Dimensions Underlying Assistive Technology (AT) Practices and Quality of AT Outcomes from the Perspective of Special Education Professors

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Abstract: *This study validated items for assistive technology (AT) evaluation and, accordingly, identified dimensions underlying AT practices and the quality of AT outcomes from the perspective of professors preparing preservice teachers for careers in special education. The statistical approach of multidimensional scaling was used, in which the proximity of similarity and dissimilarity between items was compared. Participants rated 4,851 comparisons, resulting in a dataset of 19,404 pairwise comparisons ($4,851 \times 4$). Stress and fit measures showed that the normalized raw stress was .07136, S-stress was .19190, dispersion was .92864, and Tucker's coefficient of congruence was .96366. These results revealed four underlying dimensions—Dependability and Support, Device Features, Ease of Use, and Efficiency—along with 11 clusters of quality of AT outcomes as being applicable to evidence-based AT implementation. These findings also reflect an effective framework for teaching those being prepared to work with students with mild or moderate disabilities about quality AT evaluation.*

Keywords: Assessment; Assistive Technology; Evaluation; Evidence-Based Practice; Instrument Development

1. Introduction

The Individuals With Disabilities Education Act (IDEA) of 1990 first made reference to assistive technology (AT) devices and services. An AT device is defined in the Assistive Technology Act of 1998 as “any item, piece of equipment or product

system, whether acquired commercially off the shelf, modified, or customized, that is used to increase, maintain, or improve the functional capabilities of children with disabilities” (Assistive Technology Act of 2004). Years later, the definition was altered with the amended IDEA of 2004 to clarify a school system's responsibility with regard

to providing medical devices, including the exception that the AT “term does not include a medical device that is surgically implanted, or the replacement of such device” (Individuals with Disabilities Education Improvement Act of 2004). Although variations of this AT definition are commonly cited, AT fundamentally refers to technology solutions and services that are related to instructional technology tools when recognized and legally specified as educationally mandatory in a student’s individualized educational program (IEP).

In response to growing trends in technology implementation as it relates to instruction, increasing demands in IEPs for provision of AT to help enable students with disabilities receive a free appropriate public education have revealed a need for valid measurement of AT device and service outcomes as a quality indicator (Graham & Warnie, 2012). In fact, the need for a valid measurement of AT devices and services has been well documented in the literature for some time (e.g., DeRuyter, 1995; Smith, 1996), with growing attention in recent years paid to validation and outcome measurement of AT as part of the response to the demand for evidence-based practices in special education as a whole (Agree & Freedman, 2011; Bernd, Van Der Pijl, & De Witte, 2009; Seok & DaCosta, 2014). Yet, assessments related to quality AT have lacked adequate validation processes or theoretical frameworks with regard to measuring AT outcomes (Lenker & Paquet, 2003; Lenker, Scherer, Fuhrer, Jutai, & DeRuyter, 2005). For example, until recently, user satisfaction served as a poor proxy for outcome (Lenker et al., 2005). The core issue with regard to AT provision involves enhanced performance or achievement outcomes according to the federal definition of AT devices.

One means of informing evidence-

based practices is to employ data from outcomes research (Gray, 1997). Namely, information collected using measurements with strong psychometric properties facilitates a comprehensive body of knowledge related to AT practices that includes assessment, selection, delivery, implementation, and evaluation (Karmarkar et al., 2012; Raskind & Bryant, 2002). Regrettably, few instruments with appropriate psychometric properties have been developed (e.g., Raskind & Bryant, 2002; Seok & DaCosta, 2014). That is, for outcome assessment of AT to be deemed effective for evidence-based practice and outcome research purposes, the content and dimensions represented by test items must be clearly stated and sufficiently denote these dimensions (The Commission on Instructionally Supportive Assessment, 2001).

Of the research conducted on outcomes assessment and validation of AT measures, a major focus has been on examining the quality of AT from the user’s perspective rather than other equally important points of view, such as AT subject matter experts (SME), experienced educators, and preservice teachers at the secondary level. Extensive research has been conducted to establish guidelines and standards for determining the quality of AT, such as the Functional Evaluation for Assistive Technology (FEAT; Raskind & Bryant, 2002). However, in spite of serious calls for assessing the quantity and quality of AT devices and services (Lenker et al., 2010), there continues to be a shortage of literature focused on AT evaluation and its validation from the perspective of subject matter experts (Seok & DaCosta, 2014).

That is, literature focused on AT evaluation and validation should focus on different viewpoints, to include experts and educators, such as professors preparing preservice teachers for careers in special education (Bausch & Hasselbring, 2004;

Demers, Wessels, Weiss-Lambrou, Ska, & De Witte, 2001; Gelderblom & de Witte, 2002; Pendleton & Schultz-Krohn, 2012). These individuals hold not only a wealth of knowledge in different facets of special education and the implementation and use of AT but also substantial responsibility for shaping future special educators. It is therefore imperative that scholars examine challenges related to item validation of instruments designed to assess AT outcomes from different perspectives.

1.1. Purpose of the Research

In an attempt to meet the need for an empirically supported study related to quality of AT outcomes, this study sought to collect validity evidence to sustain the use of a pool of items to enhance quality of AT outcomes for students with mild or moderate disabilities. Specifically, the study identified the dimensions underlying AT practices for outcome assessment as well as the clusters of validated items on each dimension of similarity. To accomplish these goals, the researchers asked the following research questions:

- 1) What are the dimensions of AT practices and their representation?
- 2) What are the clusters of validated items on each dimension?

Data were collected from professors preparing preservice teachers for careers in special education. This population was chosen over other SMEs because the quality of AT must be addressed not only from multiple dimensions but also from the viewpoint of different groups of people (Demers, Monette, Lapierre, Arnold, & Wolfson, 2002; Demers, Weiss-Lambrou, & Ska, 2002; Manhas, 2012).

This study is considered important for three reasons. First, it answers the call for research focused on assessing the quality of AT devices and services (Lenker et al., 2010), centering on research addressing AT evaluation and its validation. Second, it contributes to this line of research by offering a fresh viewpoint, told from the perspective of special education professors. Finally, the researchers anticipate that the dimensions and clusters revealed in this analysis can be used as a starting point toward the development of a robust assessment instrument to be used to enhance the quality of AT outcomes.

2. Method

This study comprises an exploratory data analysis focused on scale construction and dimensionality reduction using the statistical approach of multidimensional scaling (MDS). The method is presented in what follows.

2.1. Participants

The study, which began in 2011 and was completed in 2013, took place at postsecondary institutions in the midwestern part of the United States. A convenience sampling method was used. Of the 10 assistant and full professors solicited, 4 chose to participate. These were instructors responsible for preparing preservice teachers for careers in special education. Participants' teaching experience included educating preservice special education instructors about AT. Given that AT includes many topics, the professors were unlikely to be experts in all areas of this genre of technology. The following inclusion criteria were used to select participants: (a) professors in special education; (b) teaching experience in special education; (c) three or more years of experience in the selection and implementation of AT for students with mild or moderate disabilities; (d) authorship

of five or more chapters, articles, and/or conference proceedings on AT use; and (e) six or more semesters of syllabi reflecting AT implementation and practices in their courses. In addition to meeting these criteria, each of the four participants was also regarded as an expert in his or her respective area of special education. Two participants were considered authorities on learning disabilities, one on early childhood, and the fourth on behavior disorders.

2.2. Materials

The research was based on an earlier validation study by Seok and DaCosta (2014), in which the researchers identified valid items and factors applicable for students with mild and moderate disabilities derived from the FEAT (Raskind & Bryant, 2002), comprehensive literature reviews, and other relevant materials. The FEAT measure is one of few standardized measures in the special education field that can be used in AT use among individuals with learning disabilities (Raskind & Bryant, 2002). In the Seok and DaCosta (2014) study, the researchers formalized 99 items using a strict, multi-phased approach. (See Seok and DaCosta, 2014, for a detailed explanation of this process.) The items had long been used for AT evaluation without any validation process. A total of 1,472 special education teachers rated

the 99 items, that Seok and DaCosta (2014) then validated using factor analysis. These 99 items were used in the present study.

A custom website was developed to present the participants with pairwise comparisons of the 99 items for the analysis. A website was chosen because of the large number of evaluations to be conducted. Further, the online system could easily deliver, store, and retrieve the data—an otherwise difficult task when using traditional, nontechnical approaches. Figure 1 depicts one of these pairwise comparisons. The website displayed the item to be evaluated while randomly looping through each of the remaining items, allowing for rating of each pairing. Furthermore, the pairings were presented in random order to control for “a systematic item order effect” (Davison & Sireci, 2000, p. 79). Each comparison was scored using a 9-point scale with 1 representing the most extreme degree of dissimilarity and 9 representing the most extreme degree of similarity.

The item being rated (compared to all other items) was shown at the top of the screen with other items appearing one at a time below. Once the similarity of an item was rated against all others, a new item was presented. Each subsequent item was presented in a different color from the previous

The screenshot shows a web interface for rating a statement. At the top, a black bar contains the word "Instructions" on the left and "Question 1 of 4851" on the right. Below this, a light blue box contains the text: "The instructions are complete, concise, clear, and easy to follow (i.e., a logical step-by-step procedure)." Underneath the box, the statement "It will take time for the students to learn to use the device effectively." is displayed. At the bottom, a 9-point rating scale is shown, with the word "Dissimilar" in red on the left and "Similar" in blue on the right. The numbers 1 through 9 are in the center, with "1" being the largest and most prominent.

Figure 1. Tweet Frequency Histogram.

item, providing a visual queue indicating that the item being rated (to all the other items) had changed.

2.3. Procedure

Upon accessing the website, the participants were first presented with a webpage describing the purpose of the study along with instructions on how to rate the proximity of the items. Directed to the next page, the participants were presented with the informed consent statement. Those who did not agree were exited from the website. Those who agreed were next presented with additional instructions along with an example of a response comparing two items. Participants were also asked to enter a valid email address and a password before they were able to begin the pairwise comparisons. This completed the registration process and created an account for each of the respective participants.

Given the amount of time required to properly perform the comparisons, the capability to allow participants to start, stop, and resume the study at any time was added. This was done by permitting participants to access the website using the respective URL, email, and password. Upon continuing, the participants were again presented with instructions and a pairwise comparison example, where they picked up where they left off with the previous pairwise comparison rated. The email and password were only used as a way to allow participants to complete the study at their leisure (as opposed to one sitting). The information was not used for the purposes of identification.

Permission to conduct the study was obtained from the ethics committee of a research center. Invitation letters, to include an informed consent statement, were sent to each potential participant. Finally, participants

were treated in accordance with the American Psychological Association's general principles (2002).

2.4. Data Analysis

MDS was used to (a) identify dimensions underlying AT practices and (b) validate items from the perspective of subject matter experts. MDS typically uses small numbers of judges, or raters, as participants, and may include as few as one.

MDS offers a visual and mathematical depiction of the cognitive distance between items in a spatial mode (Davison & Sireci, 2000; Stalans, 1995). Specifically, the distance between two items is an inference of the proximity of perceptions between items (Sireci, Rogers, Swaminathan, Meara, & Robin, 2000). According to Stalans (1995), this spatial depiction, called a configuration, shows the location of each item of a dimension and is considered the most important result produced by MDS. Furthermore, each dimension in MDS matches up with an attribute of the items as needed to properly represent the similarity ratings.

MDS was chosen because it has been applied in other studies examining various aspects of learning (e.g., Davison & Sireci, 2000; Seok, 2009), and thus the technique is well established and accepted in educational research. It was also chosen because, as mentioned, a single rater can carry out MDS pairwise comparisons (Stalans, 1995). Multiple studies of MDS have mathematically shown that the sample size (i.e., the number of raters of the proximity between items) does not have a valid and considerable impact on the results (MacCallum, 1979; Rodgers, 1991; Stalans, 1995). Thus, MDS was well suited for the present study given the small sample size.

3. Results and Discussion

To investigate whether participants would recognize dimensions of quality of AT outcomes and if the configuration of items would be represented in the mathematical space as assumed, participants rated 4,851 comparisons, resulting in a dataset of 19,404 pairwise comparisons ($4,851 \times 4$). To develop the MDS matrices, the Statistical Package of Social Science (SPSS) 20.0 was used. The findings are discussed in what follows.

3.1. Stress and Fit Measures

PROXSCAL algorithms were employed to analyze the MDS of the proximity dataset. Generally used to determine configurations of items in a low-dimensional space, the PROXSCAL algorithms of this study minimized the normalized raw stress. Stress and fit measures showed that the normalized raw stress was .07136, S-stress was .19190, dispersion was .92864, and Tucker's coefficient of congruence was .96366. Accordingly, the results indicated that the four-dimensional model fit the data well.

3.2. Final Configurations

The purpose of the study was to collect evidence to sustain the validity of using the items to enhance the quality of AT outcomes. The findings revealed four dimensions as a result of exploring the content validity of items. A critical feature of using MDS is that, in addition to identifying key dimensions, researchers can project which clusters fall within each dimension (Seok, 2009). The findings revealed 11 clusters across the 4 dimensions.

3.2.1. What Are the Dimensions of AT Practices and Their Representation?

Table 1 shows the final multidimensional

configurations of each item as a result of the MDS analysis. Dimensions extracted from data are closely related to content validity (O'Neil, Sireci, & Huff, 2004) and contribute to framing the content of assessment (Lenker et al., 2005). The findings revealed the following four dimensions:

- **Dependability and Support.** Dimension 1 refers to the extent to which AT devices consistently operate as intended, including how they are supported by maintenance personnel and members of the AT team (Batavia & Hammer, 1990; Kajko-Mattsson, Karim, & Mirjamdotter, 2011).
- **Device Features.** Dimension 2 refers to the characteristics that affect person-device compatibility and academic success (Mirenda, 2001; Monk et al., 2006; Raskind & Higgins, 1998). This is related to unhandy, large, or massive size and format, including faulty AT, all of which are characteristics that often lead to AT abandonment (Copley & Ziviani, 2005; Rogers & Holms, 1992).
- **Ease of Use.** Dimension 3 refers to the extent to which a device is relatively simple and convenient to operate over an extended period of time (de Joode, van Heugten, Verhey, & van Boxtel, 2010; Demers, Weiss-Lambrou, & Ska, 2002).
- **AT Efficiency.** Dimension 4 refers to the effectiveness with which an AT device helps the user meet challenges and the user's comfort level with the device (Fuhrer, 2007). This is related to the effect obtained from its implementation in contrast to the outcomes expected beforehand (Gelderblom & de Witte, 2002). In other words, this dimension refers to attaining the improved or intended outcome through implementation of the AT.

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Overall, these dimensions are somewhat different from those identified in other studies. For example, Lenker et al. (2005) conducted a literature review of 82 outcome studies, mostly from the field of medical rehabilitation,

stressors users' perspectives, but most of them did not address psychometric properties. They identified six common dimensions: device usability, user satisfaction, quality of life, social role performance, functional level,

Table 1. Final Positioning of Items in the Multidimensional Space

<i>items</i>	<i>Dimensions</i>				<i>items</i>	<i>Dimensions</i>			
	1	2	3	4		1	2	3	4
1	-.272	.320	.311	-.434	51	.069	.558	.352	-.126
2	.139	-.662	-.002	-.002	52	-.072	.389	.530	.150
3	.371	-.547	-.149	.002	53	.476	.400	.151	-.222
4	-.036	-.572	.136	.333	54	.357	.549	-.146	.090
5	.043	-.015	-.051	.677	55	.261	-.192	-.103	.589
6	-.214	.115	.013	-.636	56	-.096	-.035	.672	-.027
7	-.099	-.665	.084	.004	57	.532	.326	-.212	-.167
8	-.366	-.495	.122	.256	58	.395	-.219	.010	-.508
9	-.460	.358	-.328	.096	59	.465	-.123	.413	-.237
10	.243	-.558	.163	.227	60	-.043	-.304	.285	.537
11	-.427	.475	.042	.220	61	.564	.172	-.293	-.110
12	-.189	.563	-.050	.324	62	-.154	-.277	.562	.213
13	-.617	-.262	-.076	-.048	63	-.163	-.540	-.204	-.321
14	-.651	-.025	-.104	.147	64	-.236	.037	.035	.635
15	-.229	.453	-.377	.229	65	.384	-.216	.354	.377
16	-.494	-.087	-.452	.051	66	-.341	.142	-.204	-.536
17	-.185	.456	-.380	-.276	67	-.001	.392	.165	-.533
18	-.027	-.367	-.029	-.569	68	.011	-.487	-.464	-.076
19	.128	-.246	.581	.214	69	.300	.364	-.345	.344
20	-.275	.564	.240	-.078	70	-.066	-.107	.565	-.353
21	-.090	.239	.554	-.301	71	-.087	.301	-.592	-.083
22	-.085	.621	-.046	-.259	72	.219	-.253	-.553	.175
23	-.335	-.172	-.341	-.454	73	-.204	.232	-.148	.592
24	.063	.380	-.542	.132	74	.664	.004	-.072	-.114
25	-.532	.270	-.250	-.196	75	.372	-.504	.233	-.109
26	-.531	-.253	.144	-.305	76	.210	.244	.184	.570
27	-.406	-.185	.506	-.064	77	.365	.167	-.542	.054
28	.098	.332	-.297	-.509	78	-.041	-.362	-.359	-.450
29	.419	.114	.429	-.296	79	-.621	.078	-.232	-.103
30	.361	.274	.219	-.456	80	.165	.085	-.633	-.148
31	.603	-.236	.128	-.153	81	.205	-.517	-.347	.175
32	.355	-.109	-.498	.278	82	-.362	-.456	-.289	.193
33	-.255	-.042	-.621	.039	83	-.315	-.112	-.450	.388
34	.519	-.331	-.017	.288	84	-.050	-.007	-.654	-.159
35	.214	.095	.621	-.150	85	.041	.599	-.307	.069
36	.218	.189	.488	.375	86	-.041	-.094	-.060	-.669
37	-.104	-.206	.247	-.590	87	.000	-.336	-.192	.562
38	.294	.049	-.360	-.498	88	.125	.659	.050	.067
39	.537	-.140	.355	.158	89	-.018	.384	.365	.424
40	.302	.528	.293	-.013	90	.030	-.285	-.610	.037
41	-.245	-.356	.358	-.380	91	-.270	-.366	-.498	.045
42	.359	.406	.253	.318	92	-.606	-.112	.242	.127
43	.596	.217	.107	.214	93	-.536	.228	.204	.276
44	.356	.052	.049	.574	94	-.455	.314	.300	-.254
45	.560	-.165	-.341	-.069	95	-.348	.340	.321	.342
46	.216	-.412	.417	-.249	96	-.511	-.352	.212	.163
47	.496	.124	-.205	.395	97	-.294	-.131	-.050	.599
48	.273	-.358	.121	-.491	98	-.605	.196	.198	-.117
49	-.276	-.522	.282	-.179	99	-.321	-.078	.487	.337
50	.286	.096	-.076	-.606	99	-.321	-.078	.487	.337

and cost. In a more recent study, Seok and DaCosta (2014) identified eight dimensions: effectiveness, affordability and dependability, utility, external support, operations, longevity, discomfort, and compatibility.

Although the dimensions identified by Lenker et al. (2005) and Seok and DaCosta (2014) differed based on the perspectives of the samples used, purposes of the AT used, and the context in which the AT was employed, collectively, their findings suggest guidelines for the development, design, selection, implementation, outcome assessment, and evaluation of AT and its framework (Lenker et al., 2005). In addition, they serve to delineate the aims of assessment (Keith, 1984; Lenker & Paquet, 2004).

3.2.2. What Are the Clusters of Validated Items on Each Dimension?

Clusters refer to one or more distinct constituents of a whole dimension recognized as being reciprocally related (Rogers, 2003; Vishwanath & Chen, 2006). Clusters provide the content specifications of dimensions in

a test (Shepard, 1980). Table 2 shows the final selected items in each dimension and their coordination from Table 1 and clusters with final coordinates. Four clusters were configured in Dimension 1: AT Care, AT Functionality, External Reliance, and Team Participation. Two equally generic clusters were identified that related to Dimension 2: Device-User Compatibility and Academic-Related Features. Three clusters were identified with regard to Dimension 3: User Friendliness, AT Convenience, and Long-Term Use. In this context, two clusters of Dimension 4, User Success and Operational Features, had been identified.

To develop a validated comprehensive pool of items, the researchers identified, developed, and adapted as many items as possible. The items were nested in the clusters, which were further scoped in their own dimensions, representing what was critical to the field of AT. The clusters and dimensions offered greater comprehension of what had been formally or informally considered in AT outcomes measure.

Table 2. Final Positioning of Items in Each Dimension and Cluster

<i>Dimension 1: Dependability and Support</i>		
<i>Cluster of AT Care</i>		
#	Values of Configuration	Items
74	.664	The AT device needs constant adjustment and/or excessive care in everyday use.
43	.596	A special room environment is required (e.g., heating, cooling, dust free, low or high humidity).
61	.564	The instruction book spells out all maintenance routines to be followed.
45	.560	Problems can arise if the equipment is not operated according to prescribed operating instructions.
39	.537	The device has special design features (e.g., plug-in modules) that can reduce the difficulty of repairs.
57	.532	Routine maintenance is necessary.
47	.496	Care and maintenance is necessary in order for the AT device to last throughout (and beyond) its expected life.
59	.465	The maintenance record forms are adequate.
58	.395	Maintenance record forms are provided.
3	.371	I have access to somebody whom I can consult with regarding AT.
77	.365	The turn-on/start-up routines must be followed each time the AT device is used.
30	.361	The likely cost of repair is affordable.
40	.302	Spares have been provided for the purpose of repair.
<i>Cluster of AT Functionality</i>		
#	Values of Configuration	Items
31	.603	The AT device is covered by public or private insurance (or other financing programs).
34	.519	The AT device has to interface with other devices.

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65	.384	The device functions as claimed by the manufacturer.
75	.372	There are indications that the equipment is ready to use (e.g., meter readings, lights on or off, signals).
42	.359	These types of devices have a prior breakdown history.
32	.355	There are warranties on the AT device.
50	.286	A technician or engineer is required for initial assembly or installation.
<i>Cluster of External Reliance</i>		
#	Values of Configuration	Items
53	.476	Special tools are required for assembly, installation, or start-up.
48	.273	The supplier will assemble and/or install the AT device.
<i>Cluster of Team Participation</i>		
#	Values of Configuration	Items
10	.243	The use of AT devices and services can be monitored by the AT team to ensure successful implementation.
2	.139	I feel confident in my ability to participate in an AT assessment.
Dimension 2: Device Features		
<i>Cluster of Device-User Compatibility</i>		
#	Values of Configuration	Items
88	.659	The AT device depends upon an external power supply or other hook-up.
85	.599	The AT device has safety features (e.g., emergency brakes).
12	.563	The visuals of the AT device look fine.
51	.558	Instructions for assembly and/or installation are included in the manual.
54	.549	Test equipment (e.g., computer, multimeter, oscilloscope) is required for start-up or calibration.
11	.475	The information is presented in an effective way (including use of speech, music, graphics, text, and animation).
24	.380	The visual distance is appropriate for the student.
28	.332	The price of the AT device is appropriate.
<i>Cluster of Academic-Related Features</i>		
#	Values of Configuration	Items
22	.621	The students have keyboarding proficiency (if applicable).
20	.564	The student is able to learn to use the AT device during the orientation.
17	.456	The student sustained attention using the AT device.
15	.453	The AT device relates to my school's curriculum.
67	.392	To meet the student's specific needs, other important needs are ignored, such as the student's academic needs.
9	.358	The AT device and services can help students achieve their IEP goals.
1	.320	I feel confident in my ability to assess student's need for assistive technology (AT).
94	.314	The AT device motivates the students' learning.
Dimension 3: Ease of Use		
<i>Cluster of User Friendliness</i>		
#	Values of Configuration	Items
56	.672	Maintenance is easily handled by the student (or personal assistant).
19	.581	The AT device can be used by the student for multiple tasks.
70	.565	The students independently go through all start-up and diagnostic routines.
62	.562	The instructions are effective.
21	.554	The student has sufficient overall technology literacy to use the device.
52	.530	The instructions are complete, concise, clear, and easy to follow (i.e., a logical step-by-step procedure).
<i>Cluster of AT Convenience</i>		
#	Values of Configuration	Items
27	.506	The AT device demonstrates ease of portability across settings.
36	.488	It is reasonable to expect me to carry out some of the repairs.
99	.487	The AT device helps my students become independent.
37	.247	Some types of repairs must be carried about by an expert.
<i>Cluster of Long-Term Use</i>		
#	Values of Configuration	Items
35	.621	The AT device is likely to become obsolete in the near future due to compatibility problems with devices now being developed.

29	.429	The likely cost of maintenance is affordable.
46	.417	The AT device remains dependable under repeated use.
41	.358	The device is dependable.
26	.144	The AT device is appropriate for future use.

Dimension 4: Efficiency

Cluster of User Success		
#	Values of Configuration	Item
5	.677	I am aware of my students' specific academic needs.
97	.599	The AT device helps my students learn how to learn.
95	.342	The interface of the AT device is efficient for the students.
4	.333	I have the ability to help my students achieve academically using technology.
93	.276	The AT device meets the students' academic needs.
8	.256	The AT device can help students access the general education curriculum.

Cluster of Operational Features		
#	Values of Configuration	Item
64	.635	The manufacturer addressed the function of the device.
76	.570	Certain tests or readjustments have to be made when the equipment is used during the initial warm-up/use phase.
60	.537	Operation and maintenance manuals are included with the AT device.
89	.424	The AT device can be adapted to hook up in different locations.
83	.388	The AT device has special features to enhance comfort (e.g., a special seating system or shock absorbers in the case of a wheelchair).

Each item of the four MDS models was mapped in the MDS space, as shown in Figure 2. The dimensions and respective clusters identified suggested that the validated measure resulting from the current research could contribute to the design of conceptual models that explicitly facilitated ways to enhance the quality of AT outcomes and practice. As a result, this could fill the void in the absence of validated AT outcomes measures (de Joode et al., 2010; Lenker & Paquet, 2004; Wand & Weber, 2002).

3.3. Limitations and Future Research

Certain aspects of this research, while not necessarily limitations, pose concern and warrant future investigation. Specifically, a website was used as a data collection vehicle given the large number of pairwise comparisons to be completed. Other studies have used paper-based methods (e.g., Sireci et al., 2000), but these studies comprised a small number of evaluations in comparison. Nevertheless, the presentation medium of

Figure 2. Object points in common space.

the website in the current study could have affected the results. Mathematically speaking though, factors such as sample size do not matter with regard to having a valid and considerable impact on results (MacCallum, 1979; Rodgers, 1991; Stalans, 1995). While inclusion of a greater number of participants, for example, may provide more in-depth and statistically powerful results about the dimensionalities and their characteristics, sample size is not believed to have any bearing on the results of a MDS analysis itself. Thus, pairwise comparisons performed paper-and-pencil versus computer may have little to no impact on findings. Even so, future studies may wish to take into consideration the manner in which the pairwise comparisons are administered. Further, sampling bias is a concern in that the special educators who participated may not be representative of special needs educators as a whole. Thus, caution should be exercised in generalizing the findings.

Technology changes rapidly and, consequently, can lose its relevance. Technology applicable to AT is no exception. As a result, items should be evaluated for significance before being considered for use. This includes the items used in the present study, as they need to be examined in the context of benefiting today's youth in the digital information age.

In addition, while the AT practices for outcomes assessment in this study primarily focused on the classroom setting, they could be expanded beyond this locale. Thus, future studies may wish to investigate these dimensions and clusters in other settings to include rehabilitation centers, hospitals, and private homes. This is particularly important given the eventual goal of developing a scale, from these and future findings, for assessing the quality and outcomes of AT that are fundamentally built upon different viewpoints.

Finally, the item pool validated here may be converted into scales and subscales to assess several aspects of the quality of AT outcomes. This could include extending these findings to further research, such as employing advanced psychometrics to design a series of subscales that address quality of AT outcomes and the effectiveness of performance outcomes toward the goal of developing and validating models based on the dimensions and clusters.

4. Conclusion

Increasingly, the need for valid measurement of AT devices and service outcomes as a quality indicator in special education has been widely expressed. Although this need has been well documented in the literature, to date, outcome assessments related to quality AT have lacked satisfactory validation processes or theoretical models with which to measure AT outcomes. Further, the research conducted on outcomes assessment and validation of AT measures has focused on examining the quality of AT in the context of the user's perspective rather than other equally important points of view, including those of experienced educators, preservice teachers at the secondary level, and AT SMEs.

Toward the goal of meeting the need for an empirically supported study related to the quality of AT outcomes from viewpoints other than those of the user, this study validated items for AT evaluation and, accordingly, identified dimensions underlying AT practices and the quality of AT outcomes from the perspective of professors preparing preservice teachers for careers in special education. Using the statistical approach of MDS, participants rated a total of 19,404 pairwise comparisons. The results revealed 4 underlying dimensions—Dependability and Support, Device Features, Ease of Use, and Efficiency—and 11 clusters of quality of AT

outcomes showing applicability to evidence-based AT implementation, reflecting a framework for teaching AT evaluation to those preparing to work with students with mild and moderate disabilities.

This study makes an original contribution to the literature by being one of few investigations of its type that has sampled professors preparing preservice teachers for careers in special education—an important distinction, given their breadth of knowledge and role in shaping future special educators. The study is also unique because of its advanced validation application. The multiple configurations of clusters made each dimension self-evident and the dimensions as foci of quality AT very likely for evidence-based AT practice when working with students with mild or moderate disabilities in the classroom. Thus, the study offers guidelines, or quite possibly a framework, to improve quality AT, characterized as dimensions and respective clustered items—a model that can be used to help ensure high-quality AT practices for these students.

All in all, the study contributes to a greater understanding of quality AT measures stemming from its examination of the consistency of the item pool as an instrument of the quality of AT outcomes through identification of dimensions and respective clusters. Although much more research is needed, it is hoped that the dimensions and clusters revealed in this analysis can be used as a starting point in the development of a robust assessment instrument to enhance the quality of AT outcomes.

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Acknowledgments

This study was made possible with funds granted by the National Research Foundation in Korea under the title “Development and Validation of Functional, Ecological, and Matching Evaluation Instrument for Assistive Technology and Students With Disabilities at the Elementary and Secondary Levels by Applying Multidimensional Scaling,” number B00078.

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