Global Journal of Information Technology: Emerging Technologies

Volume 8, Issue 1, (2018) 01-09

www.gjit.eu

Semantic space of elementary teacher attitudes towards computer teaching assistant

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Suggested Citation:

Uhlirova, M. (2018). Semantic space of elementary teacher attitudes towards computer teaching assistant. G*lobal Journal of Information Technology: Emerging Technologies*. *8*(1), 01–09.

Received date October 12, 2017; revised date November 15, 2017; accepted date December 22, 2017.
Selection and peer review under responsibility of Prof. Dr. Dogan Ibrahim, Near East University, Cyprus.

Abstract

This article is aimed at elementary teacher attitudes towards using educational technologies in education, especially in teaching elementary mathematics. The data used were collected by a questionnaire which was created on the principle of semantic differential. Basic statistical characteristics were calculated and a graph of the semantic space was plotted for all of the respondents participating in the study. In general, it is surprising that how differently teachers perceive the use of computers in education on the one hand, and the use of computers in teaching mathematics on the other. The results show that teachers are not convinced that it is meaningful to implement computers into primary mathematics education or that employing multimedia in teaching mathematics might bring educational benefits.

Keywords: Mathematics, computer teaching assistant, education.

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1. Introduction

Information and communication technology (ICT) has become an integral part of our everyday lives. Schools should, therefore, respond to the current social requirements and prepare individuals in accordance with the needs of an emerging information society. Nevertheless, the process of ICT implementation into the educational reality, especially in the environment of primary schools, is still at its beginning in the Czech Republic. Moreover, ICT implementation cannot be seen as an isolated phenomenon as it is associated with furnishing schools with computers. It is a complex and long-term process with the technology being a didactic tool and a modern educational environment rather than the goal in itself. In accordance with the conclusions of the research Quo Vademus (Venezky & Davis, 2002), a teacher's personality is considered as one of the key factors which influences the success of ICT implementation. The teacher's positive attitude towards the potentiality of integrating ICT into teaching is viewed as a necessary input condition. The presumption is that in order to become an active ICT implementer, the teacher must internally accept ICT as a progressive didactic tool and as an innovative cognitive environment.

Attitudes are relatively stable, general orientations of individuals towards their environment (Chraska, 2007). Nevertheless, measuring the attitudes of teachers or pupils has received relatively little attention. Attitudes are formed on the basis of a number of factors, or variables, with very complex conditioning. Pelgrum (1993) focused attention on the topic of attitudes towards using computers in school practice in the study attitudes of school principals and teachers towards computers: does it matter what they think? To identify the attitudes, the present study uses the method of semantic differential which allows a multidimensional measuring of attitudes. The paper presents the fundamental assumptions and principles of this method and outlines its standardisation, so that it can be applied in the wider context of education as well.

2. The study's attitudes towards computer-assisted teaching

The attitudes towards computer-assisted teaching (ATCAT) study focused on the analysis of teachers' attitudes at the first stage of primary school (grades 1–5) towards the potentiality of implementing computers into the educational environment at primary schools, particularly in primary mathematics education. The main objectives of the study were:

- to define and analyse a two-dimensional semantic space of the first stage primary school teachers regarding the use of computers in teaching mathematics;
- to verify the suitability of the adopted research tool (semantic differential) for determining teachers' attitudes towards selected relational indicators.

2.1. Semantic differential

Semantic differential was designed by E. Osgood as the basis for measuring the connotative meaning of concepts or concept relations. Osgood devised a method to plot the differences between individuals' connotations for words and thus, create multidimensional maps of the psychological 'distances' between concepts. The intention is that this should differentiate between attitudes in a way that other methods do not and should shed more light on the links between attitudes and behaviour. The development of this instrument provides an interesting insight into the border area between linguistics and psychology.

Osgood's method is a development of the Likert scale where Osgood adds the three major factors or dimensions of judgement—evaluation, potency and activity. Evaluative factor loads highest on the adjective pair 'good–bad'. The 'strong–weak' adjective pair defines the potency factor. Adjective pair 'active–passive' defines the activity factor. This factorial structure makes intuitive sense. In the Czech Republic, the method of semantic differential was developed by Chraska (2007). The author specified two powerful factors of semantic differential which were typical for Czech social perceiving: the Evaluation factor (which remained) and the Energy factor. The Energy factor integrates the factors of potency and activity. The collected data is converted into a two-dimensional semantic space map. In line with Chraska's experimental conclusions, this study uses a two-dimensional interpretation of the semantic differential.

2.2. Research design

A group of respondents—primary teachers—expressed their subjective evaluation of a set of concepts and concept relations. The following six concepts and concept relations referring to the educational implementation of ICT were studied:

- Me and Computer (Item A).
- Me and Computer in Mathematics Lessons (Item B).
- Me and New Methods and Forms of Teacher Work (Item C).
- Me and Technology Means (Item D).
- Use of the Computer in Lessons (Item E).
- Computer and Getting New Information (Item F).

The respondents were given a questionnaire with a set of six concept tables. They were asked to indicate where their position lay on a scale between two opposite words or in a range of words/numbers across opposing positions. Every concept was valued by the means of a set of bipolar characterisation. Every adjective pair was associated with a seven-point rating scale. Ten opposing characteristics, i.e., ten scales, were used for each concept relation (see Figure 1 showing a research table for the concept relation Me and computer). Scales S2, S4, S6 and S9 were reversed to prevent monotony in the teachers' evaluations.

Me and computer									
S1	bad	☐	☐	☐	☐	☐	☐	☐	good
S2	easy	☐	☐	☐	☐	☐	☐	☐	difficult
S3	unpleasant	☐	☐	☐	☐	☐	☐	☐	pleasant
S4	light-weight	☐	☐	☐	☐	☐	☐	☐	heavy
S5	ugly	☐	☐	☐	☐	☐	☐	☐	nice
S6	unexacting	☐	☐	☐	☐	☐	☐	☐	exacting
S7	harsh	☐	☐	☐	☐	☐	☐	☐	sweet
S8	dark	☐	☐	☐	☐	☐	☐	☐	light
S9	troublefree	☐	☐	☐	☐	☐	☐	☐	trouble
S10	unimportant	☐	☐	☐	☐	☐	☐	☐	important

Figure 1. Research table for the concept relation *Me and computer*

The design of the questionnaire rests on the assumption that each of the scales is significantly loaded by exactly one factor. The subsequent content analysis confirmed that these assumptions were correct. It showed that the evaluation dimension was loaded by six scales S1, S3, S5, S7, S8 and S10, while the Energy Dimension was loaded by the remaining four scales S2, S4, S6 and S9.

2.3. Construct validity of the questionnaire scales

To ensure the credibility of the study, the construct validity of the scales used in the ATCAT questionnaire was verified. At the same time, the aim was to confirm that the research tool was suitable for a wider use. The construct validity of the scales was verified for each concept indicator using cluster analysis. The methods of cluster analysis divide objects into a category system which reflects the similarity of objects belonging to the same category (Kerlinger, 1972). Objects within the same cluster should be the most similar while objects in different clusters should be the most different. In this study, objects (the rating scales) were divided into two disjointed categories (clusters). Figure 2 shows the result of the cluster analysis for the concept indicator A— *Me and computer*. The same clustering of scales was confirmed for all concept indicators. Scales S2, S4, S6 and S9 load only on the Energy factor while scales S1, S3, S5, S7, S8 and S10 load only on the Evaluation factor. The cluster analysis was performed using the computer program STATISTICA 6.

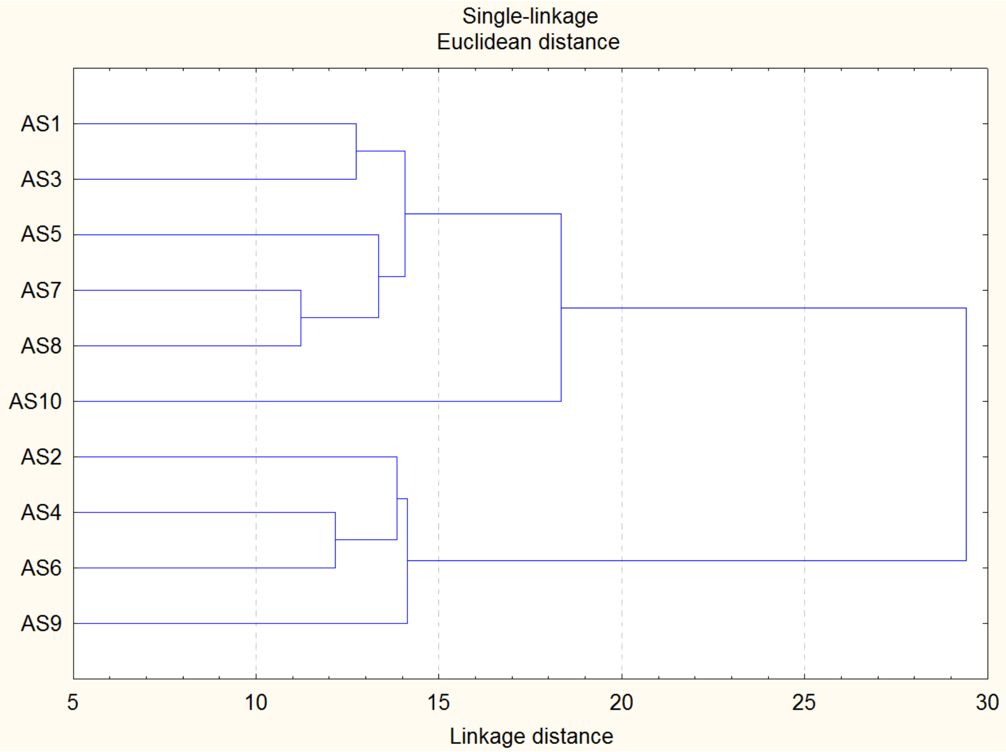

Figure 2. Cluster analysis–concept indicator A–*Me and computer*

The factor structure of the scales was also monitored using factor analysis for each concept indicator. Factor analysis is a useful general method for assessing the construct validity of the designed scale. Employing the psychometric principles, it processes data by means of various models of latent variables. Varimax factor rotation with Kaiser normalisation produced rotation matrices which showed the factor loading of each scale. The scales are arranged by the size of factor loading. Table 1 shows the rotation matrix for concept indicator A— Me and computer.

Table 1. Rotated matrix for concept relation *Me and computer*

	Factor loading	
	Factor 1	Factor 2
AS7	**0.864**	−0.203
AS3	**0.830**	−0.304
AS8	**0.799**	−0.217
AS5	**0.755**	−0.141
AS1	**0.741**	−0.456
AS10	**0.712**	−0.052
AS4	−0.166	**0.892**
AS6	−0.164	**0.873**
AS2	−0.174	**0.823**
AS9	−0.311	**0.782**

Extraction method: principal component analysis. Rotation method: varimax with Kaiser normalisation. A rotation converged in three iterations.

The results are consistent with the outcomes of the cluster analysis. The same clustering of scales was confirmed: scales S1, S3, S5, S7, S8 and S10 load on factor 1 (the Evaluation factor), while scales S2, S4, S6 and S9 load on factor 2 (the Energy factor). Based on the results of the analyses, the scales of the semantic space may be considered factor-clean.

2.4. Measurement reliability

Measurement reliability was estimated by means of Cronbach's coefficient alpha αc which is used for the assessment of test items or scales. Cronbach's alpha is sometimes called the coefficient of reliability or consistency. It is a value from $\langle 0, 1 \rangle$. The extreme value of 0 means that the individual sub-indicators are absolutely mutually uncorrelated. The higher the value of αc, the higher the mutual correlation and, consequently, the higher reliability can be attributed to a given measurement (Kerlinger, 1972). Table 2 shows the calculated values of Cronbach's coefficient alpha αc for each concept indicator and each factor. The results were processed using the computer program STATISTICA 6. In all studied cases, the value of Cronbach's alpha is high, therefore, the measurement can be considered sufficiently reliable.

Table 2. Cronbach's coefficient alpha

Concept relation	Cronbach's coefficient alpha	
	Evaluation factor f_{ev}	Energy factor f_{en}
Item A	0.899422	0.890313
Item B	0.857296	0.857914
Item C	0.860384	0.790445
Item D	0.905667	0.908712
Item E	0.888278	0.870776
Item F	0.909894	0.900669

To check the results, Cronbach's coefficient alpha was calculated also for the global results of the assessment for all indicators of the Evaluation factor (f_{ev}) (scales S1, S3, S5, S7, S8, S10) and of the Energy factor (f_{en}) (scales S2, S4, S6, S9). In both cases, the factor showed relatively high values: f_{ev} = 0.953002711, f_{en} = 0.22168664.

2.5. Data analysis of the semantic differential

The semantic differential provides a substantial amount of data which can be analysed in different ways. The basic techniques use the tools of descriptive statistics, i.e., determining the position and dispersion of each concept indicator. For the result description, graphical representation of the semantic space as an n-dimensional Cartesian system is useful. Each indicator is represented by a point on the Cartesian system. In this case, the system is two-dimensional with the axes representing the Evaluation factor and the Energy factor. If two concepts are positioned close to each other in the semantic space, their psychological meanings are similar. Conversely, if the concepts are separated from one another in the semantic space, their meanings differ (Chraska, 2007; Kerlinger, 1972).

A more detailed description of the semantic space may be obtained using the analysis of the distances between concept indicator clusters called D-Statistics (Chraska, 2007; Kerlinger, 1972). As a measure of the distance between the concepts, linear distance *D* was used. *D* is defined as:

$$D_{ii} = \sqrt{\Sigma(d_{ii}^2)} \quad (1)$$

where $d = X_i - X_i$. D is the linear distance between any two concepts i and j (i, j $\in \{$A, B, C, D, E, F$\}$), d is the algebraic (factor) difference between the coordinates of i and j on the same factor (Evaluation or Energy), X_i is the scale value of concept i and X_i is the scale value of concept j. The values of all linear distances D form a symmetrical D-matrix of the n x n type. The D-matrix can be analysed in several ways. The basis of various analyses, however, is the same. It rests on the identification of concepts which are clustered together. The lower the *D* value for the two concepts, the closer the meanings are of the concepts. Conversely, the greater the *D* value, the more distant the meanings are.

2.6. Research group

The research group in the ATCAT study consisted of 172 primary school teachers who taught grades 3–5. There were teachers both from village schools (39.6%) as well as from city schools (60.5%) (Characteristics 1). Teachers were divided into four groups by their teaching experience (Characteristics 2). The largest group (29.7%) of teachers had more than 10 years of teaching experience; 27.0% had 7–10 years of experience; 20.3% had 4–6 years of experience; and 23.0% had less than 3 years of teaching experience. The teachers were divided into five additional groups according to their user age (Characteristics 3). The user age corresponded to the degree of technical expertise that the teachers reported in using computers. According to their ages, 9.3% of teachers had more than 10 years of computer experience; 14.0% had 7–10 years of experience; the largest group (40.7%) of the teachers had 4–6 years of experience; 33.7% had 1–3 years of computer experience. Four teachers (2.3%) reported having no computer experience at all. This paper focuses only on the overall results, leaving individual characteristics aside.

2.7. Semantic space analysis

Using computer processing of the collected data, basic statistical characteristics were calculated and a graph of the semantic space was plotted for all respondents participating in the study. Table 3 shows the arithmetic means of the Evaluation factor and the Energy factor for each indicator in the set of all respondents together with the corresponding standard deviations.

Table 3. Descriptive statistics of the measurement—Evaluation factor and energy factor of the concept indicators

	Concept indicators	fev	fen	sev	sen
A	Me and computer	5.00	3.59	1.15	1.23
B	Me and computer in mathematics lessons	4.55	3.99	1.06	1.13
C	Me and new methods and forms of teacher work	5.07	3.85	0.84	0.95
D	Me and technology means	4.81	3.67	1.17	1.28
E	Using of the computer in lessons	5.05	3.70	1.08	1.19
F	Computers and getting new information	5.48	3.02	1.12	1.28

Legend: f_{ev}—Evaluation factor, f_{en}—Energy factor, s_{ev}—standard deviation of the Evaluation factor, s_{en}—standard deviation of the Energy factor

The two-dimensional semantic space for teachers in Figure 3 provides an illustrated representation of the results obtained from the answers of a whole set of teachers. Each indicator is represented by a point on the Cartesian system based on the scores obtained for the Evaluation factor and the Energy factor. As a part of the result processing, the relative position of the concepts in the semantic space was analysed. The smaller the distance between the two concepts, the more similar the perception of the concepts for the study respondents was.

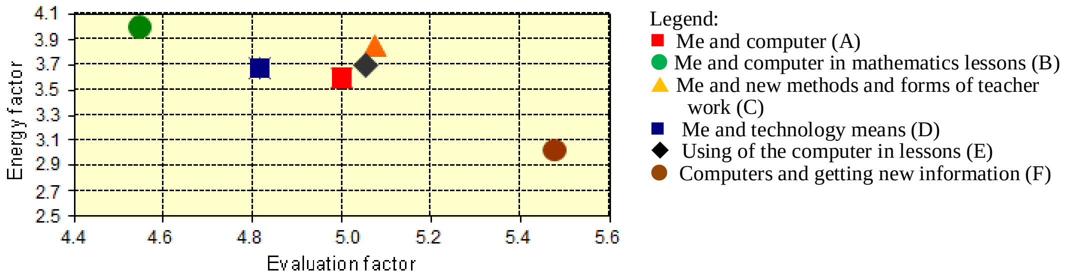

Figure 3. Semantic space of general concept evaluation of all participants

The study resulted in the following set of the concept indicators ranked in order by the decreasing values of the factors.

Evaluation factor (f_{ev})	Energy factor (f_{en})
1. Computers and getting new information (F)	1. Me and computers in mathematics lessons (B)
2. Me and new methods and forms of teacher work (C)	2. Me and new methods and forms of teacher work (C)
3. Using of the computer in lessons (E)	3. Using of the computer in lessons (E)
4. Me and computers (A)	4. Me and technology means (D)
5. Me and technology means (D)	5. Me and computers (A)
6. Me and computers in mathematics lessons (B)	6. Computers and getting new information (F)

The highest indicator ranking by teachers was Computer and getting new information (f_{ev} = 5.48) and lowest the indicator was Me and computer in mathematics lessons (f_{ev} = 4.55). Three indicators—Me and computer, Using of the computer in lessons and Me and new methods and forms of teacher work—obtained very similar values in respect to evaluation ($f_{ev} \in \langle 4.55; 5.07 \rangle$). The teachers most agreed on the evaluation of the concept Me and new methods and forms of teacher work which has the lowest standard deviation s_{evC} = 0.84. The greatest differences were found in the evaluation of the concept Me and computer with a standard deviation of s_{evA} = 1.15.

The concept which the teachers associated with the highest level of difficulty, i.e., that which obtained the highest energy value factor, was the indicator *Me and computer in mathematics lessons*

(f_{en} = 3.99). Conversely, the indicator *Computer and getting new information* represents the lowest level of difficulty for teachers (f_{en} = 3.02). In respect to the Energy factor, the teachers again most agreed on the concept *Me and new methods and forms of teacher work* which had the lowest standard deviation at s_{enC} = 0.95. The largest differences were obtained for the concept *Computer and getting new information* with a standard deviation of s_{enF} = 1.28 (see Table 3).

Taking into account both factors, the teachers associated the indicator *Computer and getting new information* with the highest level of 'utility' requiring minimal energy expenditure. Conversely, the respondents associated the use of computers in teaching mathematics with maximal effort while expecting minimal educational benefits. The attitudes of the respondents towards computers, the potentiality of using computers in education (in general), the new methods and forms of work, and the technical tools are very similar. The psychological relationship between the corresponding indicators A, E, D and C is evidenced in their clustering in Figure 3.

The perception of the concept indicator *Me and new methods and forms of work* is of interest here because the teachers associated it with high difficulty, but at the same time with high utility or educational benefits. These findings may suggest that teachers perceive new methods and forms of work more positively than technology itself. For the successful implementation of ICT, it is, therefore, necessary that the teachers regard computers not only as a useful tool but also as a resource suitable for the application of new methods and forms of work.

In general, it is surprising that how differently teachers perceive the use of computers in education on one hand and the use of computers in teaching mathematics on the other hand. Compared with the general perception of educational applications, teachers associate the use of computers in teaching mathematics with maximal difficulty bringing minimal educational benefits. The results show that teachers are not convinced that it is meaningful to implement computers into primary mathematics education or that employing multimedia in teaching mathematics might bring educational benefits.

The analysis of the distances between indicator clusters with *D*-Statistics provides a more detailed description of the semantic space. Linear distance *D* was used as a measure of the concept distance. In this study, the six concept indicators (*n* = 6) were assigned with 15 different values of linear distance *D*. The calculated distances between concepts (linear distances *D*) form a symmetric D-matrix of the 6 x 6 type (Table 4).

Table 4. D-matrix showing the linear distances of the indicators calculated for the whole set of data

Indicator	A	B	C	D	E	F
A	x	0.6100	**0.2655**	**0.1900**	**0.1059**	0.7259
B	0.6100	x	0.5480	0.4314	0.5607	1.3297
C	**0.2655**	0.5480	x	0.3002	**0.1606**	0.9110
D	**0.1900**	0.4314	0.3002	x	**0.1911**	0.8984
E	**0.1059**	0.5607	**0.1606**	**0.1911**	x	0.8022
F	0.7259	1.3297	0.9110	0.8984	0.8022	x

The D-matrix reveals which concepts are semantically similar and which are semantically distant. The values in bold highlight the four concept indicators A, C, D and E which the respondents consider conceptually close (in line with the graphical representations in Figure 3). The concepts *Me and computer in mathematics lessons* and *Computer and getting new information* remain isolated. The numerical values given in the matrix fully correspond with the previous findings.

3. Conclusions

The description of the semantic space of teachers' attitudes towards the potentiality of using computers in education revealed that there is a surprising difference in their perception concerning education in general as opposed to teaching mathematics in particular. Compared with the general perception of educational applications, teachers associate the use of computers in teaching mathematics with maximal difficulty bringing minimal educational benefits. The results show that teachers are still not convinced that it is meaningful to implement computers into primary mathematics education or that employing multimedia in teaching mathematics might bring educational benefits.

ICT can significantly facilitate the transformation of traditional schools into a modern learning environment. The study results are perceived as a challenge to reshape the undergraduate education of primary school teachers in accordance with current trends.

The paper was supported by the project CeTPo (Centre for the Science Education Theory) CZ.1.07/2.3.00/20.0166.

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