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Technology Specialists' Perspectives on Nano-technology Applications Used for University Students with Disabilities

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ABSTRACT: Assistive devices and technology have contributed to expanding the research base related to technology in the field of special education. Researchers have shown interest in technology because they find it a promising way to address a major practical problem in this field. This study aims to identify the knowledge level of assistive technology specialists in nano-technology applications used for people with sensory, physical, and health disabilities, as well as its effect on improving their quality of life. A descriptive-analytical method was employed, in which a questionnaire was developed and administered to a sample of 244 specialists. The results revealed that the knowledge level of assistive technology specialists in nano-technology applications for persons with disabilities and its impact on improving their quality of life is low. Furthermore, there were no statistically significant differences based on gender, years of and experience. The study enriches the theoretical literature on nano-technology applications and researchers' and students' knowledge by clarifying the relationship of the discussed variables with each other. It provides an opportunity for researchers to create innovations that lead to broad improvements in our lives.

Keywords: assistive technology specialist, life quality, nano-technology applications, persons with disabilities.

I. INTRODUCTION

Nanotechnology (NT) is considered one of the most innovative and influential technologies of the modern era, with immense potential to improve the quality of life in various fields, including health, the environment, and energy. The strong relationship between NT and research on its acceptance and use by individuals with impairments is justified for a number of factors [1-3]. Nanomaterials have the potential to be utilized in the development of stronger and lighter prosthetic limbs, more accurate hearing aids, and optical instruments that improve vision capabilities. People with impairments may find it easier and more autonomous to live their daily lives thanks to these developments [4-6].

Prosthetics made by NT are lighter, more flexible, and more durable, which makes it easier for users to operate and use for extended periods of time without becoming tired. People with hearing impairments can benefit from improved quality and accuracy of hearing aids thanks to nanotechnologies. When NT is used in the development of lenses and optical equipment, people with visual impairments can see more clearly. The efficacy and efficiency of assistive technology utilized by individuals with disabilities can be significantly improved by NT.

Additionally, NT contributes significantly to modern medicine by offering efficient treatment options. Drugs can be delivered more accurately using NT, increasing therapeutic results and lowering side effects. These technologies can improve the general health of people with disabilities or make certain disabilities easier to treat [7–9]. Furthermore, NT enables accurate drug delivery to the appropriate locations, enhancing therapeutic results and reducing side effects. The use of NT in diagnostics can raise the chance of a successful course of treatment by detecting diseases early [10, 11]. To understand how NT can best assist people with disabilities, it is crucial to investigate how they use and embrace this technology. Since these studies might highlight the technical, social, psychological, and other difficulties that people with disabilities may have when utilizing NT, they may be helpful in identifying obstacles. For example, some people may experience anxiety when using new technologies [12–14]. By increasing awareness and providing technical and psychological support, studies may also help design policies that encourage the usage of technology. To educate people about the benefits of nanotechnologies, for example, workshops might be organized. They might therefore ensure that NT is affordable and available to everyone, promoting fairness in the use of the benefits this technology provides. Businesses may work to make nanodevices more affordable and available to a larger range of people [15, 16]. However, contemporary technology has negative social and psychological effects.

Research on NT adoption and use can help us better understand how technology may affect people with disabilities psychologically, as well as how it could enhance their social interactions and quality of life. People might feel more strong and autonomous thanks to modern technology, which improves their happiness and mental well-being. Some people may find it challenging to adapt to new technologies. Research on the uptake and application of NT provides useful information for those who developed the technology. By considering the needs and preferences of people with impairments, developers can produce more user-accepted nanoproducts [11–15].

Nanodevices may be customized to meet the specific needs of each user, increasing their efficacy and user satisfaction. Products may be improved and further developed to satisfy changing demands with the aid of ongoing consumer input. In conclusion, there are several important factors that promote the interaction between NT for people with disabilities and research on the uptake and application of this technology. These studies enhance the overall benefits of NT and improve the quality of life for people with disabilities by ensuring that these innovative and cutting-edge technologies are widely available and well-received [17–19]. By figuring out what influences NT adoption and usage, effective ways to empower people with disabilities and take use of this promising technology may be developed [17]. Research on the use of assistive technology for students with disabilities has significantly increased during the past several decades. Numerous educational initiatives and innovative applications in the fields of special education training, assessment, and evaluation have resulted from this. Studies on assistive technologies have contributed to the expansion of the body of knowledge on technology in the field of special education [20–23].

Numerous studies have examined the extent to which assistive technology helps people with impairments and enhances their quality of life. This study found that persons with disabilities utilize technology at moderate to low levels, with computer applications and visual impairment seeing the most utilization. Nanotechnology is one of the fundamental principles of 21st-century technology and an important indicator of national progress. It has sparked revolutions in every area of life, including medical, pharmacology, materials science, energy, computers, and information technology. In fact, nanotechnology is present in a lot of objects around us, and its new uses are expanding daily [24].

1. PROBLEM STATEMENT

Research on the use of assistive technology for students with disabilities has increased significantly over the last 20 years, which has resulted in the creation of a large number of educational initiatives and cutting-edge applications in the areas of special education training, assessment, and evaluation. Previous studies have shown that the use of assistive technology has been relatively limited, with most applications focused on visual impairments and computer applications. However, nanotechnology has become one of the main pillars of 21stcentury technology, transforming a number of industries, including information technology, materials science, medical, pharmaceuticals, and energy. Through applications that potentially prevent impairments or lessen their effects, NT offers enormous potential to improve the quality of life for those with disabilities. Despite these important technical developments, little research has been done on how much assistive technology specialists (ATSs) know about NT apps and how to utilise them to improve the quality of life for people with disabilities, particularly in Jordan. The research aims to respond to these queries:

What is the level of knowledge of assistive technology specialists in nano-technology applications and their role in enhancing the standard of living for people with disabilities?

- Are there statistically significant differences in the level of knowledge of assistive technology specialists in nano-technology applications and its impact on enhancing the standard of living for people with disabilities based on gender, years of experience, and the field of assistive technology

2. STUDY OBJECTIVES

This study aims to:

- Measure the level of knowledge assistive technology specialists have regarding nanotechnology applications designed for individuals with sensory, physical, and health-related disabilities, in light of the evident knowledge gap in current literature particularly within the Jordanian context concerning these specialists' awareness of nanotechnology and its role in improving the quality of life for this population.
- Analyze the perceived impact of nanotechnology applications on enhancing the quality of life for individuals with disabilities, as viewed by assistive technology specialists, especially given the limited research directly linking nanotechnology to quality-of-life outcomes.
- Identify differences in the level of knowledge among assistive technology specialists regarding nanotechnology applications based on gender, years of experience, and specialization in assistive technology.

3. THE SIGNIFICANCE OF THE STUDY

Previous research has revealed barriers to the effective use of assistive technology, particularly in cutting-edge nanotechnology applications that might enhance these individuals' quality of life. Despite technological advancements, there is still a lack of knowledge and comprehension of the applications of NT among ATS. This necessitates a thorough investigation to evaluate this level and determine strategies for improving the community's utilisation and advantages of this technology. The study is important because it advances knowledge of how to improve assistive technology, including NT, to better serve Jordan's disabled population. This entails determining possible uses, identifying obstacles that can prevent this technology from being used effectively, and offering helpful suggestions to raise expert knowledge and training. The ultimate goal is to improve the quality of life for people with disabilities and integrate them more effectively into society.

II. LITERATURE REVIEW

In order to prepare the upcoming generation of technicians to handle this cutting-edge sector, Fazarro et al. [25] examined the reality of nanotechnology knowledge and its training in higher education, concentrating on the theoretical underpinning for developing and implementing a nanotechnology safety course. Similarly, Stoebe et al. [26]. sought to identify the abilities needed for nanotechnology experts to do their jobs effectively. The results showed how urgently training and a broad foundation in nanotechnology are needed.

Ayyad's [27] study examined the effects of a proposed unit on the cognitive achievement and learning satisfaction of university students in Gaza and assessed the knowledge of nanotechnology among technology teachers in the southern provinces of Palestine using a sample size of 196 teachers. The findings revealed a decline in technology teachers' knowledge of nanotechnology, which was ascribed to factors like gender, experience, preparation institution, and province. The study also discovered that teaching a suggested nanotechnology unit had a favorable impact on students at Al-Aqsa University in Gaza's cognitive achievement and happiness with their education. Using a sample of 115 students, Darwish [28] examined the degree of awareness of nanotechnology applications among scientific education college students in Gaza universities. The results showed a low cognitive level among students in nano-concepts and applications.

Babatunde et al. [29] conducted a thorough assessment of studies on NT applications and stakeholder perspectives on the effect of NT. The results revealed that NT has various effective applications. The extent to which nanotechnology will revolutionize and modify the environment is heavily influenced by public perception. Religious views and moral concerns, faith in governmental regulatory bodies and the industry, and societal participation in product design, development, and commercialization are all important factors in the acceptability of nanotechnology technologies. The expression of objective opinions on the advantages, limitations, and hazards, as well as sufficient education of the general public, risk regulators, and other stakeholders, are critical in determining the fate of nanotechnology. Al-Atiyat and Mohamed [30] investigated the effectiveness of a proposed program in nano-science and technology in developing evaluative thinking skills and awareness of nano-technology issues and applications among students. The outcomes demonstrated how well the curriculum developed students' critical thinking and understanding of challenges related to nanotechnology. In a similar vein,

Monden et al. [31] investigated perceived barriers to accessing and using assistive technology (AT) among experts and citizens. The participants were asked to share their perceptions of (1) the facilitators and barriers to AT access and utilization, and (2) the benefit of AT use in everyday life. Being linked to resources, trial and error, and peer expertise were all factors that facilitated AT utilization and access. Barriers to AT usage were device costs, a general lack of understanding of resources, and eligibility restrictions; only Veteran participants supported the last two topics. Improved independence, engagement, productivity, quality of life, and safety were among the benefits of AT. The results highlight the importance of AT for individuals with SCI by identifying important enablers of AT acquisition and use, obstacles that result in underutilisation of AT, and noteworthy benefits of adopting AT.

The goal of Loveys and Butler's [32] study was to identify differing opinions on the degree to which AT fosters independence in visually impaired pupils, and the results showed that the degree differs per student. Each member of the teaching staff was watched in five classrooms and four students were questioned.

This article focusses on teacher and student opinions on the extent to which ATs allow students with VI freedom in their learning, as well as whether ATs play an important part in these students' educations. The data demonstrated overwhelmingly positive attitudes of AT's potential for students with VI. The level to which pupils gain from these benefits varies by individual. The students focused mostly on their own sentiments about utilizing technology, but the professors commented on their feelings and went into depth regarding specific students' achievements and failures when using ATs. Participants voiced concerns about keeping up with technology, which is continuously evolving. higher research recommendations include a longitudinal study at the institution where this research was conducted to see if partnership higher education promotes inclusiveness.

The aforementioned studies discussed the level of knowledge in society, teachers, and students in schools and universities regarding nano-technology. No studies were found that discussed the extent of knowledge among ATSs regarding its applications and uses for individuals with disabilities. Hence, the importance of this study arises, as it is the first of its kind, to the best of the researchers' knowledge, to address this topic. The researchers, through their work in the field of special education, observed a lack of attention and knowledge among many professionals and stakeholders in the field of assistive technology for individuals with disabilities regarding the importance and potential improvements in using and deploying applications of 21st-century modern and distinctive nano-technology, known for its quality, efficiency, and low cost, to serve various segments and categories of disabilities. These applications could provide practical solutions to enhance the daily and vital tools used by individuals with disabilities, enabling them to live independently.

III.METHODS

1. STUDY POPULATION AND SAMPLE

The study population comprised all assistive technology specialists for individuals with disabilities in Jordan, numbering 244 specialists. The population was determined using the comprehensive census method. After excluding the survey sample, which comprised 30 specialists, the final study sample size is 100 specialists. A sample size of 100 participants is statistically appropriate for the purposes of comparative analytical research, particularly given the stable demographic structure and relatively small size of the total population. Moreover, it meets the requirements for conducting multivariate statistical analyses such as Multivariate Analysis of Variance (MANOVA). The researchers distributed the study tools to them manually, and all were retrieved. The data underwent a statistical analysis. Table 1 illustrates the distribution of the study sample according to their personal and functional variables.

Table 1. Distribution of study participants according to personal and functional variables.

Variable	Category	Frequency	Percentage
Gender	Male	186	%76.2
	Female	58	%23.8
	total	244	%100.0
Experience years	less 5 years	54	%22.1
	5-10 years	98	%40.1
	more 10 years	92	%37.8
	total	100	%100.0
Assistive technology field	hearing impairment	91	%37.3
	Visual impairment	55	%22.5
	Physical and health disability	98	%40.2
	total	100	%100.0

2. STUDY TOOL

The researchers developed a tool to measure the level of knowledge of assistive technology specialists in nano-technology applications role in improving the standard of living for people with disabilities. This tool was based on theoretical literature studying the uses of nano-technology to assist individuals with disabilities. Several studies were reviewed, including Al-Iskandarani's [33] Macoubrie's [34], Fazarro et al. [25], and Ayyad's [27]. The questionnaire consisted of 30 items distributed across two domains: the level of knowledge of ATSs in nano-technology applications, represented by items (1–10), and the role of nano-technology applications in enhancing the quality of life for persons with disabilities, represented by items (11–20). Likert's five-point scale was used to distribute the responses of the sample individuals according to the following arrangement: a high level of knowledge received a score of (5), a moderate level (4), a low level (3), a very low level (2), and no knowledge at all received a score of (1). Thus, the highest score a respondent could get on the tool is 150, and the lowest score is 30. Up to this study, arithmetic means were used to assess the level of knowledge of specialists in assistive technology across domains and items.

3. VALIDITY AND RELIABILITY

The validity of the tool was verified by presenting it to ten professors from the University of Jordan who have expertise in measurement, assessment, and special education. This was done to verify the clarity of the items, the linguistic accuracy of their formulation, and the extent of the items' correlation with the domain and the domain with the tool. Several observations were taken into account, and a criterion of (80%) or above was adopted to retain, delete, or modify the item.

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The reliability of internal consistency was verified by calculating the correlation coefficient between the item, its domain of belonging, and the total score. The tool was applied to a sample from the study population and beyond, with a sample size of 30 specialists. Table 2 presents the results.

Table 2. Correlation coefficients for the item with the domain and the total score.

Item	Item correlate to domain		Item correlate with total degree		Domain correlate with total degree	
	R	P. Value	R	P. Value	R	P. Value
Domain 1: knowledge level of ATSs in nano-technology applications					**0.91****	**0.000**
1	0.60**	0.000	0.58**	0.001		
2	0.71**	0.000	0.59**	0.001		
3	0.78**	0.000	0.73**	0.000		
4	0.69**	0.000	0.60**	0.000		
5	0.55**	0.000	0.57**	0.001		
6	0.70**	0.000	0.54**	0.002		
7	0.76**	0.000	0.60**	0.000		
8	0.66**	0.000	0.70**	0.000		
9	0.65**	0.000	0.68**	0.000		
10	0.62**	0.000	0.54**	0.002		
Domain 2 : Nano-technology applications role in improving life quality for individuals with disabilities					0.94**	0.000
11	0.78**	0.000	0.77**	0.000		
12	0.52**	0.002	0.49**	0.007		
13	0.63**	0.000	0.70**	0.000		
14	0.71**	0.000	0.74**	0.000		
15	0.75**	0.000	0.85**	0.000		
16	0.80**	0.000	0.79**	0.000		
17	0.66**	0.000	0.67**	0.000		
18	0.46*	0.010	0.44*	0.016		
19	0.59**	0.001	0.57**	0.001		
20	0.74**	0.000	0.69**	0.000		
21	0.47**	0.009	0.43*	0.016		
22	0.79**	0.000	0.74**	0.000		
23	0.75**	0.000	0.70**	0.000		
24	0.60**	0.000	0.53**	0.002		
25	0.79**	0.000	0.72**	0.000		
26	0.73**	0.000	0.65**	0.000		
27	0.74**	0.000	0.71**	0.000		
28	0.73**	0.000	0.70**	0.000		
29	0.41*	0.024	0.45*	0.013		
30	0.48**	0.007	0.42*	0.022		

Table 2 reveals that the correlation coefficients between domains and the total score ranged from (0.91-0.94), while the correlation coefficients between the items and the domain ranged from (0.41-0.80), and the correlation coefficients between the item and the total score ranged from (0.42-0.85). All of these coefficients are statistically significant at the ($\alpha \leq 0.05$) significance level. This shows the validity of the tool, making it suitable for the study.

4. RELIABILITY OF THE TOOL

The reliability of the study tool was verified using the coefficient of internal consistency stability with the Cronbach's Alpha formula. The overall stability value for the study tool was (0.94), as shown in Table (3), which illustrates the coefficients of internal consistency stability for the domains and the entire scale.

Table 3. Coefficients of internal consistency stability (Ronbach's alpha).

No.	Domain	Item numbers	Cronbach Alpha
1	Knowledge level of the assistive technology specialist in nano-technology.	10	0.86
2	Nano-technology applications have an important role in enhancing the quality of life for individuals with disabilities.	20	0.93
-	tool as a whole	30	0.94

Table 3 reveals that the Cronbach's alpha stability coefficients for the domains ranged between 0.86-0.93, indicating a high level of stability.

5. STATISTICAL ANALYSIS

The descriptive-analytical approach was used to assess the level of knowledge of ATSs in nano-technology applications and their role in enhancing the standard of living for people with disabilities.

5.1 Study Variables

5.2 Independent Variables

- Gender: two categories (male and female).
- Years of Experience: Three categories (less than 5 years, 5–10 years, and more than 10 years).
- Assistive Technology Field: Three categories (Physical and Health Disability, Hearing Impairment, and Visual Impairment)

5.3 Dependent Variables

- Level of knowledge of ATSs in nano-technology applications.
- The role of nano-technology applications in improving the quality of life for persons with disabilities.

IV. RESULTS

To answer the first study question which states, "What is the level of knowledge of ATSs in nano-technology applications and their role in enhancing the standard of living for people with disabilities?" the mean values and standard deviations for the domains and the total score were extracted as presented in Table 4.

Table 4. The level of knowledge of ATSs in nano-technology applications and their role in enhancing the standard of living for people with disabilities.

No.	domain	mean	Std. devi.	rank	level
1	Knowledge level of ATSs in nano-technology applications.	2.29	0.288	1	low
2	Nano-technology applications have an important role in enhancing the quality of	2.19	0.158	2	low

life for individuals with disabilities.				
Tool as whole	2.22	0.137	-	low

According to Table 4, the average knowledge of ATSs in Jordan regarding the applications of nanotechnology and how they might improve the quality of life for people with disabilities was 2.22, with a standard deviation of 0.137. This indicates a poor degree of gratitude. First place went to the area of ATS knowledge in nanotechnology applications, with an average score of 2.29 and a standard deviation of 0.288. The domain that came in second place was related to the function of nanotechnology applications in enhancing the quality of life for people with disabilities. It had a low level average of 2.19 and a standard deviation of 0.158 for the two domains. The mean values and standard deviations for the items in each domain are presented in Tables 5 and 6.

Table 5. The level of knowledge of ATSs in nano-technology applications.

No.	Domain	mean	Std. Devi.	Rank	level
1	Assistive technology provides a decent life for individuals with disabilities.	3.83	0.911	2	high
2	I know that there is a legal text that requires the use of assistive technology for individuals with disabilities.	3.86	0.876	1	high
3	I have an idea about the concept of the twenty-first century technology "nano-."	2.18	0.500	6	low
4	Nano-technology provides enormous potential for finding new materials by controlling matter at the molecular level.	2.37	0.506	4	Moderate
5	Nano-technology has significant economic implications.	2.38	0.546	3	Moderate
6	Nano-technology is used to manufacture high-quality products with efficiency and low costs.	1.39	0.790	10	low
7	Nano-technology has revolutionized the medicine world, cancer treatment, energy, computers, environmental cleaning, warplane production, and engineering fields.	1.47	0.834	9	low
8	Nano-technology exists in many things around us and is a common denominator for many industries.	1.53	0.870	8	low
9	Nano-technology can be used to improve the quality of tools and equipment used for individuals with disabilities.	1.63	0.960	7	low
10	Nano-technology is a double-edged sword. It has useful and harmful applications.	2.23	0.649	5	low
-	domain total degree	2.29	0.288	-	low

According to Table 5, the average total knowledge of ATSs in Jordanian nanotechnology applications was 2.29, with a standard deviation of 0.288. This indicates a poor degree of gratitude. With an average score of 3.86 and a standard deviation of 3.86, item number 2, which reads, "I am aware of the existence of a legal text requiring the use of assistive technology for individuals with disabilities," was placed highest.

The statement "Assistive technology provides means for a decent life for individuals with disabilities" (item number 1), which has an average of (3.83) and a standard deviation of (0.911), comes in second. The statement "Nano-technology has significant economic implications" (item number 5) is ranked third with an average of 2.38 and a standard deviation of 0.546. Last but not least, item (6), which has an average of (1.39) and a standard deviation of (0.790), is in the fourth position and says, "Nano-technology is used in manufacturing high-quality, efficient, and cost-effective products".

Table 6. The role of nano-technology applications in enhancing the standard of living for people with disabilities.

No.	domain	mean	Std. Devi.	Rank	Level
11	Nano-technology contributes to preventing disability and reducing its negative effects	2.55	0.520	3	Moderate
12	Nano-technology is used in manufacturing cars with high quality, which reduces accidents and disabilities	2.53	0.540	4	Moderate
13	Nano-photocatalysts are used to kill viruses in the air, which reduces respiratory disease	2.20	0.921	10	low
14	Silver nano-fibers are used inside the diabetic patients shoes, which reduces the amputation of their feet and the incidence of motor disability	1.43	0.655	17	low
15	Carbon nano-tubes reduce air pollution, which reduces complications in respiratory disorders patients	2.28	0.494	8	low
16	Nano-chemical sensors are used to detect mines and explosives, which reduces physical and hearing impairments	3.10	0.745	1	Moderate
17	Nano-technology improves prostheses and wheelchairs properties for people with physical disabilities and athletes with disabilities, which enhances their self-confidence	2.60	0.696	2	Moderate
18	Coating prosthetic devices surfaces with nano-materials for persons with disabilities to reduces bacterial effects	2.20	0.910	10	low
19	Nano-technology offers Electronic prostheses (such as nose, tongue) to distinguish smell and taste for people with sensory disabilities, which compensates functions loss of those senses	1.60	0.853	16	low
20	Nano-drugs are used to treat mental disorders for persons with disabilities and to promote mental health	2.35	0.592	5	Moderate
21	Pharmaceutical nano-particles are effective in treating diabetes	2.32	0.750	7	low
22	Nano-compounds are added to fracture sites for healing and bone injuries prevention and skeletal disorders	1.93	0.742	14	low
23	Nano-laser is used to prevent age-blindness in visual impairment cases	1.94	0.736	13	low
24	An artificial retina made of nano-crystal diamond membranes could be developed to help the visually impaired	1.64	0.659	15	low
25	Pharmaceutical nano-particle systems directed through the eye treat diseases cause visual impairment	2.23	0.737	9	low
26	The Verso hearing aid uses nano-technology as an advanced solution for people with hearing disabilities	2.06	0.617	11	low
27	Verso earphone is characterized by its water resistance, and it tunes in to all the sounds that the individual wants to hear naturally	2.34	0.517	6	Moderate
28	Sensorineural hearing loss is treated by implanting a modified nano-technology device behind the cochlea	2.28	0.753	8	low
29	I reviewed conferences recommendations emphasizing the nano-technology use to increase academic achievement, social interaction, and independent living skills for individuals with disabilities	2.23	0.423	9	low

30	I dealt with people used nano-technology to develop supportive equipment and tools that facilitate life of persons with disabilities	2.00	0.876	12	low
-	domain total degree	2.19	0.158		low

Table 6 presents the overall mean (2.19) with a standard deviation of 0.158 for the domain of the role of nanotechnology applications in improving the quality of life for individuals with disabilities in Jordan. This indicates a poor degree of gratitude. With an average of (3.10) and a standard deviation of (0.745), item number (16), which reads, "Chemical nano-sensors are used to detect landmines and explosives, reducing physical and auditory disabilities," ranked best. With an average of 2.60 and a standard deviation of 0.696, item number 17 (which reads, "Nano-technology improves the features of artificial limbs and wheelchairs for individuals with physical disabilities and athletes with disabilities") is in the second position. The statement "Nano-technology contributes to the prevention of disability and the reduction of its negative effects" (item number 11) is in the third position, with an average of (2.55) and a standard deviation of (0.520). The statement "Silver nano-fibers are used inside the shoes of diabetic patients, reducing amputations and mobility impairment" (item number 14), with an average of (1.43) and a standard deviation of (0.655), is in the last position.

Table 7. The tool's domains and overall score according: gender, years of experience, and field of assistive technology.

Domain	Variable	Variable categories	No.	mean	Std. Devi.	Modified mean	Standard error
knowledge level of ATSs in nano-technology applications	gender	male	74	2.30	0.301	2.325	0.036
		female	26	2.25	0.250	2.275	0.061
	Experience year	Less 5 years	25	2.32	0.300	2.238	0.117
		From 5-10 5-10	35	2.21	0.272	2.225	0.078
		More 10 years	40	2.33	0.289	2.436	0.098
	assistive technology field	Hearing impairment	24	2.23	0.305	2.367	0.133
		Visual impairment	20	2.29	0.270	2.346	0.081
		Physical and health impairment	56	2.27	0.291	2.367	0.133
Nano-technology applications play a role in improving life quality for individuals with disabilities.	gender	male	74	2.17	0.132	2.161	0.019
		female	26	2.24	2.10	2.242	0.032
	experience years	More 5 years	25	2.12	0.132	2.063	0.062
		5-10 years	35	2.21	0.160	2.281	0.042
		More 10years	40	2.21	0.162	2.260	0.052
	assistive technology field	Hearing impairment	24	2.14	0.124	2.296	0.071
		Visual impairment	20	2.18	0.161	2.140	0.043
		Physical and health impairment	56	2.22	0.166	2.169	0.040
total degree of study tool	Gender	male	74	2.21	0.129	2.215	0.017
		female	26	2.25	0.156	2.253	0.029
	experience years	Less 5 years	25	2.19	0.144	2.121	0.056
		5-10 years	35	2.21	0.146	2.263	0.037
		More 10 years	40	2.25	0.119	2.319	0.046

assistive technology field	Hearing impairment	24	2.20	0.142	2.319	0.063
	Visual impairment	20	2.21	0.153	2.208	0.038
	Physical and health impairment	56	2.24	0.129	2.175	0.036

Table 7 indicates the presence of significant differences between the mean values of the study sample individuals in the level of knowledge of ATSs in nano-technology applications and their role in enhancing the standard of living for people with disabilities across domains and the overall score. This is based on the variables of gender, years of experience, and the field of assistive technology. To verify whether the differences are statistically significant, the Multivariate Analysis of Variance (MANOVA) test was applied. Table 8 presents the results:

Table 8. The significance of differences in the level of knowledge of ATSs in nano-technology applications and their role in enhancing the standard of living for people with disabilities according to variables.

Variance resource	Dependent variable	Sum of Squares	FD	squares average	(F) Value	P. Value
Gender Hotelling's Tace/ 0.060, sig=0.067	Knowledge level	0.045	1	0.045	0.560	0.456
	nano-technology applications role	0.119	1	0.119	5.204*	0.025
experience years Wilk'sLambda 0.886, Sig=0.023	Knowledge level	0.508	2	0.254	3.129*	0.048
	nano-technology applications role	0.129	2	0.064	2.809	0.065
assistive technology field Wilk'sLambda 0.942, Sig=0.234	Knowledge level	0.222	2	0.111	1.364	0.261
	nano-technology applications role	0.068	2	0.034	1.491	0.230
error	Knowledge level	7.636	94	0.081		
	nano-technology applications role	2.158	94	0.023		
total	Knowledge level	531.250	100			
	nano-technology applications role	482.292	100			
Corrected total	Knowledge level	8.213	99			
	nano-technology applications role	2.463	99			

*Statistically significant at $\alpha \leq 0.05$.

The results of Table 8 show that there is no statistically significant difference between the mean values of the study sample individuals in the domain of the level of knowledge of ATSs in nano-technology applications concerning the gender variable. However, there are statistically significant differences regarding the role of nano-technology applications, favoring males, where their average was the highest. Also, there is no statistically significant difference between the mean values of the study sample individuals in both domains: the level of knowledge of ATSs in nano-technology applications and the role of nano-technology applications in enhancing the standard of living for people with disabilities concerning the variable of the field of assistive technology. There is no statistically significant difference between the mean values of the study sample individuals in the role of nano-technology applications in enhancing the standard of living for people with disabilities, according to experience. However, the results of the same table showed differences in the level of knowledge of ATSs in nano-technology applications. To determine the direction of the differences, the Bonferroni multiple comparisons test was applied, and Table 9 presents the results. Table 9 indicates that the differences in the level of knowledge of ATSs in nano-technology applications according to years of experience were in favor of those with more than 10 years of experience.

Table 9. The direction of differences in the level of knowledge of ATSS in nano-technology applications according to the variable of years of experience.

Variable	Mean	Less 5 years	5-10 years	More 10 years
Less 5 years	2.238	-	0.013	-0.198
5-10 years	2.225	-0.013	-	-0.211*
More 10 years	2.436	0.198	0.211*	-

Table 10. The level of knowledge of ATSS in nano-technology applications role in enhancing the standard of living for people with disabilities

Variance source	Sum of Square	FD	Square average	(F) Value	P. Value
gender	0.025	1	0.025	1.388	0.242
experience years	0.089	2	0.044	2.430	0.094
Assistive Technology	0.045	2	0.023	1.242	0.294
Error	1.719	94	0.018		
total	495.871	100			
Total Corrected	1.846	99			

V. DISCUSSION

The results of the first question revealed that the level of knowledge of ATSs in nano-technology applications and their knowledge of their role in enhancing the standard of living for people with disabilities in Jordan was low. The lack of knowledge this technology suggests ignorance of its significance in raising the standard of living for individuals with impairments. The lack of awareness about nanotechnology is consistent with earlier research by Ayyad [27] and Darwish [28], and it can be explained by the fact that nanotechnology is still relatively new both internationally and in the Arab world. Applied in industrialized economies, nanotechnology is regarded as a fifth-generation technology of the twenty-first century. As a developing nation, Jordan encounters difficulties in embracing and executing nanotechnology because of its high expense and requirement for substantial resources.

The discussion also brought to light the fact that Arab civilizations are largely unaware of nanotechnology and that it is mainly used for industrial, scientific, and medical purposes. The fact that it is not incorporated into training programmes and curricula for specialists and instructors leads to a lack of awareness among professionals. Based on gender, experience, and the field of assistive technology, the second question's results showed no statistically significant differences in the level of knowledge of ATSs in nanotechnology applications and its impact on improving the quality of life for people with disabilities. The lack of discernible differences between the male and female specialists may be explained by the fact that neither group participated in any particular training or activities pertaining to nanotechnology.

The survey also revealed that neither gender was motivated or interested in growing personally or keeping up with the latest developments in technology, and that neither gender's university curriculum included any courses on nanotechnology. Additionally, there were no statistically significant differences in experience between ATSs with less than five years, more than five years, and more than 10 years, according to the results. This discovery is explained by the similarity in the degree of awareness regarding applications of nanotechnology that both novice and seasoned specialists possess. This has to do with the government's lack of interest and the accountability of relevant organizations and organizations in creating tools, programmes, and cutting-edge assistive technologies particularly nanotechnology for those with disabilities. Until now, this field has not received its fair share of research, work, and development in Jordan and other developing countries. Consequently, ATSs, regardless of their years of experience, have not undergone any training programs to develop their competencies and use currently used global technologies, such as nano-technology. This is particularly true in light of the limited financial support allocated for training and the use of nano-technology in general, and for people with disabilities in particular. This aligns with the findings of Ayyad [27], which indicate a lack of significance in the knowledge level attributed to gender and years of experience.

Concerning the variable of the field of assistive disabilities, the results did not show statistically significant differences in the knowledge level of specialists in nano-technology and its applications to improve the quality of life based on the field of work in assistive technology for visual, auditory, physical, and health disabilities. The majority of the sample consisted of professionals working in the field of physical and health disabilities, as these categories include a wide range of neurological, skeletal, muscular, and health disorders. They are widespread compared to visual and auditory disabilities; hence, the use of assistive technology is more extensive. However, there were no significant differences in the knowledge level of specialists in nano-technology applications based on their different fields of work. This can be attributed to the nature of nano-technology as a recent and unfamiliar technical field for many specialists. This situation closely resembles the level of knowledge in many Arab and global societies, as indicated by previous studies.

These studies, conducted in advanced countries such as the United States and Australia, found that individuals in society generally possess limited information about nano-technology. It is considered a recent scientific field with specialists and various applications in life. The expected decrease in awareness in a country like Jordan, considered a developing country, stems from the delayed technological development, small size, and limited resources. This has impacted the lack of interest among institutions and their employees, including specialists from various fields or disability categories. Professionals in state institutions and centers still use traditional and modest methods, both in terms of tools and assistive technology for people with disabilities, without seeking to keep up with their development using modern technologies such as nano-technology. This is especially true in light of the limited available resources and the high costs associated with using and developing nano-technology and its applications to serve and improve the quality of life for people with disabilities.

VI. CONCLUSIONS

The results of the first question showed that the level of knowledge among ATSs regarding NT applications and their role in enhancing the standard of living for people with disabilities in Jordan was low. This lack of knowledge is attributed to several factors: The novelty of NT globally and in the Arab world, as it is considered a fifth-generation technology of the 21st century; The association of nanotechnology with advanced economies, while Jordan is a developing country that cannot invest significantly in this technology due to its high cost; and The absence of topics covering NT and its applications in the preparation programs and curricula for specialists and educators in universities.

The results of the second question showed no statistically significant differences in the level of knowledge among ATSs regarding NT applications and their impact on improving quality of life attributed to gender, years of experience, and the field of assistive technology. No statistically significant differences were found, although the sample of males was larger than that of females. This is because specialists did not receive training related to NT. Also, no statistically significant differences were found between new and experienced specialists, indicating a lack of governmental and institutional interest in developing training programs related to NT. Additionally, no statistically significant differences were found among specialists working in visual, auditory, or physical and health disabilities. This is due to the lack of widespread knowledge about NT in these fields, even among advanced communities.

The study suggests that by including NT themes and their implementations into curriculum and training programs for experts and educators, assistive technology professionals in Jordan can improve their understanding of NT. It is also advised to host training sessions and seminars to increase awareness of the significance of this technology. It is necessary to create specialized training programs with adequate funding from public and commercial organizations and to promote cooperation with top international organizations. The report also highlights the importance of boosting NT spending, particularly in research and development, and encouraging scientific studies that concentrate on how NT might be used to enhance the quality of life for people with impairments. In order to get access to cutting-edge knowledge and technology, it is also critical to strengthen international collaboration and increase public understanding of the importance of NT through awareness campaigns and community activities. In order to improve the quality of life for individuals with disabilities, it is also essential to offer incentives and rewards to professionals who work hard to advance their knowledge and expertise in this area.

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Conflicts of Interest

The authors declare no conflicts of interest regarding this research, and the study was conducted without any commercial or financial relationships that could create conflicts of interest.

Data Availability Statement

Upon request, data can be obtained from the authors.

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