with the results of the study performed by Işıksal and Aşkar (2003). Both genders did not consider their institution as enough for the implementation of the project. This result can be explained by their age, by having a lifestyle that is full of technological devices, and by expectations of being presented those technological devices also in the schools as they get very familiar with the technology so early.

Examined the opinions of general high school students on the use the Project FATIH dependent on branch variable, there was no meaningful differences in all factors. According to branch variable, students thought that they needed a training on the use of the project and the use of e-content presented by the project in their lessons were in a moderate level. On the other hand, for the factor "self-adequacy and project yields" they had a high level of positive opinion. Although there was no meaningful difference in the factors "institution adequacy" and "teaching processes", when the mean values were analysed, it might be said that students studying in the social sciences had a lower level of positive opinion than other fields. This result gave an idea to us about that in each element of teaching processes faced by social sciences students, there was no enough update for the project and also about that the components of the project were not used efficiently in their lessons.

Dependent on the education level variable, there were meaningful differences in the opinions of the student for all factors except the factor "training requirement". All students, independent of their grade level, thought that they needed training in a moderate level for the use of the project. About the use of e-content in their lessons, 9th grade students thought that there was a high level of usage while all other grade levels thought there was a moderate level of usage. For the factor "institution adequacy", 12th grade students thought that their institution was not enough for the implementation of the project while other groups thought that the institution had a moderate level of adequacy. Analysed the mean values of the factor "teaching processes", it might be seen that the meaningful difference occurred between 9th grade students and all other grade levels. Although there was a meaningful difference between groups, students in all grade levels thought that an update in teaching processes for supporting the implementation of the Project FATIH was necessary. According to the mean values, 9th grade level students' reason for having a high level of positive opinion on the use of e-content might be explained by they had lots of e-content prepared for their grade level. Having lots of e-content but not having those materials integrated with the current curriculum as well could be shown as the cause of 9th grade level students' discomfort. Moreover, it might be thought that high level of e-content usage in 9th grade level affected students' high level of expectations on the changes provided by the Project FATIH and students' perceptions of self-adequacy directly.

In the scope of the Project FATIH, installations of interactive smart boards in the schools were completed and it was found that the students had high level of expectations from the project. However, it was also found that students thought the hardware settings were not enough to apply the project. It was necessary that the lack of hardware infrastructure should be identified and fulfilled by the authorities. Moreover, there should be a team of technicians to solve immediately the problems occurring in schools.

In this study, curriculum and classroom activities are known as the factor "teaching processes". These components should be in coherence with the interactive smart boards and e-content such as animations, simulations, online question banks, and online exams and also these components should be presented in an online platform.

A collaboration between Ministry of National Education and Higher Education Board should be established to train teacher candidates for preparing and managing the e-contents in education faculties. By doing that, teacher candidates will be ready for the use of the Project FATIH and so that students will benefit from their teachers at a maximum level.

The Project FATIH has started to be carried out in general high schools in 2012 - 2013 academic year, and then on it is going to be carried out in all primary and secondary schools. In the studies related with this subject, researchers may expand the population to primary and secondary schools' principals, teachers, and students. By doing that a general opinion of different kinds in terms of the role in school can be obtained for the use of the project.

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Information on Coordinate System as a Tool for Developing Mathematical Thinking

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Abstract

The present paper presents activities tested and tried in class, which are designed to promote and develop mathematics knowledge, based on visual illustrations .It presents activities designed to stimulate creative thinking while developing mathematical thinking and more thorough comprehension of the meaning of information in an axes system. Activities like those, as a multi-disciplinary practice, will entail pupils' better and more meaningful learning of mathematics and will enrich knowledge of this subject. Furthermore, being well acquainted with unusual graphic representations will greatly enhance the study of algebra and other mathematics subjects later on.

Key words: Coordinate System, Graphic representation, Meaningful learning, Creative thinking

Introduction

Everyday events or processes can be presented in various ways; one of them is graphic representation by axes. There are different graphic representations which enable us to get a visual picture of the information as well as an option of using them for making calculations, comparison of sizes and shifts from one representation to another.

Information presented by an axis offers numerous options of mathematical activity at different thinking levels, starting at elementary school where pupils are first exposed to the axes and up to the high grades of high school. Moreover, introducing technology into mathematics study enables expansion of computer-aided mathematical activities, thus facilitating graphic drawings in an axes system.

In the curriculum and in textbooks, axes are mainly presented with numerical values. In this way learners are exposed to the meaning of the points indicated on the graph. Reading information from such a system constitutes an initial basis for comprehending the values of the points and the graphic descriptions.

This paper presents activities designed to stimulate creative thinking while developing mathematical thinking and more thorough comprehension of the meaning of information in an axes system. This is done without any numerical values on the axes as is prevalent in most textbooks. Furthermore, being well acquainted with unusual graphic representations will greatly enhance the study of algebra and other mathematics subjects later on.

Theoretical Background

Developing mathematical and creative thinking within the framework of mathematics lessons

Research of mathematics education (Gazit & Patkin, 2009; Leikin et al., 2009; Shriki, 2010; Levav-Waynberg,& Leikin, 2012) reinforces the need for seeking various ways of developing mathematical thinking and creativity. One of the ways of promoting this issue is the presentation of exceptional activities which require 'out of the box' mathematical thinking.

Teaching mathematics at elementary school usually focuses on the inculcation of algorithms and through them acquaintance with logical thinking which complies with the rules of mathematics. All these leave mathematics

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teachers a little time and latitude for open-ended activities which facilitate expression of creative thinking. In fact, only when teachers' objective is to develop higher-order thinking should they implement even some of the recommendations made by Resnick (1987). For example: design assignments which allow learners to find several solutions, activities requiring use of different criteria or activities which are not algorithm-based.
In his paper, Mann (2006) reviews the different definitions of creativity in mathematics. He argues that when learners graduate, they are adequately capable of calculating and performing algorithms but are unable to apply this knowledge in a meaningful way. According to him, teaching mathematics with no investment in the promotion of creativity does not allow learners to see the beauty of mathematics. Moreover, it prevents talented and gifted learners from developing their special skills in this subject.

To sum up, the frameworks of mathematical activities prevalent in class and their levels are dictated by the textbooks. The way they are presented to learners depends mainly on mathematics teachers. The higher teachers' awareness of developing mathematical and creative thinking is, the better they will know how to cope with the challenge.

Graphic representations and the teaching

Since the beginning of the 21stcentury, graphic representations have become much more common and available in any field, not only in mathematics but also in other sciences. New technological tools allow an almost immediate translation of information about varied subjects into different graphic representations. Shah & Freedman (2011) showed that between the years 1984-1994 the number of graphic representations in academic magazines has doubled. This is also demonstrated in daily newspapers. Graphs have turned into the tangible, available and easiest 'tool' for presenting information of all types. Consequently, it has become necessary to enhance the issue of teaching graphs at schools and higher education institutions as part of the inculcation of scientific literacy.

Moreover, scientific research of graphs has increasingly expanded. For example, Berg & Smith (1994) investigated the way learners read and explain information presented by a graph. They identified a significant relation between learners' logical thinking capability and graphing skills. Other studies (Canham & Hegarty, 2010; Cook, Wiebe & Carter, 2008; Hipkins, 2011) explored what affects learners' mastery in graphs. The findings illustrate that in addition to the learners' thinking capability, educators' teaching strategies and learning the use of computers while teaching the subject arealso important. All these factors combined together affect learners' capability of creating new graphs and explaining the information presented to them.
The study conducted by Carpenter & Shah (1998) presents the three stages of becoming versed in the issue of graphs. First, learners should be acquainted with the visual part, namely the representative shape of the graph, the importance of the shape and its representative features. Second, they have to know the numerical and quantitative components and what they represent. Third, they should connect the quantitative and graphic part of the conclusions.

As to the determination of learners' knowledge of graphs, Wainer (1992) suggests the type of questions which can be asked: Basic level questions which relate to data extraction; intermediate level questions which engage in trends emerging from the information; and high level questions which deal with the depth of the information meaning while comparing trends.

To sum up, the research literature (Friel, 2001; Shah& Freedman, 2011; Wang, 2012) classifies the information presented by graphs into three types which also represent the various thinking levels required by learners.

1. Explicit information – this information is usually presented already in the axis names and it is easily identified.
2. Tacit information – for obtaining this information, learners should examine more thoroughly what is represented by the graph. For that purpose mathematics knowledge (basic or advanced) is necessary.
3.Conclusive information – the highest level of information which requires reasoning and justification by means of mathematical tools in order to draw the conclusions.

Acquaintance with René Descartes as an introduction to the teaching of the Cartesian Coordinates

"***Cogito ergo sum***" – I think, therefore I am (René Descartes)

René Descartes, the French mathematician and philosopher (1596-1650), was the first to come up with the idea of accurately presenting the location of points on the plane and later in space. He conceived the idea while serving in the army as an officer on the banks of the Danube. Some say that the innovation was created following a dream-vision. Descartes delayed publishing his invention and only in 1637 he printed his treatise *Discourse on the method* – a method through which he presented his philosophical concept "The method of leading intelligence in the right way". At the end of the treatise there are three appendices. The third appendix, which is 106-page long, is entitled: "Geometry" and includes Descartes' greatest contribution to science: every point on a plane can be presented by means of a pair of real numbers. The mathematician and philosopher Leibnitz invented calculus at the same time as Newton during the second half of the 17^{th} century and called it on the name of the person who conceived it: 'Cartesian Coordinates System' (Gazit, 2004).

The "Cartesian Coordinates System" – is derived from Descartes, a name which is pronounced 'Cartesius' in Latin. The Cartesian Coordinates System is defined by two straight lines called axes which are usually located at a right angle. The horizontal axis is indicated by X and the vertical axis by Y. The point of intersection of the axes is called *origin of the axes*. In order to indicate a certain point on the axes system, we indicate the values of the X and the values of the Y on the point, thus creating the ordered pair of numbers(X,Y). The expression "Cartesian Coordinates System" serves only in 2 and a 3-dimensional space.

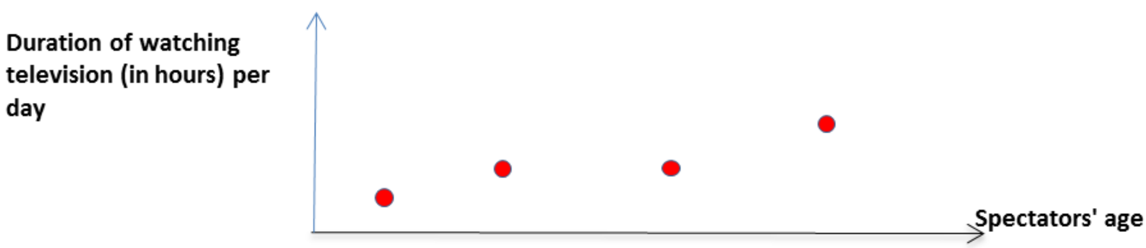
This system paved the way to analytical geometry and modern mathematics. It is inconceivable to imagine the existence of numerous developments in mathematics and their implementation without the Cartesian Coordinates System. Hence, we should start teaching this subject by first presenting Descartes and his extensive contribution to mathematics in general and to the subject of axes in particular. The narrative behind the invention of the Cartesian Coordinates System and their mathematical development in future generations should be the basis for the study of this essential subject. Teachers can tell the learners about Descartes who saw a fly on the wall and conceived the idea of an axes system as a mathematical tool by means of which one can present the walking course of the fly and the possibility of presenting at any given moment its location on the wall.

Examples of activities based on reading information from a graph

The following activities promote and enhance mastery in reading information presented by axes. The activities bridge between mathematics learnt in class and occurrences in the learners' environment. Moreover, this kind of activities can facilitate better understanding of the topic of functions which will be studied later.

For the purpose of presenting information or reading it from a graph, learners need first to be acquainted with axes and understand the meaning of the graph and its various representations. In order to draw conclusions based on a graphic representation, mathematics knowledge as well as logical thinking capability are also required.

Preliminary activity:
Please write in words what is presented in the graph below, your conclusions and insights.



Acquaintance with and comprehension of the above graph while writing or verbalising things enables moving to the next activities which are more complex and require coping with higher-level assignments.

Suggestions for teaching the subject in class:

a. Ask the learners to 'tell', describe in writing or orally what the narrative of the graph is.

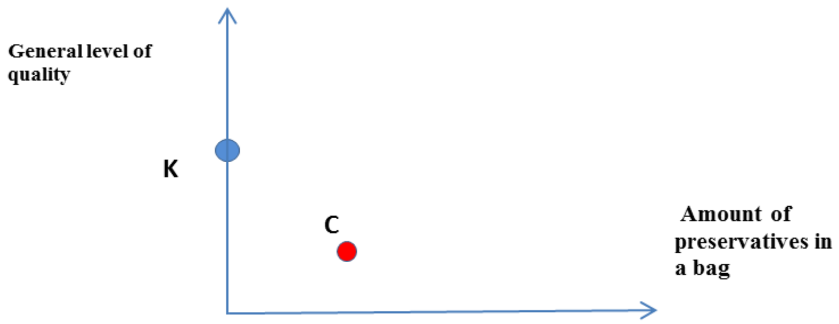
b. Ask the learners to 'tell', describe in writing or orally each of the assertions and indicate which of them are correct and according to which graphs.
c. Ask the learners to raise additional questions for a given graph.
d. Present examples from the press or from everyday life in order to describe a real graph.

Activity No. 1 is the easiest and requires only initial and basic knowledge of reading information. Activity No. 2 requires a higher-level thinking as well as a capability of formulating assertions and drawing conclusions about a graph which is not explicit. Here too the issue of creative thinking development is integrated.

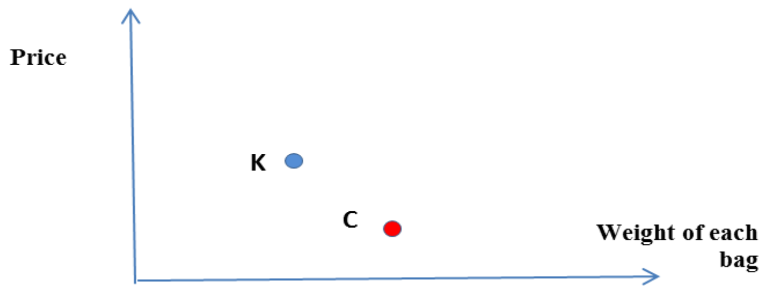
Activity No. 1

Below are graphs which describe information about two snacks, 'Aces' and 'Champions'.
The `**Knight**` snack bag is marked with the letter **K** and the **'Champions'** snack bag is marked with the letter **C**.

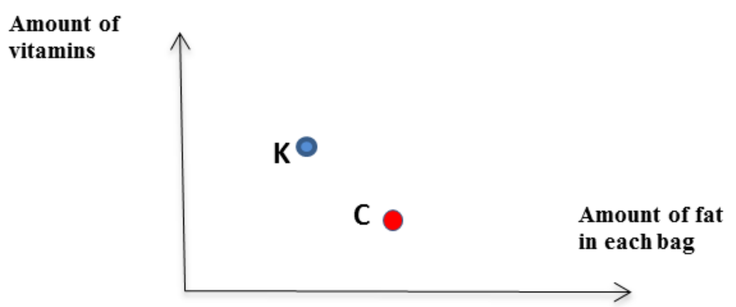
Graph No. 1:



Graph No. 2:



Graph No. 3:

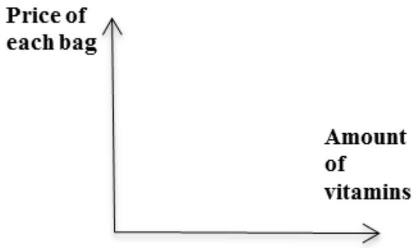


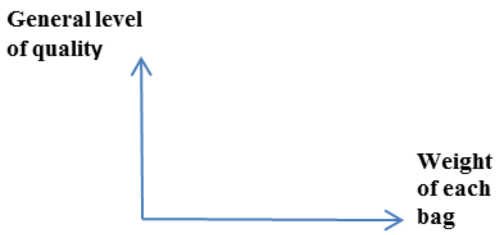
I. Check each of the following assertions and indicate which of them are correct and according to which graphs.
   1. The `Knight`snack is cheaper than the 'Champions' snack.
   2. The `Knight' snack bag weighs more than the 'Champions' snack bag.

3. The \`Knight\` snacks are better for weight watchers.
4. The \`Knight\`snack has more vitamins than the ‘Champions’ snack.
5. The \`Knight\`snack is of higher quality than the ‘Champions’ snack.

II. Please indicate the location of snacks K and C in the axes system, according to the information obtained from the previous graphs.

III.

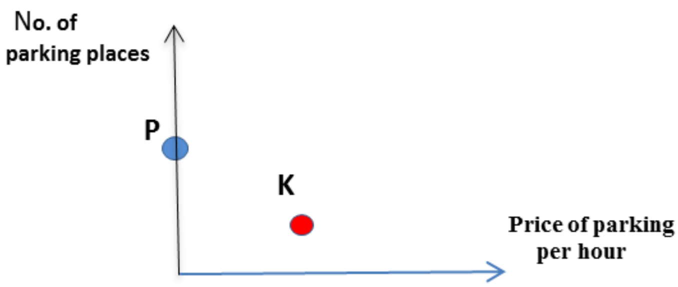




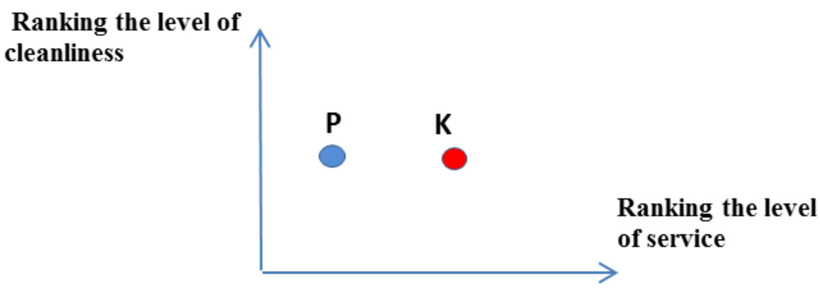
Activity No. 2.

The following graphs describe facts associated with two shopping centers, ‘Knights’ Mall and ‘Princes’ Mall. The **‘Knights’** Mall is marked with the letter **K** and the **‘Princes’** Mall is marked with the letter **P.**

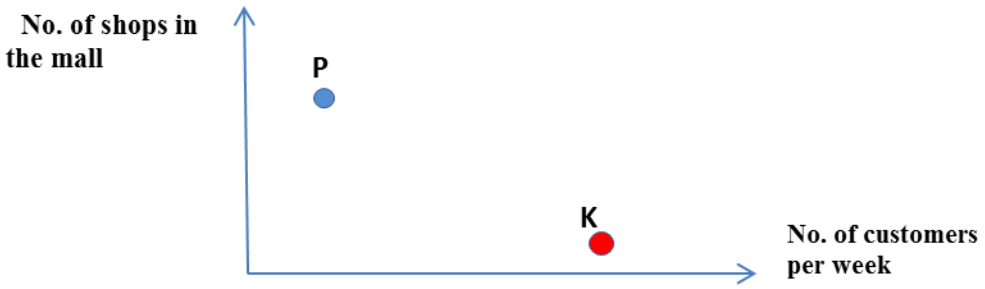
Graph No. 1



Graph No. 2



Graph No. 3



I. Check each of the following assertions and indicate which of them are correct and according to which graphs.
   1. In the 'Princes' Mall the level of cleanliness is lower than in the 'Knights' Mall.
   2. In the more popular mall there are more parking places.
   3. In the mall where the level of service is low, parking is free of charge.
   4. In the mall with a small number of parking places, the number of customers is higher.

II. Here is another fact: in the mall where the number of shops is greater, the prices are higher.

III. Use the information in the previous item and in the previous graphs in order to indicate the malls (points P and K) in the following axis systems.

a. Based on all the information you have about the two malls, please formulate three assertions which are correct and three assertions which are incorrect.
b. Which assertions were easier to formulate, the correct or the incorrect ones?
   Please give reasons for your answer.

Discussion and Conclusions

The activities described above were given to learners in elementary school (5^{th} – 6^{th} grades -42 pupils), junior high school (7^{th} grade- 24 pupils) and pre-service teachers (35 students at the first year of study).

a. All three group of population got the same activities.
b. Despite the fact that the pre- service teachers had much more mathematics knowledge then the school pupils, for most of them this was a new experience.
c. They were versed in reading 'non-numerical' information yet they found it difficult to decide whether the assertions were correct or not.
d. All three groups' encountered difficulties in creating new graphs based on prior information.
e. The next assignment for all the research populations was creating a similar activity about a different subject.
f. Most of the school learners re-wrote the presented activities with slight changes while only 7 pre-service students designed activities which were harder and more complicated than the ones presented to them.

To sum up , learning the subject not by calculating numerical values stimulated development of logical thinking by formulating assertions and practicing 'graphic literacy', which they had not experienced before. The shift from a preliminary and easy activity of reading information on a graph to more complex activities following learners' being asked to design activities by themselves in this spirit actually integrate the two aspects – developing mathematical thinking and creativity.

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Reflections on the Importance of Reference for Understanding Thinking

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Reflections on the Importance of Reference for Understanding Thinking

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Abstract

An intentional form of the semantics of algebraic expressions in the tradition starting with Frege is popular in mathematics education. On the other hand, mathematical logic including predicate calculus and lambda calculus is dominated for more than 50 years by referential semantics. A third field of investigation is the semantics of mathematics as realized in programming languages and computer algebra systems. The paper explores the tension between these approaches and tries to clarify the role of reference both in he developed mathematics as well as in the learning process. Referential semantics simplifies theories but requires mental objects to be constructed to be useful. This links the topic to reification theory. A small collection of observations of learners' behavior adds support to the claim that reference is of some importance in the learning process.

Key words: Semantics, algebra, variables.

Introduction

The semantics of logic has been a subject of change for a long time. At least for mainstream mathematics this process has reached a stable state with the works especially of Tarski. Predicate calculus together with set theory has shown to be a powerful combination that fulfills the needs of mathematicians and moreover of computer scientists. In the present paper we investigate the fundamental role of reference in this theory of the semantics of logic language. A brief outline of this is described in section 1. Yet, in mathematics education it is more common to refer to the older semantical theory by Frege. Notably Arzarello et al. (1994, 2001) have dealt with this in detail and came to the conclusion that his intentional semantics is well suited for education (section 2). On the other hand, the modern referential view of logic has advantages in giving a short and concise description of the formal background of mathematics (section 3,4), but may be dangerous as model for what students should be presented (section 3). Hence, the central question that should be clarified is the relation between understanding and reference (section 5). We collect some simple observations that might help in giving an answer to this question (section 6), but find that further research is needed to clarify the situation.

Predicate Calculus, Lambda Calculus

The notion of reference plays a central role in modern formal mathematics (see e.g. Li 2010). In predicate calculus, formulae are build up from symbols for variables, functions and predicates, logical conjunctions (not, and, or, implication, …) and quantifiers (for all, exists). The well-formed formulae are described on a purely syntactical level. Meaning is given to them by fixing an interpretation that consists of a domain and an assignment of a value from this set to every free variable in a formulae and of functions and predicates over this domain for every predicate and function symbol that arises in this formula. Focusing on variables, an interpretation is thus a set of references from variables to the domain of the theory. If a formula is true for some, all or none interpretations applied to it, it is called satisfiable, tautology, or contradictory, respectively. The role of variables is to refer to objects from the domain. All variables are equal, but they may play different roles, depending on the quantifiers applied to them. But even then their function is to refer to an object.

Note that in each interpretation, the variable is assigned a unique object that is fixed in the interpretation. One may write this assignment as $v \to a$ (here v is a variable (i.e. a part of the logical meta-language) and a is an object of the domain). An interpretation consists of exactly one such assignment for each variable. Evaluating if

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a formula is true or false in a given interpretation amounts to applying all these assignments as substitution rules and then checking in the domain if a statement is true. In general we use the term evaluation (w.r.t an interpretation) for the process of determining the object of the domain that an expression refers to.

Note that understanding change on the level of this formal language requires either the introduction of two variables to capture initial and final states or that of a function of formalized time, or, on the Meta level - the consideration of many interpretations.

Of course, this whole story only makes sense if the domain is well-understood. A prototypical example is arithmetic, where an axiom system assures that only domains are possible that are isomorphic to the standard set of integers. To work successfully in this logic theory one has to understand this set of integers, i.e. one needs to be able to decide the truth of predicates (such as 3|12) over this set. What the logic adds to purely having the integers as mental objects is the ability to make general statements over this set.

We conclude with a short look at lambda calculus which is an equivalent logical system that is essentially suited for understanding computation (Michaelson 2011). It is so to say the calculus of pure functions and used e.g. as a theoretical basis of functional programming languages. Variables appear as parameters of functions. Their role is to refer to the input given to the function. This short description is enough for our purpose as we need only the conclusion that with regard to variables, both logic systems, predicate and lambda calculus, don't differ much: Variables refer to something.

Semantics based on Frege

Arzarello et al. (1994) and many mathematics education researchers in the sequel work with an intensional semantics of algebraic expressions that derives from Frege's theory. Especially they draw on Freges distinction between sense and denotation (Frege used the German word 'Bedeutung', but it would be misleading to translate this as 'meaning', and most translators avoid this). His most cited example is that of the expressions 'venus', '*morning star' and* 'evening star'. They have, according to Frege, the same denotation (i.e. they refer to the same object) but their sense (i.e. all the connotation these expressions may have for you) is different. Thus, when evaluating an expression using a replacement $a \rightarrow b$ we may lose some information (namely the sense of *a*) when substitution *b* for *a*.

Now, we focus on the application of this to understand the use of the algebraic language. In the words of Arzarello who develops Frege's theory into more detail, one may say that the expressions $n(n+1)$ and n^2+n have

1. the same **denotation** (or the same reference), namely a function in *n*
2. different **algebraic senses**, i.e. one is expanded, the other factored. The algebraic sense “represents the very way by which the denoted is obtained by means of computational rules”.
3. different **contextual senses**, e.g. the first may have the sense of the area of a class of rectangles or it may be the product of consecutive integers.

This distinction is appealing because it can be used to explain certain problems of students, e.g. as being the result of students mixing up these levels or neglecting one.

Interestingly, the denotation, which might seem to be the easiest to characterize, proves to be delicate and is handled differently by authors who base their presentation seemingly on the same theoretical grounds. First note that there is some arbitrary choice made: One might have expected $n\cdot(n+1)$ or n^2+n to be a polynomials in *n* rather than functions. However, (Arzarello et al 1994, p. 110) says that functions are denoted: “For example, the expressions $4x + 2$ and $2\cdot(2x + 1)$ express different rules (senses) but denote the same function.” Taking the denotation as functions may not be what one wants and on the next page they state “The denotation of a symbolic expression in algebra is the numerical set, possibly empty, which is represented by the expression itself.” In this understanding, the denotation (when working over the reals) of $n\cdot(n+1)$ and n^2+n would be the semi-open interval $[-\frac{1}{4}, \infty)$. Moreover, following this line of thought one has to say that *x* and *x*+1 have the same denotation when working over the integers or reals (but different denotations over the natural numbers).

The problems to define denotation in a coherent fashion seem to be rooted deeply in Frege's theory. We continue to explore these difficulties by focusing on the somewhat different presentation given by Drouhard & Teppo (2004) that draws on Frege as well. They put out, consistent with Arzarello et al. in the first of his explanations of denotation) the interpretation that $2{\cdot}x+2$ denotes a function $\mathbb{R} \to \mathbb{R}$ and that $2\cdot(x+1)$ denotes the same function (although they differ in sense). Furthermore, $2{\cdot}x+2=1-x$ denotes a function from numbers to Boolean values $\mathbb{R} \to \{true, false\}$.

There are two severe problems with this approach:
First problem: Because 4+1 and 3+2 denote the same number, one may replace one for the other without affecting the truth of sentences, e.g. „4+1 is a prime" will stay true after the substitution. On the other hand, the statement „$n(n+1)$ is a factored polynomial" will become false upon replacing the expression by n^2+n. Thus, following Frege's intentional semantics, we must say that the truth of statements is not affected alone by what objects expressions refer to, but also what sense they are attributed. This is problematic, because 'sense' is a notion that is in itself not clearly defined. Thus, doing substitutions is a dangerous operation that requires deep analysis each time it is to be carried out – although it is a very frequent operation in mathematics. Quine (1960) has analyzed such situations and called them opaque contexts – which should be warning enough to chase students in this direction of thinking.

Second problem: Algebraic language is context free in the following sense of formal languages (i.e. context is not meant to be a real world context): The rules of the language apply to sub-expressions independent of their position in larger expressions, e.g. is you know that $a+b$ equals $b+a$ then you may replace one of these expressions with the other, independent of its position in some larger expression. And if you know that n refers to a number, then in $n+1$ the n refers to a number as well. This context freeness obviously simplifies a language very much and is reflected nicely in the view that algebraic expressions are trees where each leaf is a tree in itself that can be arbitrarily complex. In the Frege tradition, however, we are told that $x+1$ and $2{\cdot}x-1$ are both functions $R\to R$ and these functions are different, so that we must conclude that $x+1=2{\cdot}x-1$ is a false statement because the objects on both sides of the equal sign differ. To overcome this, and allow for equations to be solved for unknowns, Frege followers must scarify context-freeness. They have to claim (and Drouhard&Teppo do this explicitly), that in $x+1=2{\cdot}x-1$ the part $x+1$ does not reference a function, rather as a part, it references nothing, but the whole refers to a function to the Boolean values. Thus, students can't learn one simple rule of what $x+1$ refers to, but they have to ask in each new context, what sense it has there. Thus they are urged to ask the question, Am I allowed to do this *here?*".

To summarize: Taking Frege's intensional semantics as a basis of algebra gives the vague but useful notion of sense but comes at the cost of leaving denotation unclear and seemingly precise statements are bound to use the vague notion of sense as well.

Reference for simplicity!?

Within logic and moreover lambda calculus, many programming languages and so forth it has been realized that the complexity of the semantics of formal systems is reduced and streamlined if you assume that all symbols refer to something in a unique way. This does not only apply to variables for objects from the domain but also for function and predicate symbols. For example, one may hold the view that (depending on the domain) the equal sign = is not just a syntactical mean like parentheses but refers to something, namely a function from $\mathbb{R} \times \mathbb{R}$ to the set {true, false}. This point of view is very clearly articulated in one of the programming language with the slimmest yet most powerful semantics, namely Scheme (Abelson et al. 1998). In this language the equal predicate that the sign = refers to can handled like any other object (e.g. stored somewhere, passed as parameter). To be more precise, entering an expression in this language gives its evaluated value, e.g. entering 5 gives 5 and entering (+ 5 2) gives 7. After (define a 3) we have that (+ a 1) gives 4. The interesting thing is that entering = gives a procedure, e.g. in the racket implementation this prints out as #<procedure:=>. The symbol = is just a name. A standard name that comes defined in the initial environment while a in the example above was a name introduced by the user. Thus even the equal predicate (and as well operations such as +) are used in the same referential setup: These are symbols that refer to a procedure. However, not every part of the language has a reference – a single (does not have. Nevertheless, this approach greatly simplifies things: Symbols refer to something and that's the value used upon evaluation.

So, a consequence could be to set out the goal to base school mathematics on such a simple and consistent referential semantics that is successful in a vast variety of areas. Every symbol used is then to be understood as a reference to some object and the logic of quantifiers on them may set students in the position to master all mathematical questions in a consistent, simple semantics system.

However, although logically consistent, such an attempt could very easily prove to fail. Its simplicity draws on the following facts that are given for most adult users and creators of mathematics but seem very questionable when looking at learners:

1. The domain of objects S needs to be clearly understood. As a quantification „for all x in S we have ….“ needs an overview of what the elements of S are. Yet learners may not have constructed the objects mentally as their own objects, and even if they have constructed some or all of them, it may turn out that the learner is still missing the overview of this domain.
2. Even if the domain of objects is mastered, it may be the case that functions on this domain are not yet constructed as mental objects, e.g. the learner may still have the process view without having it reified yet. E.g. it may be that learners can use the definition $f(x)=2\cdot x+1$ of a function N→N to calculate function values, but they may fail to see f as an object. Especially they may fail to see that the part f of these expressions refers to something. That learners often accept or produce such writings as $f(x)=n+1$ (thus not linking the variable in both sides of the equation) shows that they view this more like a ritualized way to express a calculation procedure than as an expression composed of parts that have individual meaning by their reference to some objects.

So, from his considerations it is not yet clear, what the relevance of reference is, expect that is desirable. We will explore some more aspects before trying to put bits together.

Technology: Computer algebra systems

The last section has already alluded to a connection to technology and this will be addressed in more detail in this section. When you enter an expression in a computer algebra system (see e.g. Davenport 1988) it builds up a certain structure in the computer's memory that we call an object (it may be a number, a list, a polynomial or some other thing). If one assigns the expression to a variable, then the variable refers to it and in evaluation will henceforth give this object. Thus, we have a referential structure as the working model of such a system. However, it would be absolutely infeasible to have objects used in the way suggested by Frege's theory. Instead, for all modern systems the expression $n\cdot(n+1)$ and n^2+n denote two different objects. Thus, sticking with Frege's theory would mean to explain students, that these expressions denote the same objects, but that the CAS does treat them as different. Or, put differently, it hinders students in synchronizing their mathematical objects and operations with that of the system, and as a result they are not able to learn from the system as a model of correct mathematical behavior. The only way out would be to say that the CAS deals with the sense of the expression, not with its denotation. But certainly, a computer can't work with the contextualized sense, at best with the algebraic sense. This notion is left a bit vague by Arzarello and Drouhard, at least it seems to be not so clearly defined as to become a criterion for checking if a computer algebra system works correctly. For example, one may ask if 1 seen as a number and 1 seen as a constant polynomial have different algebraic sense – if so, it can't be detected by standard computer algebra systems (although, there are strongly typed systems that make this distinction). To say that CAS works with algebraic sense would then require to say that the algebraic sense is identical. The same applies to examples such as $1+x$ as being either a polynomial or a rational function with unit denominator. One of the explanations Arzarello et al. give is that “it represents the very way by which the denoted is obtained by means of computational rules.“. But as most CAS treat $x+y$ and $y+x$ as identical objects they can't represent the difference of the algebraic sense between these two writings. I think that the only definition of algebraic sense that is compatible with the use of computer algebra would boil down to say that two expressions have the same algebraic sense if they are represented in the CAS by the same object. But this would eliminate the need for sense as it replaces it with denotation.

Given these problems, I suggest that the easiest way to deal with the problems is to adopt for mathematics in general the way algebraic objects are dealt with in computer algebra systems. This is not to be mistaken as saying that technical decisions of computer algebra makers should have normative power for teaching mathematics. In the contrary, the science of computer algebra systems has established, that the best way to build such systems is to stick close to the ideas of formal mathematics such as predicate and lambda calculus. Thus, supporting a completely different view of mathematical objects would mean to increase the distance between school mathematics on one side and logic, mathematics and computer algebra on the other side at the same time.

To summarize the joint result of the last three sections: We propose that writings of compound signs such as $2\cdot x+1$ or $2\cdot x+1=3\cdot x$ refer to mathematical objects which are expressions. Thus, besides standard domains like integers, rationals and polynomials we also consider expressions as a valid domain in predicate calculus. These expressions may – if needed – further be mapped to specific domains such as polynomials, rational functions etc. but as they are created by writing them down $2\cdot(x+1)$ and $2\cdot x+2$ denote different objects. By mapping them to specific other domains, such as polynomials, different expression objects may be mapped to the same polynomial object. This allows for a fine grained understanding of identity. In the large domain of expressions we can attribute properties like 'expanded' to these objects rather than to have the need to speak about the vague notion of sense. This is a consistent and clear referential view of mathematics, compatible with mathematical logic and computer algebra systems. Yet, it has to be discussed, if this view is adequate for learners of mathematics. There are some subtle points to be clarified but first let's look at an observation that illustrates that thinking about expressions may be rather close to students intuitive conceptions:

> For instance, a child asked by an interviewer to write down the length of a space-ship's path composed of *y* 1l-light-years long segments said: "What, shall I write what I would do?"; and after she eventually contrived the formula $11\cdot y$, she exclaimed to the interviewer: "What, is that all it was? Why didn't you say so? I thought you wanted an answer." Thus, for this child the expression was a mere prescription for the sought-for quantity, not the quantity itself. (Sfard&Linchevsky 1994, p. 207)

This shows that this student feels comfortable with $11\cdot y$ as an expression but struggles with Frege's view that this denotes a number.

Understanding by form and by reference

As explained above, modern logic and mathematical software and programming language are extensively based on the idea of reference. When a new mathematical subject is created, researchers define their new domain of objects to be able to use the referential semantics of logic. The assumption that such objects exists at least relatively to some frame (ontological commitment in the language of Quine (1960)) is the first step in doing mathematics. As mentioned at the end of section 3, this view may not be adequate for learners who have not yet constructed the mental objects that variables should refer to. Consider, as an example, functions. There are various theories that describe the learning process of functions. One theory that is prominent in Germany is the theory by Vollrath who describes four steps in the learning of the function concept. Only the last one considers function as objects. A three step theory by DeMarois (1998) similarly puts functions objects on the highest layer. So, if these theories are correct, there must be a way for students to gain meaning other than the referential semantics of developed mathematics. How this way may look like is a difficult question. Besides by Frege, non-referential theories were influenced by Wittgenstein's language games. This is certainly attractive for natural languages, but the approach lacks the rigor needed for formalized proofs. For the purpose of understanding learning however, it may be quite adequate. One may say, e.g., that students learn the rule that after $f(x)$ one puts the rule of some calculation, or they may view the vector analytic description of a line $\vec{x} = \vec{a} + t\vec{b}$ as a ritualized way to give a point on a line and the direction of a line without seeing any referential meaning (of *x* standing for a vector to a point on the line or of seeing the whole as a logical statement with free variables that can be used, e.g. to substitute a vector for *x* and determine if there is a solution for *t*, i.e. if the point is on the line.). Such language games allow processes to take place and thus they form the basis of reification and the creation of mental objects that can then serve as the basis for referential understanding. The roles of diagrams in thinking can also be understood from this purpose. In (Oldenburg 2011) we put out the thesis that the inscriptions used by some programming languages are ideally suited to support the creation of mental objects. The diagrams are thus means to provide objects.

This gives a perspective on what might be a sensible didactical approach: Language games may be good starting points for the novice but ideally they are structured in a way to ease the creation of mental objects and form the domain of a referential understanding. The various forms of process-object theories such as reification theory (Sfard&Linchevski 1994) and procept theory (Tall 2012) may inform on how this object creation may take place. So the conclusion of this very sketchy paragraph is that successful learning is likely to happen if it is geared towards the creation of mental objects.

Then, how important is reference really for understanding?

Here we collect some hints, that reference is an important key in student's use of algebraic formalism. The first observation here is one from Meyer (2013). He led 11th grade students solve a problem of a number triangle, which is a complex arrangement of 7 numbers obeying several rules like that the sum of two adjacent numbers must be the number in a neighboring field. The details are not important, but it is of interest to look at the transcript (which was found to be interesting by Meyer for completely other reasons) and ask what activities triggered the use of a symbolic variable as a problem solving tool. The student Frank interacts with another student and they talk a lot about numbers, experiment and try out, but they never use any algebraic concept. Then the interesting break in thought happens:

> Frank: "...This is two times 7, basically (writes 2·7 above the number triangle). And here we have one times 9 (writes 9 into the lower outer field) [...] and here (*points at the left inner field*) we have one part, *I mean, one x of 9*, I mean, times *x*, I don't know how to put it, say *x* from 9, and ..." (He intended 9-*x* and finally got to this. Highlights (italics) by RO)

The use of a symbolic variable was thus triggered by the embodied action of pointing to a place and this brought up the use of a variable. Thus, at least in this case, referencing is deeply linked to using variables in a sensible way!

Another (this time negative) example is based in the area of analytic geometry. Certain curricula define vectors geometrically as equivalence class of arrows of the same length and direction. As these objects (equivalence classes) are not so easy to construct mentally, many students pretend that the vectors defined by the arrows attached to parallel edges of a cube to be different. Thus, they often fail to setup adequate vector equations to solve problems, because of the inadequate referential system they have set up.

A third example is given by the composition of functions, especially in the case of function and inverse function. As long as there is no reference to functions as objects, students hardly make sense of a recipe for finding the inverse function such as interchanging *y* and *x* and isolating.

The conclusion here is that referential understanding is at least of some importance for the learning of math and the lack of referential understandings may be an obstacle. However, further research is needed to allow more specific statements.

Conclusion

To get access to the advantages of referential semantics students must construct mental objects to refer to. Thus, it is an important question of educational research how to foster the development of concepts. There are some important contributions in this direction: As mentioned above Sfard, Dubinsky, Tall and others have developed various theories of how objects arise from processes and Dörfler (2005) and others have looked into how inscriptions of mathematical symbols may actually be the mathematical objects that are dealt with. These are important contributions that one can build on (see e.g. Oldenburg 2011) but still establishing a domain to be suitable for use as the domain of a referential logic theory is a lot of work: One must define (and create) the objects and one must be able to decide identity of objects. This is a non-trivial task and students may fail to do cope with this. We think that further research if necessary to clarify how objects are created and to what extend this is a necessary precondition for understanding (or for particular forms of understanding). Especially the paper urges the math education community to rethink if Frege's semantics is an adequate foundation, especially if technology is used in the learning process.

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