TEACHERS' CERTIFICATION ON BASIC COMPUTER SKILLS

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Abstract

Teachers need to acquire technology and digital skills in order to be able to follow the rapid changes in society. Since 2003, a national project has been carried out in Greece concerning the certification of teachers in basic computer skills. During this project (2003–2009) many teachers have participated in and been certified through a Computer Based Assessment system (CBA) that has been developed by the Research Academic Computer Technology Institute at the University Campus of Patras-Rion. This paper gives a brief view of syllabus, item bank, and tools used for preparing and delivering examinations for teachers' certification on basic computer skills is given. Moreover, the participants' profile based on teachers' responses is explored.

Introduction

Acquiring basic skills is a crucial factor for our society due to the rapidly changing environment. Recognizing the importance of acquiring skills, the European Council defined a "new basic skills" set. A proposed framework covers what an active citizen must know (knowledge), can do (skills), and how to act (attitudes). This framework is based on eight competences:

- communication in the mother tongue;
- communication in foreign languages;
- mathematical, science and technology competence;
- digital competence;
- learning to learn;
- social and civic competences;
- sense of initiative and entrepreneurship; and
- cultural awareness and expression.

These competences are equally important and must be enhanced by educational systems. This fact poses challenges for assessment of these skills in an accurate and measured way. Nowadays there is a shift on Computer Based Assessment (CBA) or Computer Adaptive Testing (CAT) (Scheuermann & Björnsson, 2009;

Scheuermann & Pereira, 2008). These systems are actually software tools for administering e-tests in order to assess candidates through the responses that have been recorded electronically. Some of the most obvious advantages of a CBA could be the unbiased test administration and scoring, the ability to apply testing methodologies, and the suitability for large-scale assessment (Asuni, 2008).

Computer Based Assessment is carried out globally due to certified computer skills following automated or semi-automated methods for assessment. Some commercial projects in this field are: a.) European Computer Driving License (ECDL); b.) Microsoft User Specialist (MOUS); and c.) Internet and Computing Core Certification (IC ³). Certification of knowledge and skills can be a complex task when the following parameters are involved: a.) large scale assessment; b.) simultaneous consideration of many people; c.) geographical dispersion; d.) multiple and equivalent tests; and e.) different cognitive subjects.

Teachers need to acquire technology and digital skills in order to be able to follow the rapid changes in society. During the last years a national project has been carried out in Greece concerning the certification of teachers in elementary and secondary education in basic computer skills. During this project (2003–2009) almost 90,000 teachers participated and certified through a Computer Based Assessment system (CBA) developed by the Research Academic Computer Technology Institute (Androulakis et al., 2006). Most of the participants followed a dedicated training program on using computers (48 hours) covering five cognitive objects: (a) theory–MS Windows; (b) word processing; (c) spreadsheet; (d) Internet & e-mail; and (e) management presentations (Papadakis & Chatziperis, 2000).

The data gathered (2003–2009) is considered interesting for educational policy makers and need to be analyzed because:

- different type of participants are involved (elementary teachers, mathematicians, philologists, literature teachers, physicists, etc.);
- certifications are carried out in a national level (large scale);
- five cognitive objects are involved (theory-Windows, word processing, spreadsheets, Internet-e-mail, presentation); and
- time (date and time, items' response time, etc.) and spatial (prefecture, city, etc.) data have been recorded.

Computer Based Assessment System for Teachers' Certification in Basic Computer Skills

Syllabus

Syllabus is found in the core of each assessment. By this term we mean a well defined structure that clearly identifies what the candidates must know (knowledge), can do (skills), and how to act (attitudes) according to basic computer skills. The syllabus was based on relevant training of teachers and structured into four levels: cognitive, unities, subunities, topics.

Cognitive objects. The first level covers five cognitive objects: 1.) theory: Windows; 2.) word processing: 3.) spreadsheets; 4.) Internet & e-mail; and 5.) management presentations. Each cognitive object contributes a different number of items to the examination.

Unities. The second level explores each cognitive object by defining some general unities based on teachers' training. For example, the unities for cognitive object 3-spreadsheet are: 3.1) interface (MS Excel); 3.2) processing (data and objects); 3.3) format; 3.4) graphs; (3.5) formulas and functions; and 3.6) advanced data processing.

Subunities. The third level explores each unity. For example, unity 3.5: Formulas and Functions is described by the following subsections: 3.5.1– simple formulas; 3.5.2 – functions; 3.5.3 – macros; 3.5.4 – troubleshooting and testing formulas.

Topics. The last level of syllabus includes all the primitive concepts that compose a subunity. For example, some of the topics that describe the subunity about Simple Formulas are: 3.5.1.1 – numerical expressions; 3.5.1.2 – references; and 3.5.1.3 – other expressions (e.g., string, logical).

The leafs of this syllabus structure are the testing items that are attached on the topics' nodes. The items can be grouped in a unique way under topics.

Item Bank

The set of items (item pool or item bank) used for assessment is considered to be the most important module in a Computer Based Assessment system (CBA). It is not a simple set of questions but a well-organized collection of entities where each element is characterized by a well-defined set of attributes. These attributes can be divided into three categories: quantitative, categorical, and logical (Van der Linden, 2005).

In teachers' certification on computer skills, three types of items are used:

- InApplication items (a candidate has to act using a desktop application. The final result is stored and is assessed automatically by a grading script).

- Closed items (a candidate has to choose the right answer from a set of given possible answers).

- Pseudo-InApplication items (a candidate has to choose the right answer but the answer is based on action that has to be taken on an attached working file using a specific desktop application).

Certification Processes

Teachers' examinations are carried out at centers that are certified computer laboratories in higher education (universities, technological institutions) all over Greece. In order for the testing items to be prepared, computer laboratories to be certified, and finally e-tests to be delivered to candidates many people need to cooperate. For this reason a number of tools have been developed.

Authoring tool. An authoring tool enables distinct groups of people (authors, evaluators, testers, scripters, etc.) to communicate and collaborate via the Internet in order to prepare the item bank. The basic functions provided by this system are: the preparation of items, monitoring of items' life-cycle, creating an equivalent set of items (cloning), and item testing through a two quality circles of evaluation.

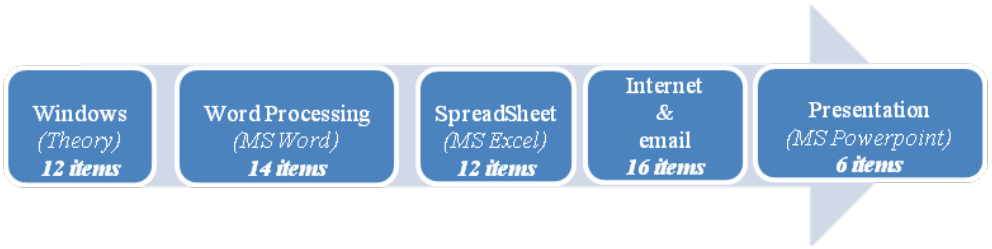
Testing application. This module is a standalone application running on candidates' computer and has the following features: delivering of testing items to candidates, record teachers' responses, and automatic evaluation and scoring.

Management system. A management system is needed for administering the certification's processes on a large scale. This system includes a laboratories registry, candidates' data, certifications' programs data, and an information portal.

Based on the above infrastructure, teachers in elementary and secondary education in Greece are been assessed on computer skills. The Ministry of Education in collaboration with the Research Academic Computer Technological Institute (RA-CTI) adopted two certificates that use the above infrastructure: The A-level certificate (covers basic computer skills); and the B-level certificate (regarding the use of computers to enhance the teaching in different cognitive objects such as mathematics, physics, languages, etc,).

During the A Level certification process the testing items are given in a linear way to examinees. An e-test consist of 60 items (items vary in difficulty, in type, and in syllabus node); is produced automatically by the test generator (based on specified criteria); and can be used in many exams (e.g., in another city, at another time but not in the same certification program). A candidate must complete the examination process in 2:30 hours most and can pause the timer when having a break. In order to be successful a threshold of 60% of correct answers must be recorded. A typical test is structured is shown in Figure 1.

Figure 1: The Linear Structure of Tests



Research

The data gathered during the A-Level certifications were analyzed in order to explore the participants' profile. The research issues of this paper are:

- what is the profile of teachers who have been granted an A-level certificate on basic computer skills,
- what are the main factors that affected teachers' behaviour, and
- what conclusions can be derived from teachers' responses?

Data analysis has been done using R that is available for free use in the scientific community as an open source (free and open source) statistical package (R Development Core Team, 2006).

Data Profile

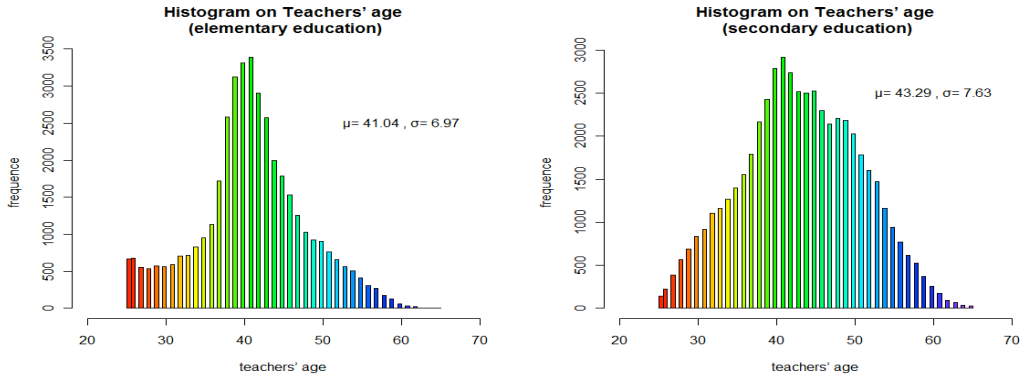
The teachers' certification program has been carried out since 2003 through repeated certification periods over consecutive years (2003–2009). There were 13 certification periods carried out in computer laboratories in higher education (universities, technological institutions). The data sample for this research is based on 96,310 certification attempts that have been recorded until the end of 2009. Almost 89,000 teachers tried to be certified all these years. A brief view of teachers' results over the years is given in Table 1.

Table 1: Certifications attempts over years
(a) elementary education (b) secondary education

Year	Certification's Attempts			Proportion of Success *(95% confidence interval)*			Total Score *(95% confidence interval)*		
	total	a	b	total	a	b	total	a	b
2003	627	37%	63%	[0.81-0.87]	0.79-0.88	0.80-0.87	[0.74-0.76]	0.73-0.77	0.74-0.77
2005	45984	44%	56%	[0.89-0.90]	0.88-0.89	0.91-0.91	[0.77-0.78]	0.76-0.76	0.78-0.79
2006	17288	44%	56%	[0.79-0.81]	0.78-0.8	0.80-0.82	[0.71-0.72]	0.70-0.71	0.72-0.73
2007	4087	44%	56%	[0.80-0.83]	0.77-0.81	0.82-0.85	[0.72-0.74]	0.70-0.72	0.74-0.76
2008	23624	46%	54%	[0.77-0.78]	0.73-0.75	0.79-0.80	[0.70-0.71]	0.68-0.69	0.72-0.73
2009	4700	45%	55%	[0.87-0.89]	0.85-0.88	0.88-0.91	[0.76-0.77]	0.74-0.76	0.77-0.78

The average age of participants was 42 years. Teachers in elementary education are younger with smaller standard deviation compared to teachers in secondary education. The age distribution by level of education is shown in Figure 2.

Figure 2: Teachers' Age Distribution



Methodology

A set of control variables that describe teachers' behavior were defined: (v1) examination time (how much time was used by a candidate in order to complete the test); (v2) threshold time (how much time was needed by a candidate in order to pass the examination's threshold); (v3) total items answered (how many items have been answered by the candidate); (v4) total score (how many correct answers have been recorded); (v5) skipped items (how many items in average were skipped by the candidate); (v6) number of views (how many times in average an item has been viewed before the candidate decides to respond); and (v7) number of breaks (how many breaks have been taken by the candidate during the examination).

The above control variables were statistically explored based on a set of grouping factors: (f1) year of certification (2003–2009); (f2) time of certification (by 14:00, between 14:00 and 17:00, after 17:00); (f3) day of certification (week day); (f4) number of attempts (how many attempts have been made by a candidate); (f5) institution type (university, technological institution); (f6) regions (13 regions over the Greek territory); (f7) candidates' age (young, middle age, older teachers); and (f8) school level (secondary or elementary).

The control variables were exposed to one-way, non parametric statistical tests that explore the following set of hypothesis testing as described in Formula 1.

$$\text{Ho: } m_{ij1} = m_{ij2} = \ldots = m_{ijk} \qquad (1)$$
$$H_1: \text{ at least one } m_{ijk} \text{ is different}$$

where, μ_{ijk} is the median of variable (v_i) over subgroup k of factor (f_j)

The Kruskal–Wallis one-way analysis of variance by ranks (Hollander & Wolfe, 1973; Kruskal & Wallis, 1952) was used with a = 0.05 in order to test equality of

population medians among subgroups in each grouping factor. If the null hypothesis was rejected (pvalue < 0.05) by a grouping factor, then multiple comparisons were made using pair wise comparisons based on Wilcoxon rank sum tests (Hollander & Wolfe, 1973) with a Bonferroni correction (Abdi, 2007) in order to determine if the post-hoc tests are significant.

Moreover, teachers' behavior was explored by creating the participants' profile. Four different groups of data were defined based on completion time (less or equal to 2:30 hours) and on final result (pass or fail). Statistically counters were calculated for the main control variables (v_i) in each group.

Results

A set of 56 different one-way, non parametric statistical tests were done using seven control variables (v_i, I = 1..7) and eight grouping factors (f_j, j = 1..8). The results of these statistical tests are given in Table 2.

Table 2: Results (p.values) of One-way, Non parametric Statistical Tests

f_i \ v_i	v_1	v_2	v_3	v_4	v_5	v_6	v_7
f_1	1.105E-97	1.452E-139	7.936E-123	1.730E-206	4.047E-195	8.533E-214	9.770E-01
f_2	8.353E-07	2.154E-02	7.441E-13	5.532E-21	2.053E-02	1.614E-03	1.430E-93
f_3	6.734E-29	4.926E-36	3.958E-43	9.362E-54	3.576E-22	5.364E-35	2.877E-07
f_4	1.263E-03	9.215E-10	3.246E-12	1.737E-03	8.613E-13	1.290E-10	4.831E-23
f_5	1.300E-190	2.960E-289	3.009E-80	2.345E-272	1.926E-264	3.150E-254	1.263E-01
f_6	5.450E-155	4.344E-109	4.018E-148	7.922E-183	9.772E-100	1.856E-100	2.919E-182
f_7	2.197E-249	2.427E-241	0	0	9.427E-259	0	0
f_8	0	0	0	0	2.251E-258	0	1.234E-57

Those factors that result on p.value < a = 0.05 are considered to affect the corresponding control variable. Multiple comparison tests were done by a Wilcox test using Bonferroni correction. Based on these multiple comparison tests the following outcomes can be mentioned by grouping factor.

(**f1) Year of certification.** Almost half of the certification attempts had been recorded during the first two years of the project (2003–2005). Most of these teachers had followed the dedicated training program. These candidates tend to pass the examination's threshold earlier, respond to more items, gain a higher score, skip fewer items, and take fewer breaks than candidates on the following years. During the first year of the program most of the teachers didn't take any breaks (80%) and only a small percentage of participants (20%) used the privilege of having a maximum of three or four breaks during the examinations. Since 2005 the percentage of breaks has been constantly increasing. In 2009 94% of the participants took five breaks during the examination.

(f2) Time of certification. Teachers who chose to be examined from 14:00 to 17:00 h. tend to perform better.

(f3) Day of certification. Candidates' performance over the weekend is better than the during week days. Candidates tend to complete the examination and to pass the examination's threshold earlier, respond to more items and achieve higher scores. During the last days of the week (Wednesday–Friday) candidates tend to have fewer breaks than in other days.

(f4) Number of attempts. If candidates fail to pass the examination they can try again after at least a month (a maximum of three tries per candidate is allowed). In each try less capable teachers participated. Nevertheless, teachers who try for a second or for a third time tend to respond better compared to their previous performance. No evidence has been found that this factor (f4) affects the number of breaks taken by the candidates.

(f5) Institution type. Candidates who have been assessed in technological institutions in higher education tend to complete the test earlier than those who have been assessed in university laboratories but they reach the examination's threshold later. Teachers who choose to be assessed in universities tend to gain higher scores even if they respond to fewer items.

(f6) Region. There are 13 different regions in the Greek territory. There is no strong evidence on differences in teachers' performance in these regions but teachers in South Aegean islands complete the test and reach the examination's threshold earlier having a lot of breaks during the examination period. Also, teachers in Attica and in Central Greece need more time to complete the test and to pass the threshold while they respond to fewer items and gain a lower score.

(**f7) Age.** Young teachers respond better to the examination. They respond to more items, skip fewer questions, respond to items with fewer views, and achieve a higher score. Middle-age teachers follow while older teachers need more time and gain a lower score. Young teachers tend to take more breaks than middle aged or older teachers.

(f8) School type. Teachers in secondary education perform better than teachers in elementary education. There are no differences in the breaks taken by secondary and elementary teachers.

Successful and Failed Attempts

A-level certification of teachers in basic computer skills doesn't target on clustering candidates according to their ability on using computers. This examination is a "pass or fail" type of assessment and has been structured in order to certify that a candidate possesses the basic computer skills. So, the profile of successful and failed attempts is most important for this type of assessment. Certifications' attempts separated into two major groups: (a) Successful Attempts (group 1) and (b) Failed Attempts (group 2).

Successful attempts. A number (84%) of certifications' attempts were successful over the years. Most teachers succeed in the exams taking only one attempt (93%), while a smaller number of certifications' attempts have been successful in the second (6%) or in the third (0.6%) try. Young teachers are found to have the highest success rate (96%) while older teachers have succeeded at a lower rate (72%). Based on completion time, the successful attempts can be separated into two subgroups:

Group A1. Teachers who succeeded in the exams and completed the test before the examination's time limit (before 2:30 hours). Most of the successful attempts (80%) belong in this group. Candidates tend to complete the test in two hours after they have responded to all the available items. They are able to reach the examination's threshold in approximately one hour and gain a higher score than teachers who use all the available time.

Group B1. The rest (20%) of successful attempts have been done by teachers who have used all the available time (2:30 hours). Even if candidates in this subgroup used all the available time they didn't respond to all the available items. They managed to pass the examination's threshold in 1:45 hours with a lower score compared to subgroup A1. The total profile of teachers who succeeded is given in Table 3.

Table 3: Profile of Successful Attempts
(a) elementary education (b) secondary education
(b)

	Successful attempts (group 1)			**Group A1** (completion time < 2:30 hours)			**Group B1** (completion time = 2:30 hours)		
	Profile of Success								
	total	elementary	secondary	total	(a)	(b)	total	(a)	(b)
older	0.15	0.04	0.11	0.14	0.03	0.10	0.20	0.06	0.14
middle aged	0.68	0.31	0.37	0.67	0.29	0.38	0.73	0.38	0.35
young	0.16	0.08	0.09	0.19	0.08	0.10	0.07	0.04	0.03
	Success Rate								
	total	elementary	secondary	total	(a)	(b)	total	(a)	(b)
older	0.72	0.65	0.75	0.73	0.71	0.74	0.27	0.29	0.26
middle aged	0.85	0.82	0.88	0.79	0.76	0.81	0.21	0.24	0.19
young	0.96	0.95	0.97	0.91	0.89	0.92	0.09	0.11	0.08

Failed attempts. A number (16%) of certification attempts failed. Candidates could try again if they had failed but this was not mandatory. A candidate could try to pass the examination three times maximum. Evidence showed that those candidates who try again performed better than previous attempts. They completed the test earlier, responded to more items with fewer skips and achieved higher scores. Nevertheless, during the first attempt, a number of attempts (15%)

were unsuccessful. This percent increased on second and third attempts (over 20%). A number of teachers who failed on the first attempt (54%) did not make another attempt even though they had this privilege. Half of the teachers (50%) who failed twice gave up. Older teachers were more frustrated when they failed in their first attempt. The profile of teachers who gave up after each attempt is given in Table 4.

Table 4: Profile of teachers who resigned
(a) elementary (b) secondary
(b)

	resigned after 1st attempt			resigned after 2nd attempt		
	Teachers' Profile					
	total	elementary	secondary	total	elementary	secondary
older	0.33	0.11	0.22	0.18	0.05	0.12
middle aged	0.65	0.39	0.26	0.69	0.32	0.37
young	0.03	0.02	0.01	0.13	0.06	0.07
	Resignation Rate					
	total	elementary	secondary	total	elementary	secondary
older	0.64	0.66	0.63	0.52	0.54	0.51
middle aged	0.50	0.50	0.49	0.49	0.47	0.50
young	0.47	0.48	0.46	0.50	0.48	0.53

Based on completion time, the failed attempts can be separated into two subgroups:

Group A2. Teachers who have failed in the exams and completed the test before the examination's time limit (before 2:30 hours). A number (40%) of failed attempts are found in this subgroup. These attempts are made by candidates who decided to complete the test in approximately 2 hours even if there were some unanswered items. They completed the test either because they were frustrated by their results or because they overestimate their responses.

Group B2. The rest (60%) of failed attempts were made by teachers who used all the available time (2:30 hours). They responded to fewer items but gained a higher score in relation to group A2. The most important control variables that describe teachers' behavior are: completion time, threshold time, item answered, and total score. The median and the interquartile range were calculated for these variables. The statistical counters of the most important variables for the above groups of interest are given in Table 5.

Table 5: Statistical Counters over Groups of Interest

(a) Group A (<2:30 hours) (b) Group B (=2:30 hours)

		Completion Time (hours)		Threshold Time (hours)		Answered Items (integer)		Final Score (integer)		Success Rate (95% ConfInt)
		group A	group B	group A	group B	group A	group B	group A	group B	Group A
1 pass	median	1:58	2:30	0:53	1:43	60	56	50	43	[91.32-91.70]
	IQR	0:40	0	0:40	0:35	0	5	7	7	Group
2 fail	median	1:57	2:30	-	-	55	48	25	30	B
	IQR	1:10	0	-	-	20	10	17.5	8	[63.53-64.72]

Conclusions

Within the European Union, the requirement to assess knowledge and skills pushes the development and use of CBA systems on a large scale. The automatic grading of candidates' responses presupposes the existence of a large item bank and an algorithm for the selection of items.

This paper gives a brief description about the: syllabus, item's structure, and tools used for teachers' certification in basic computer skills in Greece. Teachers' responses were analyzed according to grouping factors based on one way, non parametric statistical tests. The results lead to the following conclusions:

- teachers' performance is better at noon, at weekends and close to the training period,
- examinees tend to take more breaks as the years go by,
- teachers benefit from the privilege of another try and they become better as they try to pass the exams again,
- younger teachers possess computer basic skills on a higher level than middle aged or older teachers and they tend to have more breaks during the examination,
- the participation rate in secondary education is higher than in elementary education but in recent years a balance in this has been tendency, and
- secondary school teachers appear to have gained more skills about using computers in relation to elementary teachers.

Teachers' performance was evaluated based on four groups of interest according to the final result (pass or fail) and the completion time of the examination:

- Most of the teachers who feel confident about their responses complete the exam in 2 hours and reach the examination's threshold in approximately 1 hour (group A1).
- Candidates who are frustrated or have overestimated their responses failed to pass the exam and tended to complete the test in 2 hours leaving enough items unanswered (group A2).
- Most teachers who use all the available time manage to succeed in the exam but they perform worse than teachers who feel confident.
- Almost half of the candidates who fail to pass the examination don't make a second attempt. Older teacher are more frustrated when they fail to pass the exams.

The findings and related questions arising from this survey will be used to further analyze the recorded data in two directions: a.) multivariate analysis of factors influencing the teachers' responses, and b.) qualitative analysis of items used for teachers' certification in basic computer skills.

Notes

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References

Abdi, H. (2007). Bonferroni and Šidák corrections for multiple comparisons. In N. J. Salkind (Ed.), *Encyclopedia of Measurement and Statistics*.

Asuni, N. (2008). *Quality features of TCExam. An Open Source computer-based assessment software, towards a research agenda on CBA (Challenges and needs for European Educational Measurement)* (pp. 58–63). Luxembourg: Office for Official Publications of the European Communities.

Androulakis, G., Zagouras, Ch., Skiniotis, P., & Triantis, A. (2006). In *TeCert: A management system for administering certification of knowledge, skills and attitudes concerning IT* (pp. 3–27). Mentoras: Pedagogical Institute of Greece.

Hollander, M., & Wolfe, D. A. (1973). *Nonparametric statistical methods*. New York: John Wiley & Sons.

Kruskal & Wallis. (1952). Use of ranks in one-criterion variance analysis. *Journal of the American Statistical Association, 47*(260), 583–621.

Papadakis, S., & Chatziperis, N. (2005). *Basic skills on information and computer technology*. Ministry of Education, Lifelong Learning and Religion Affairs – Pedagogical Institute of Greece

R Development Core Team. (2009). *R: A language and environment for statistical computing.* Vienna: R Foundation for Statistical Computing.

Scheuermann, F., & Björnsson, J. (2009). The transition to computer-based assessment: New approaches to skills assessment and implications for large-scale testing. *European Commission Joint Research Centre Institute for the Protection and Security of the Citizen.*

Scheuermann, F., & Pereira, A. (2008). Towards a research agenda on CBA: Challenges and needs for European Educational Measurement. *European Commission Joint Research Centre Institute for the Protection and Security of the Citizen.*

Van der Linden, W. J. (2005). *Linear models for optimal test design*. New York: Springer-Verlag.