Development of a Scale to Explore Technology Literacy Skills of Turkish 8th Graders

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Abstract

The use of emerging technologies shape learners' knowledge creation and transformation processes. In this regard, this study aimed to develop a scale to investigate 8th graders' competencies regarding the educational technology standards based on ISTE-NETS. After a review of relevant literature, an item pool was prepared. The pool was improved through expert opinions and pilot implementations. The items were administered to 620 Turkish students from six different cities for the exploratory factor analysis (EFA). A four-factor structure with a total of 21 items emerged and explained 51 percent of the total variance. Factors were named technical proficiency, creativity, digital citizenship and participation, and innovativeness. Each factor had acceptable internal consistency coefficients. For the confirmatory factor analysis (CFA), the scale was administered to 210 new participants from a different city in Turkey. A few modification indices led to acceptable fit values. Thus, the suggested factor structure was considered plausible. Implications of the study were provided, followed by the recommendations for further research.

Keywords: *Technology integration; Technology literacy; Educational technology standards; NETS-S; Scale development*

Introduction

Advances in emerging information and communication technologies (ICTs) have created new opportunities in terms of globalization, acculturation, knowledge creation and widespread diffusion of new practices. Moreover, these opportunities have transformed individuals' thinking, behaviors, communication patterns, working habits, and life styles (UNESCO, 2005). Because of the tremendous increase in the volume and circulation of knowledge, it is getting harder and harder to keep up. Therefore, individuals' competencies and skills should change in order to survive in the knowledge era since they are now expected to know better how to reach critical information, use the knowledge they have, and create new knowledge through reconfiguring their existing skills.

As a consequence of increasing emphasis on the information society, a general consensus has been reached on issues like lifelong learning, creativity, and constant progress. These are significant characteristics of a learning society. Thus, one can argue that equipping people with information and communication technology (ICT) competences, starting from the early years of the childhood is integral to preparing them for the requirements of a hectic working and thinking environment. In order to address this problem, many countries have implemented ICT courses in schools or carried out ICT-related educational reforms (Bereiter & Scardamalia, 2006; Fox & Henri, 2005; Greenhow, Robelia, & Hughes, 2009; Jonassen, Howland, Marra, &

Crismond, 2008; National School Boards Association, 2007). For instance, No Child Left Behind (NCLB) Program initiated by the US government in 2001 aimed to improve student achievement through the use of technology in elementary schools and narrow the achievement gap between the highest and the lowest-performing students. Similarly, the Turkish Ministry of Education (MNE) has made considerable investments to improve the quality of education through enriching learning environments with ICTs (Gulbahar & Guven, 2008). However, empirical evaluations of these investments are yet to be investigated.

Throughout the world, ICT-related educational reforms focus primarily on infrastructure whereas the investment on human performance seems to lag behind. In this respect, investigating both teachers' and students' technology literacy skills carry the utmost importance to help 21st century individuals keep pace with technological advances. Individuals need to be literate regarding new and constantly changing technologies. However, there is also the inevitable reality that the meaning of being 'literate' itself changes constantly in response to new technological developments (Leu, Kinzer, Coiro, & Cammack, 2004). To address this fact, scholars and policy makers are developing indicators to measure technology literacy of the students. For instance, the US Department of Education (DOE) initiated the Enhancing Education through Technology Act in 2001. The primary aim of the act was to improve student academic achievement through technology use in elementary and secondary schools (US DOE, 2001a). More specifically, the aim was 'to assist every student in crossing the digital divide by ensuring that every student is technologically literate by the time the student finishes the eighth grade, regardless of the student's race, ethnicity, gender, family income, geographic location, or disability' (US DOE, 2001b). Such standards are important in helping teachers to reflect on their classroom teaching and understand what they need to address in student learning (Watts-Taffe & Gwinn, 2007).

Several standards have been proposed to address IT literacy of learners (e.g. ACER, 2007; ETS, 2006). One of the prominent frameworks on educational technology standards has been proposed by The International Society for Technology in Education (ISTE). Referred to as National Educational Technology Standards for Students (NETS-S), these standards aim to evaluate the skills and knowledge of students who are supposed to learn and live productively in a digital world. Being able to use technology or putting ICT facilities in educational settings are no longer adequate for successful ICT integration (Angeli & Valanides, 2009; Tapscott, 1988). Students need to be able to use recent technology to learn, explore and evaluate. Therefore, standards like NETS-S are crucial to provide teachers with appropriate guidelines so that they can effectively employ technology in accordance with their students' needs. NETS-S has been based upon a constructivist philosophy of instruction that considers schooling as being vital to prepare students for a changing workplace (ISTE, 2007). In this regard, it provided a useful framework for technology integration that incorporates active student learning through the use of technology to increase productivity, to improve effective communication and problem solving skills, and to enable students to conduct independent research (Niederhauser, Lindstrom, & Strobel, 2007).

In Turkey, the Ministry of National Education (MNE, 2012) has recently initiated the "Movement of Enhancing Opportunities and Improving Technology" project, which was abbreviated as FATİH in the national alphabet. The project aims to improve computer literacy in schools through providing students with access to emerging ICT tools and resources. A total of 570.000 classrooms in 42.000 schools will be equipped with tablet PCs, interactive white boards, data projectors, Internet connection and so on. As a digital school means a lot more than investments on infrastructure (Akbaba-Altun, 2006; Lee, 2008), the project also includes training of teachers to use this technology in the classrooms effectively. If the aims are realized, all students graduating from secondary education are expected to possess the basic skills to use ICTs. Preliminary official findings of the investments look promising whereas empirical and politics-free evaluations are not available yet.

Aforementioned projects rely upon the expectation that ICTs might shift the pedagogical outcomes and teaching methodologies in the classroom (Kozma, 2003). Likewise, the growth of ICT has had an impact not just on secondary school teaching and learning, but also in higher education (Pulkkinen, 2007). However, to address relevant instructional methodologies with regard to ICT-related outcomes, a robust definition of technology literacy is needed. Hansen (2003) defines this literacy as individuals' abilities to adapt, create and evaluate technology to improve their lives, community, and environment. Analogously, Eisenberg and Johnson (2002) define a technologically literate person as someone who can use technology for organization, communication, research, and problem solving. Both definitions focus on human performance; however, the skills development process requires access to certain ICT infrastructure at the inception.

Technological literacy and its effective deployment in the classroom are shaped by a whole range of pedagogical, social and environmental considerations (Ertmer, 2005). For instance, there is a strong correlation between students' access to computers at home and academic success, both in general, and more specifically, in mathematics and science (BECTA, 2003; National Center for Educational Statistics, 2000). In this regard, a positive relationship between the Internet access and the quality of the learning process can be suggested (Jackson, Von Eye, Biocca, Barbatsis, Zhao, & Fitzgerald, 2006). Studies further imply a positive relationship between access to computers and the quality of technology integration endeavors at educational settings (e.g. Akbaba-Altun, 2006; Akbulut, 2008; Goktas, Yildirim & Yildirim, 2008; Gulbahar, 2008; Knezek, Miyashita & Sakomoto, 1993). However, a set of additional contributory factors in addition to ICT access should be considered while addressing this positive relationship such as the parental income and education.

In such a sophisticated, technologically rich and rapidly changing context, it is expected that teachers not only be capable of integrating technology into traditional aspects of literacy (e.g., reading and writing), but also to have the capabilities to engage students in increasingly important technological literacies like online reading and writing (Karchmer, Mallette, Kara-Soteriou, & Leu, 2005). While traditional approaches to education tended to regard the teacher as the "gatekeeper" of the information conveyed to students, the needs of the emerging Net Generation (i.e. N-Generation) demand not only the basic information and facts, but also the skills to negotiate through, to process and to synthesize huge volumes of information effectively. This shift from the mere transmission of information to an interactive learning process is one of the distinguishing characteristics of the N-Generation who want to be active users rather than recipients (Tapscott, 1988). ICTs can be used to make them active; however, effective technology integration into classroom is often difficult and complicated, particularly in the initial stages when considerable background information and prior preparation may be required, and there may be uncertainty about how it will work out (Niederhauser & Perkmen, 2010). Moreover, emerging technologies are constantly and rapidly evolving. Both hardware and software are changing and schools need to constantly deal with new technological developments. In some countries, educational administrators have even implemented a compulsory ICT program in schools, which focused on ICTs as instructional tools rather than as a means to enhance technical skills (Vanderlinde & van Braak, 2010). In brief, such a rapid transformation of policies, pedagogies, technologies and expectations from learners requires scholars to develop up-to-date standards and measures to investigate learner competencies, which can be used as clues for further policy making.

The purpose of the current study was to generate an objective measure to evaluate Turkish 8th graders' technology literacy within the framework of initiatives like the NCLB, ISTE NETS-S and MNE goals. Such measures addressing ICT integration carry importance for policy makers; however, relevant examples are primarily realized in tertiary education settings (e.g. Akbulut, 2009; Akbulut, Odabasi & Kuzu, 2011). Areas of technical proficiency, creativity, digital citizenship and participation, and innovativeness were particularly addressed in the current study. The following section will first discuss the scale development methodology followed by the reliability and construct validity concerns. The article will conclude through reflecting on the current findings within the context of ICTs in education.

Methods and Procedures

Research Model

A quantitative research method was employed in the current study with the purpose of scale development. This was in line with the assertion by Ary, Jacobs and Razavieh (2002) that quantitative research should include a review of literature, instrument development, data collection, data analysis, and conclusion. The current study adopted this methodology; however, instrument development was the focus of successive data collection endeavors as illustrated in Figure 1. While creating this roadmap, suggestions of Worthington and Whittaker (2006) were particularly helpful.

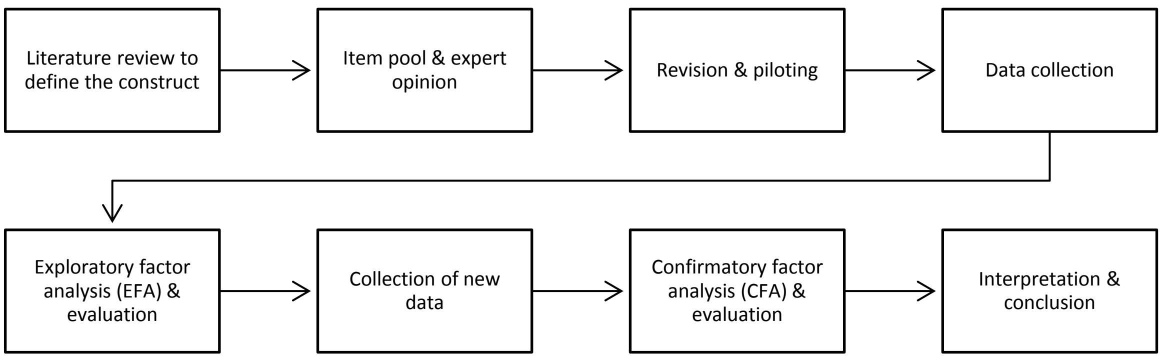

Figure 1. Steps of the Current Study

Scale Development

As there was not any standardized measure addressing 8th graders' competencies regarding educational technology standards, a Likert instrument addressing 'Technology Standards for Students' was constructed. Items were primarily derived from the NETS (ISTE-NETS, 2007). One of the main purposes of ISTE NET-S is to define students' technology literacy prior to their undergraduate education. Students' needs of having relevant qualifications of productivity, creativity, analytical thinking, and cooperative skills were particularly addressed. Further items were prepared through the review of the contemporary literature.

The scale development process involved item pool development through literature search, expert opinion, initial piloting, data collection from a development sample, EFA, new data collection and CFA (Worthington & Whittaker, 2006). The expert committee who reviewed the first item pool included 10 research assistants from Computer Education and Instructional Technology (CEIT) departments, 9 undergraduate CEIT students, two research assistants from a curriculum development department, two scholars from social sciences teaching and two scholars from elementary education. The committee members were first informed about the ISTE NETS-S standards. Consequently, a total of 76 items proposed by the researchers were discussed. To sustain the face and the content validity, experts were asked about their opinions. Six of the items were removed, since they were either regarded as off-topic or overlapping with others. This reduced the number of items to 70. Several items were rewritten by the committee members as well.

The data collection tool was comprised of two parts. The first part addressed background information regarding the participants such as gender, having a PC at home and having regular Internet access. The second part required their responses on technology use standards with a 5-point Likert scale, which ranged from strongly agree (5) to strongly disagree (1).

Participants

In order to collect data from a representative sample, 10 different schools from six different cities were randomly selected. The scale was administered to a total of 830 eight graders. Participants from different socio-economic backgrounds were available in the data. Since the participation was voluntary, 182 surveys were unanswered, which were excluded from the analysis. The data obtained from 28 students were also excluded since all items were marked with the same value (e.g. 1 or 5). This reduced the number of respondents to 620 participants (75%).

For a robust EFA, the size of the sample should be at least 5 times more than the number of items in the scale (Kass & Tinsley, 1979). According to another view, the size of the sample is considered weak with 100 participants, mediocre with 200, good with 300, very good with 500, and perfect with 1000 participants (Comrey & Lee, 1992). According to Field (2005), at least 300 participants should be reached. Thus, an adequate number of students was accessed in the first implementation, which was used for the EFA.

To confirm the initial factor structure proposed with the EFA, the scale was administered to 210 new students in a different city, of which 182 responded voluntarily and reliably (87%). According to above resources, this number could be regarded as mediocre. However, the Kaiser-Meyer-Olkin measure of sampling adequacy (KMO) revealed that the sample size was adequate. The KMO can take values between 0 and 1 (Field, 2005). Values which are equal to or above 0.6 are regarded as acceptable in several resources (Hair, Anderson, Tatham, & Black, 1998; George & Mallery 2001; Kline, 1994; Pallant, 2001; Tabachnick & Fidell, 2005). In the present study, KMO of the first sample was .928 and that of the second sample was .926 both of which were considered highly acceptable in the literature. Demographics regarding both samples are provided in Table 1.

Table 1. Demographics of the Studies

Variable	Levels	Study 1 (EFA; n=620)		Study 2 (CFA; n=182)	
		n	%	n	%
Gender	Male	311	50,2	87	48,1
	Female	308	49,8	94	51,9
Computer at home	Yes	534	88,3	170	93,4
	No	70	11,7	12	6,6
Internet access	Yes	464	78,1	148	81,3
	No	129	21,9	34	18,7

Data Collection

After the bureaucratic procedures were completed and the official consent letters were received, the first set of data for the EFA was collected in May 2011. The second set of data for the CFA was collected in September 2011. Students responded to the scale voluntarily and anonymously which reduced the response rate slightly. The administration was conducted by regular classroom teachers in normal class hours. Aside from the scale items, participants were asked about their background information. They were provided with clear instructions about the purpose of the study and items in the measure.

Findings

Exploratory Factor Analysis (EFA)

In order to analyze the responses, a principal component analysis with Varimax rotation was performed with 620 participants to see the items which contributed to the scale poorly. During the item deletion process, several criteria were taken into consideration. First of all, factors with eigenvalues less than 1 were suppressed (Hair et al, 1998). Each factor was generated in a way that they had at least three items with plausible item loadings (Gorsuch, 1997). Moreover, items with low contribution to its factor were excluded. To see an item’s contribution, factor loadings were examined. Even though there are studies considering a cut-off point of 0.30 as plausible (Pallant, 2001), the current study determined the cut-off point as .35. In follow-up studies where the constructs become clearer, a cut-off point of 0.4 or 0.5 can be preferred to develop relatively stronger scales.

The EFA revealed a four-factor structure and the factors were named as technical proficiency (1), creativity (2), digital citizenship and participation (3), and innovativeness (4). The total explained variance was 51% which can be regarded as ideal (Henson & Roberts, 2006). The number of the items in each factor was not equally distributed. While the technical proficiency subscale had 10 items, the innovativeness subscale had only three items. Thus, the numbers of the items under each subscale were different from the structure originally planned.

Table 2 shows scale items and descriptive values including the mean, standard deviation, item total correlation and factor loading. Internal consistency coefficients (Cronbach’s α) for each subscale are also provided, which ranged from 0.574 through 0.874 for the subscales.

Table 2. Descriptive Statistics of the Scale Items

Factors and items	Explained variance (%)	x̄	SD	Item total r	Factor load
Technical proficiency (α=.874)					
I can use social networking sites (e.g., Facebook).	21.77	4.530	1	0.563	0.752
I can use my e-mail account effectively (adding attachments, making e-mail lists).		4.241	1.074	0.597	0.744
I can block someone I don't want to contact in social networking environments.		4.389	1.005	0.564	0.676
I can prepare an assignment by using a word processing program.		4.279	1.016	0.567	0.66
I can use search engines effectively (Google, Yahoo, Bing…).		4.252	1.079	0.604	0.612
I can access information I want using different ICT resources.		4.265	0.986	0.559	0.588
I use up-to-date Internet resources while preparing my assignments.		4.392	0.945	0.524	0.584
I can access Internet resources from mobile devices.		4.139	1.134	0.572	0.583
I can compare the information I find in different web pages.		4.069	1.107	0.593	0.572
I can use technology effectively.		4.294	0.918	0.577	0.524
Creativity (α=.729)					
I can prepare a PowerPoint presentation.	11.24	4.071	0.98	0.498	0.712
I can draw a picture by using graphic editing software.		3.673	1.122	0.331	0.691
I can use audio, graphics and animation in my presentations.		3.859	1.129	0.494	0.746
I can make a video about my class and school.		3.943	1.15	0.441	0.666
Digital citizenship and participation (α=.574)					
I use technology while paying bills or making applications.	9.17	3.502	1.409	0.373	0.7
I participate in online discussion boards.		3.235	1.441	0.326	0.668
I express my opinions on Internet surveys.		3.716	1.274	0.444	0.645
Before buying a technological device I search for user reviews on the Internet.		4.129	1.081	0.394	0.364
Innovativeness (α=.620)					
I share my knowledge on new technologies with my friends.	9.00	4.411	0.893	0.416	0.79
I follow developments about technological innovations.		3.96	1.063	0.499	0.649
I can adapt technological innovations.		4.338	0.917	0.547	0.431

The factor loadings of the items ranged between .752 and .364. According to Comrey and Lee (1992), factor loadings of .71 or higher can be regarded as 'excellent', 0.63 as 'very good', .55 as 'good', .45 as 'fair', and .32 as 'poor'. These guidelines reveal that five items were excellent, six items were very good, seven items were good, one item was fair and two of the items were poor.

Confirmatory Factor Analysis (CFA)

A CFA was conducted through IBM SPSS Amos 20.0.0 in order to confirm the four-factor structure proposed through the previous EFA. As indicated in Table 1, the confirmation was realized with 182 new participants. The KMO of .926 indicated adequate sample size. Moreover, the internal consistency coefficient of the whole scale was really high (α=.923). The explained variance was quite plausible (i.e. 58%, Henson & Roberts, 2006). Alpha values for individual factors were as follows: Technical proficiency (.885), creativity (.729), digital citizenship and participation (.752) and innovativeness (.639).

The four-factor solution was examined in terms of its fit values; and the model fit was found acceptable since the $\chi2/df$ ratio was below 2.5 ($\chi2$=386.501; df=183; $p<.001$; $\chi2/df$=2.112) (Kline, 2005). However, according to more conservative resources like Tabachnick and Fidell

(2005), this value may be considered weak. Subsequently, error covariances of the items within the same subscale were checked as a modification alternative. Modifications should be used sparingly in CFAs (Simsek, 2007). In this regard, only three error covariances were added which improved the model fit ($\chi 2=355.4$, df=180, $p<.001$, $\chi 2/df=1.974$). That is, a four-factor model was confirmed better after defining these error covariances.

Table 3. Evaluation of the CFA

Index	Good fit	Statistic	Rationale
χ^2	$0 \leq \chi^2 \leq 2df$	355.4 < 360	Yilmaz & Çelik (2009)
p value	$0.05 \leq p \leq 1.00$	<0.000	Hoyle (1995)
χ^2/df	$0 \leq \chi^2/df \leq 2$	1.974	Tabachnick & Fidell (2005)
RMSEA	0 ≤ RMSEA ≤ 0.05	0.073	Schumacker & Lomax (2004), Raykov & Marcoulides, (2006)
	0 ≤ RMSEA ≤ 0.08		Hooper et al. (2008), Steiger (2007)
SRMR	0 ≤ SRMR ≤ 0.10	0.093	Kline (2005)
CFI	0.90 ≤ CFI ≤ 1.00	0.9	Hu & Bentler (1999)
GFI	0.90 ≤ GFI ≤ 1.00	0.84	Hu & Bentler (1999)

Chi-square:355.4; df:180

A number of further indicators were used to describe the fit of the model as summarized in Table 3. The root mean square error of approximation (RMSEA) of less than .05 is accepted as a good fit in some resources (Schumacker & Lomax, 2004, Raykov & Marcoulides, 2006); whereas the RMSEA was .073 in the current implementation. Since there are studies considering values below .08 as acceptable, the current value was not considered problematic (Hooper, Coughlan & Mullen, 2008; Steiger, 2007). On the other hand, two of the fit values were fairly beyond the acceptable limits (i.e., GFI & p value), which requires further implementations to improve the wording of current items. The summary of the complete CFA is provided in Figure 2.

Conclusion and Discussion

In recent decades, ICTs have become an integral component of the modern society. Correspondingly, mastering and demonstrating basic ICT skills is regarded as crucial to education (UNESCO, 2002). Today's students are supposed to be able to use technology to analyze, learn, and explore because these skills are vital for them to work, live, and contribute to the social and civic fabric of their communities. Prensky (2006) regarded these students (i.e. digital natives) as empowered in terms of several ways outside the schools because their lives are surrounded by a variety of digital tools. He further argues that students today are fluent in the language of the digital world. While it is plausible to claim that contemporary students are immersed in technology in their daily lives, this fact does not necessarily equate with them to being technologically literate. Thus, students need to be able to use relevant technology to analyze and engage with complex problems (Judson, 2009). This assumption is somewhat parallel with the idea that student learning can be enhanced substantially when the instructional material gets integrated with technology (Taylor, Casto & Walls, 2007). Because real life may require frequent technology use, using relevant technology in instructional settings can make learning more authentic.

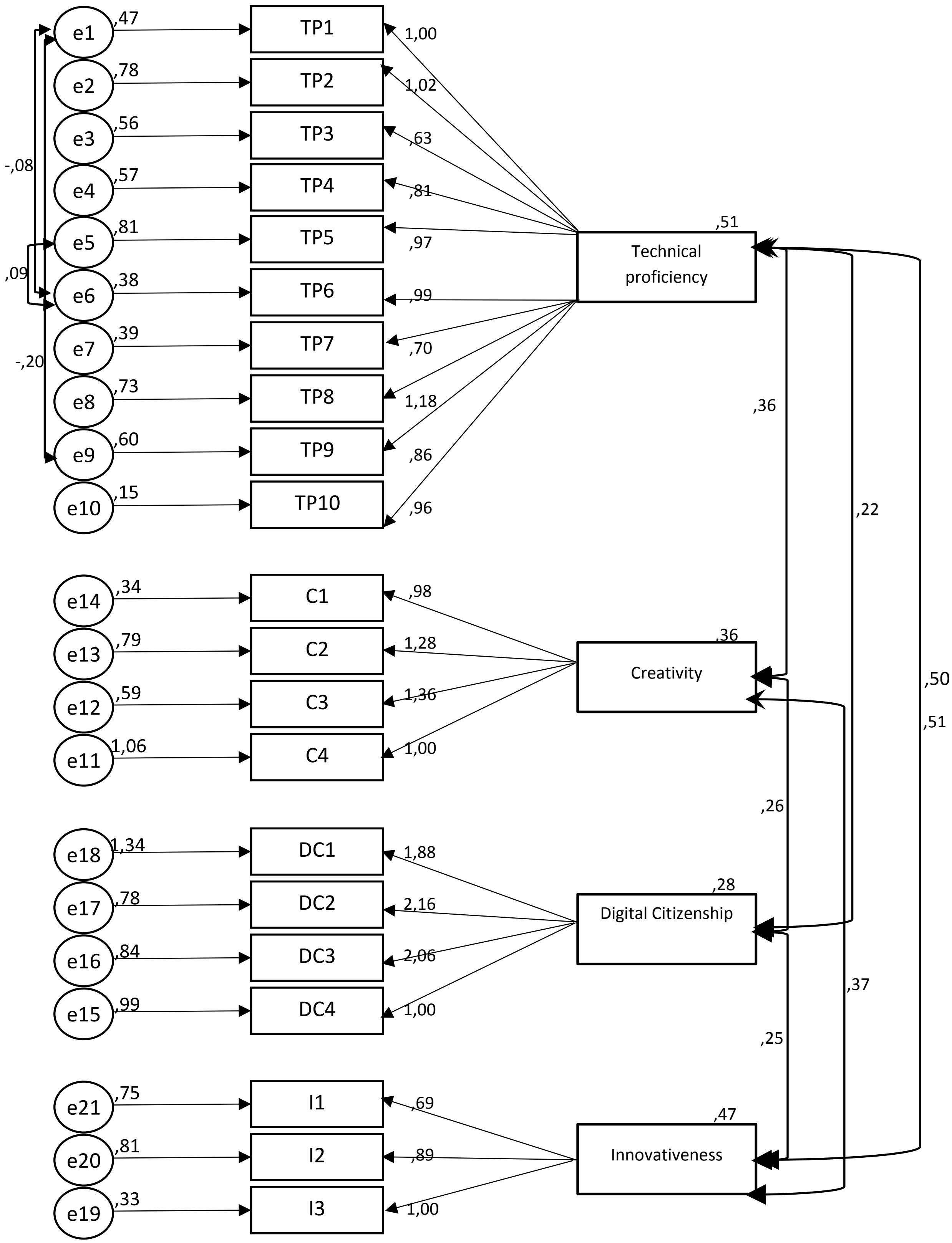

Figure 2. Results of the CFA

As pointed out earlier, NETS-S offered a set of criteria for measuring students' ICT literacies. These criteria provided educators with guidelines to equip students with crucial lifelong learning skills, as well as clues to survive and properly engage in the future community (NETS-S, 2007). On the other hand, the lack of objective measures to investigate ICT-related needs of students makes the evaluation more subjective and arbitrary (Reeves, 2002). Furthermore, developers of the NETS-S assumed that all students would have equal access to technology in order to develop relevant ICT skills. However, socio-economic and cultural characteristics may not allow such an equal access to technology in some societies. For instance, the current study investigated the case of a secular, western-oriented and developing country, where socio-economic and cultural conditions differ drastically from that of affluent industrialized countries. More specifically, according to the Better Life Index Chart of the Organisation for Economic Co-operation and Development (OECD, 2010), household net-adjusted disposable income in Turkey was 10.997 USD, which was considerably lower than that of the USA (i.e., 37.708 USD). The value for Turkey is also lower than the OECD average (i.e., 22.387 USD). The same report further draws attention to the fact that higher economic wealth may improve access to high-quality education. In this regard, the standards determined specifically for the US may result in different findings in Turkish educational settings.

In order to address aforementioned standards among 8th graders in Turkey, the NET-S related item pool was exposed to a series of analyses in the current study. At the inception the scale was designed to address all six dimensions defined in the NETS-S (ISTE-NETS, 2007), which are creativity and innovation (1), communication and collaboration (2), research and information fluency (3), critical thinking, problem solving and decision making (4), digital citizenship (5), technology operations and concepts (6). However, the majority of items were suppressed and 21 items constituted a robust and coherent structure sheltering four factors: technical proficiency, creativity, digital citizenship and participation, and innovativeness. The explained variance and internal consistency coefficients were plausible as well. Further statistical confirmation with a new sample was marginally acceptable in the beginning but more successful after some modification indices were defined. Thus, the current short form of the scale could be used reliably to evaluate Turkish 8th graders perceived level of technology literacy. Even though an extensive and thorough process was followed to define the current indicators, additional items can contribute to the reliability of the measure since several crucial competencies may have been suppressed during the statistical analyses. In this regard, the scale can be regarded as a modest contribution to the diagnosis of technology literacy skills among 8th graders so that further educational technology actions in the classroom can be planned accordingly.

ICT skills and standards contribute to delineating student achievement, teacher expectations and educational policy-making. As the world becomes increasingly digital and as education becomes increasingly globalized, these standards gain further significance. They also guide teachers and school administrators to utilize ICTs to provide instruction in an increasingly competitive environment (Thomas & Knezek, 2008). The current items were mapped to these indicators and addressed each indicator to some extent. Thus, it can be adapted in different technology literacy projects worldwide to investigate students' perceived ICT competencies. Even though the current findings have been collected from different cities and schools in Turkey, new contexts may suggest a different item and factor pattern. Thus, subsequent administrations with different target populations are needed. Finally, even though the coverage of the current item pools is somewhat limited, the structure of the scale may facilitate easy administration with large samples in order for policy makers to diagnose the overall picture. On the other hand, elaboration of the current factor structure through adding further indicators may be plausible in subsequent administrations.

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