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Development and Validation of the Inspiration from Nature Scale for Primary School Students

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Abstract

This research aims to develop a valid and reliable scale that determines primary school students' level of inspiration from nature. The scale is called the Inspiration from Nature Scale (IfNS). Participants are primary school students studying in Konya in the second semester of the 2021-2022 academic year. In line with the purpose of the research, the literature related to the scale development process was reviewed, and an item pool was created. In line with the opinions of field experts, 19 of these items were decided, and the scale was applied to 847 students studying in different provinces. Exploratory and confirmatory factor analysis, Cronbach alpha analysis, item analysis, test-retest reliability and criterion validity were performed to examine the validity and reliability of the scale. As a result of the factor analysis performed with the data obtained, the scale structure was determined as three factors (interest, bonding, fear) and 13 items. The Inspiration from Nature Scale has been determined as a valid and reliable tool that can be used to reveal primary school students' levels of inspiration from nature.

Keywords: Inspiration from nature, Biomimicry training, Primary school students, Scale development.

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Introduction

Nature and humans have been inseparable whole since the existence of life. Humankind, which obtains all the substances it needs to live from nature, has been inspired by nature for millions of years. People try to overcome the difficulties they encounter with the solutions they see in nature. The efforts of people to harmonize their own designed products with nature in some way have led to the emergence of biomimicry. The concept of biomimicry, which means 'imitating nature, being inspired by nature, emerged at the end of the 21st century, although it is as old as the history of humanity (Kennedy, 2004). Biologist Janine Benyus first mentioned biomimicry's concept, and its usage levels were examined in three dimensions. Accordingly, the organism level that imitates a single organism directly, the imitation of how more than one natural area or entity behaves in a broad context is classified as the behavioral level, and the imitation of an ecosystem itself is classified as the ecosystem level (Benyus, 1997). Today, biomimicry is generally considered a design methodology that can take place under the roof of different disciplines for a sustainable future (Speck, Horn, Gantner, & Sedlbauer, 2017). As a result of the widespread use of alternative or preliminary uses of natural and living sciences in the field of design, biomimicry has started to take place in many disciplines as a separate discipline (Iouguina et al., 2014).

Biomimicry has become a useful source of fieldwork in architectural and urban design, computer, coding, digital design, robotic informatics and space sciences, materials and engineering sciences, industrial product development, the agriculture industry, health sciences, and even art and fashion. Examining where and why biomimicry is used can help us understand the wide range of applications and the impact it has.

According to a bibliometric study on architectural and innovative space designs, biomimicry has been described as an innovative field of philosophy with natural solutions (Meena D'Costa et al., 2021). Biomimicry focuses on natural processes or functions humans can apply to the manufactured world. In this sense, creating a properly designed space depends on integrating creative processes learned from nature (Karabetça, 2018; Öztoprak, 2020). When the wealth of information in technology and tools is synthesized with biomimicry, it will be effortless to create living spaces compatible with nature (Goss, 2009; Jamei & Vrcelj, 2021; Karabetça, 2018; Öztoprak, 2020). When the wealth of information in technology and tools is synthesized with biomimicry, it will be effortless to create living spaces compatible with nature (Goss, 2009; Jamei & Vrcelj, 2021). For example, the ability of water mimosas to adapt to flood and tsunami natural disasters in response to the current climate crisis has inspired creative industrial modular designs (floating capsules) (Haryanti & Susilawati, 2022). Considering that energy is one of humanity's greatest needs, energy-efficient facade systems have become essential in biomimicry. According to the problems experienced in the creation of these designs, biological solutions should be well-defined, and biomimicry features should be integrated into the design (Gündoğdu & Arslan, 2020; Nalçacı & Nalçacı, 2020; Radwan & Osama, 2016). In addition to human needs, biomimicry principles were used in designs such as bat houses and snail nests for the well-being of other living things in nature (Ak & Özen Yavuz, 2019; Keskin & Özen Yavuz, 2019). In architectural designs, biomimicry has not only been used in the context of basic requirements and problems but also has been a source of inspiration for architectural structures with its visual dimension. Studies have shown how architecture can use biomimicry to create visually striking designs. For example, some religious buildings have been made to resemble trees, stairs have been designed to look like snail

shells when viewed from above, and interiors have been decorated with flower drawings and stones. In addition, stained glass details on windows can create a rainbow effect through light refraction (Buck, 2017; İnner, 2019). Students' awareness and knowledge about using biomimicry in architectural and innovative space design are beneficial in getting better inspiration while observing nature.

When the subject was examined in terms of informatics, robotics, materials, and engineering, it was seen that biomimicry-based cognitive agents and simulators were developed by imitating living things (Lawniczak, Ernst & Di Stefano, 2014). The contributions of biological information to the studies in the field of space with the use of robotics have been examined by many researchers (Knigh, 2017; Menon, Broschart & Lan, 2007; Ramezani, Chung & Hutchinson, 2017). Inspired by flying birds and insect species, micro-aircrafts for defense and security have been tried to be developed (Moses, 2020). In another study, the creation of nano-scale radiation cooling systems was tested by calculating the rate of change in air pressure during the flapping of a butterfly's wings (Didari & Mengüç, 2018). Biomimicry inspires scientists and manufacturers in engineering and addresses everyday issues that concern everyone (Wahl, 2006). Innovations inspired by nature are becoming increasingly common. For instance, moth eyes have been studied to develop screen technology, and the rosary beetle has influenced furniture design. Scientists have looked at the unique properties of a cat's tongue to create toothbrushes, and the interlocking and sticking properties of phlox inspired the invention of Velcro, which has since been patented under that name. Foldable and modular products have also been produced based on nature's designs. It concerns the daily life of all humanity (Yıldız, 2012). It has also been evaluated that biomimicry can be used to make the packaging used by all segments sustainable (Caferoğlu, 2021).

Considering the agricultural sector, it can be said that the return to biomimicry-based natural agricultural practices has accelerated since it is understood that artificial agriculture practices are not sustainable. The search for renewable resources, especially for water scarcity, leads scientists to imitate stable natural ecosystems (Othmani, Sahak & Yunos, 2021). Regarding technological developments in health, micro-scale engineering technologies are frequently used in cell studies. In a technology developed based on the acculturation phenomenon in nature, cells are prepared to be propagated by culturing on a chip and used to compensate for organ damage (Huh et al., 2012). Biomimicry was also used to answer the question of where collagen, the most abundant protein in mammals, and silica, one of the most abundant minerals in nature, can be used in the health field apart from their current usage areas (Brannum, 2017). When the subject is approached in the context of art, Karataş (2020) has historically examined how biomimicry can be used within the scope of ecological art and how it can contribute to sustainability. In addition, it has been proven with an applied thesis that digital art designs can be made in an ethnic-futuristic style with an algorithmic biomimicry approach (Dündar, 2019).

Since there are dozens of fields of science in which biomimicry is used, it is essential to have interdisciplinary educational content. When the studies on the subject are examined, it is evident that biomimicry, which contributes significantly to various fields of human life, has not been adequately incorporated into basic education curricula. Educational applications of biomimicry have been implemented in different age groups and education levels. For instance, in a quasi-experimental study, biomimicry designs were combined with design-based learning approaches to enhance undergraduate students' educational outcomes in an evolutionary biology course.

Biomimicry design is an interdisciplinary field that requires biology and design skills and provides information on creating sustainable designs by emulating biological structures and functions that emerge from natural selection. In this context, biomimicry designs were integrated into the curriculum and processed with design-based learning. Natural examples were examined by integrating biomimicry designs into two randomly selected groups of four undergraduate biology students. On the other hand, the design-based learning method was applied to the students in the control group, but no application was made outside the curriculum. When students were taught biomimicry designs as part of their evolutionary biology course, they showed a greater tendency to apply their knowledge of biological structure and function to benefit society. This was revealed by comparing their pre-test and post-test results (Fried et al., 2020).

Since biomimicry manifests itself in many areas, children should be introduced early (Williams, Barber & Sheppard, 2019). In the process of acquaintance with biomimicry, students need to show interest in nature, establish a connection between structures in nature and technological products, and determine their fears about structures in nature so that they can be inspired by living things in nature. The studies have determined that children's perception of being inspired by nature has been examined through qualitative data collection methods such as interviews, observations, practices, or drawings (Yakışan & Velioğlu, 2019). On the other hand, no measurement tool was found to determine the children's inspiration from nature. The Inspiration from Nature scale fills a critical gap in the literature by providing a valid and reliable measure of the extent to which the natural environment inspires individuals. The development of the Inspiration from Nature scale represents a significant contribution to the field, as it allows researchers to investigate the relationship between nature and creativity, well-being, and a host of other outcomes. By creating the Inspiration from Nature scale, we are advancing our understanding of the benefits of nature exposure and providing a valuable tool for educators, designers, and policymakers to create environments that foster creativity, learning, and mental health.

Such a measurement tool will also provide researchers with easy application in schools. With this developed scale, the development of children's inspiration from nature will be quantitatively and practically determined. In this sense, it is predicted that it can contribute to the literature and future biomimicry and STEM education at the preliminary stage.

Method

Research Design

The research was examined with exploratory and confirmatory factor analyses within the construct validity framework. Exploratory factor analysis (EFA) is a statistical analysis technique used to determine the latent variables (factors) underlying the observed variables and formed by the combination of the observed variables. Confirmatory factor analysis (CFA), on the other hand, means that the relationships between the variables whose existence was determined before and the structures created are studied with a new participant group and tested with the data obtained (Büyüköztürk, 2018; Orçan, 2018). The criterion validity of the scale (Seçer, 2018) was calculated, and the internal consistency coefficient, test-retest, and item analysis were used within the scope of reliability studies.

Research Study Group

The maximum variability sampling method determined the study group, considering the time and appropriate conditions. This method is a sampling method in which a sample is selected to reflect maximum variability. This method increases the variability in the sample, allowing a more precise estimate of the variability of the population. Thus, the sample group consisted of 847 primary school students who answered the data collection tool. For the first-year students to participate in the research and give healthier answers, the scale was applied in the second semester when their reading skills improved. Due to the Inspiration from Nature Scale (IfNS) development process, different participant groups were used at various stages of the study—primary school 1st-4th grades within the framework of exploratory factor analysis (EFA). There were 395 participants from the students continuing their education between the classes. In this context, the data regarding the selected sample are given in Table 1.

Table 1. Demographic Information of the Sample Determined for Exploratory Factor Analysis

Gender		Female	Male						
	n	189	196						395
	%	47.84	52.26						100
		State	Foundation						
School Type	n	12	5						17
	%	70.59	29.41						100
		1st Class	2nd Class	3rd Class	4th Class				
Grade Level	n	86	102	106	101				395
	%	21.76	25.82	26.83	25.57				100
		Mediterranean	Eastern Anatolia	Aegean	Southeastern Anatolia	Central Anatolia	Black Sea	Marmara Region	
Region of residence in the process	n	54	59	55	49	62	54	62	395
	%	13.67	14.93	13.93	12.41	15.69	13.68	15.69	100

Primary school grades 1-4 for confirmatory factor analysis (CFA) in the research. There were 340 participants from the students continuing their education between the classes. In this context, the data regarding the selected sample are given in Table 2.

Table 2. Demographic Information of the Sample Determined for Confirmatory Factor Analysis

Gender		Female	Male						
	n	169	171						340
	%	49.71	50.29						100
		State	Foundation						
School Type	n	240	100						340
	%	70.59	29.41						100
		1st Class	2nd Class	3rd Class	4th Class				
Grade Level	n	83	86	91	80				340
	%	21.47	25.29	26.76	23.53				100
		Mediterranean	Eastern Anatolia	Aegean	Southeastern Anatolia	Central Anatolia	Black Sea	Marmara Region	
Region of residence	n	48	49	51	49	46	54	43	340
	%	14.12	14.41	15.00	14.41	13.53	15.88	12.65	100

In order to determine the test-retest study and criterion-dependent validity of the research, 112 participants were studied. Participants in the test-retest and criterion-dependent validity studies also participate in the CFA study.

Research Instrument and Processes

In order to be developed in the research, the IfNS was studied and used as a data collection tool. In addition, IfNS was used to determine the predictive validity of the Inspired by Nature Scale, which was desired to be developed.

Developing the Scale

When preparing the "IfNS," steps were taken to align with the scale development process. We reviewed the existing literature on how children perceive nature and identified the competencies teachers should possess to facilitate children's perception of nature. In this context, studies carried out in this field at home and abroad were examined, and expressions that could be used in the scale were determined. After receiving expert opinions on item expressions, the age group was determined primarily. Educational institutions where nature consciousness is presented formally; are schools. It was deemed appropriate to work with primary school children studying in primary school 1st, 2nd, 3rd, and 4th grades since primary school is the earliest period in which children's perception of being inspired by nature begins to form and it is possible to measure it (Avcı, 2019; Buo, 2021).

In another step, creating an item pool (Carpenter, 2018; DeVellis & Thorpe, 2021), a 45-item item pool was created, which also considers the affective characteristics of primary school children to determine their perceptions of being inspired by nature following their comprehension and grammar levels. The experimental form, consisting of 25 items, was submitted to the opinion of two experts working in the field of natural sciences, two from the field of Educational Sciences, who were knowledgeable in the subject area and were informed about the study subject in order to receive expert opinions. The candidate scale continued to be created by reflecting the experts' feedback on the scale. In order to get the opinions of the experts, a 3-point rating was used. In the prepared form, experts were expected to choose one of the options, "Suitable," "Should be corrected," or "Must be removed" for each item. Combining all expert feedback forms in a single form determined how many experts approved the possible options for each item. In this process, in line with the experts' opinions, the content validity of the items was determined by the content validity rate developed by Veneziano and Hooper (1997; cited in Yurdagül, 2005). The ratios in question were arranged by taking the ratio of the total number of experts who answered positively for each item to the total number of experts minus one. For the content validity indices of the items, the number of experts and the values of the obtained content validity rates were determined. Items with a content validity ratio of less than 0.80 were excluded from the study. On the other hand, in some articles, regulations that increase understanding are included in line with the calculations of the content validity ratios obtained. After these studies, a trial form consisting of 19 items was created. Participants were expected to express their perceptions on a 3-point Likert-type scale ranging from "Agree", "Neutral" and "Disagree."

After the item pool was completed, pilot applications were started to determine the scale items' intelligibility and

the average time it took to complete the answer. Ten from primary school 1st, 2nd, 3rd, and 4th-grade levels from a mixed group living in rural and urban areas; A pilot study was conducted with 40 children. While applying the "Inspiration from Nature Scale," practitioners read each item to the children individually and asked them to explain what they understood from each item. Items that were found to be poorly understood were rephrased. After the sample selection process, the scale was administered as a questionnaire. The validity and reliability of the scale were then determined through statistical analysis.

Data Analysis

The construct validity of the Inspired by Nature Scale was examined using exploratory and confirmatory factor analysis. Item analysis was conducted to determine the discrimination level of the scale items. The reliability of the measurement tool was assessed by calculating the Cronbach alpha and test-retest reliability coefficients. Correlations between scores obtained from the scale and the environmental attitude scale developed by Peker (2020) were examined to establish criterion validity. SPSS 25.0 and AMOS 24.0 statistical software packages were used for the analyses.

Ethic Consideration

The ethics committee approval of the research was obtained with the decision of the Necmettin Erbakan University Social and Human Sciences Scientific Research Ethics Committee, dated 28.10.2021, and numbered 7556.

Results

Exploratory Factor Analysis Results

Exploratory factor analysis was applied to explore the factor structure of the IFNS. The Kaiser-Mayer-Olkin (KMO) test is applied to test the suitability of the data structure in terms of sample size for factor analysis (Çokluk, Şekercioğlu, & Büyüköztürk, 2018). It has been stated that the data set cannot be factored for KMO ≤0.50 (Field, 2013). According to Tavşancıl (2005), the KMO value is a measure of sampling adequacy that ranges from 0 to 1, where values between 0.50-0.60 are considered bad, between 0.60-0.70 are weak, between 0.70-0.80 are moderate, and between 0.80-0.90 are moderate, while values above 0.90 are considered perfect.

A KMO value close to 1 indicates that the correlation model is compact enough to produce discrete and reliable factors (Surastina & Dedi, 2018). The KMO value was calculated as 0.86. It has been understood that the data structure is sufficient for factor analysis. The suitability of the data for factor analysis is determined by applying the Barlett Sphericity test. This test tests whether there is a significant difference between the actual correlation matrix and the unit matrix. The fact that the p-value of this test is below 0.05 shows that the matrix with the relations between the items is different from the unit matrix without the relations (Can, 2018). When the test results applied for factor analysis are evaluated, it is seen that the chi-square value (Barlett Sphericity ($\chi^2(465)$) = 4553.43; $p<0.001$) is significant. This result indicated that the data were suitable for factor analysis.

Factor analysis was carried out by applying the Principal Components Analysis method. Six factors with eigenvalues greater than one were formed. In the line graph formed as a result of the factor analysis, it was determined that the third point was the breaking point, and after this point, the training waist decreased somewhat. Accordingly, it was decided that the number of factors would be three, and the scale items were forced into three factors in the subsequent analysis. The factors in which the items were found were clarified using the Oblimax rotation method. 0.40 was determined as the cut-off point for factor loadings (Comrey and Lee, 1992). Items with low factor loading (M1, M3, M17) and loaded on more than one factor (M7, M12, M16) were excluded from the scale. As a result of repeated analyzes, it was observed that 13 items remained in the measurement tool. The factor loads of the scale items are given in Table 3.

Table 3. Values Obtained as a Result of Exploratory Factor Analysis

Item no	Factor loadings			Com*	Cor**	Initial Eigenvalues	% of Variance	Cronbach alpha
	1	2	3					
M18- I would like to have a lesson about plants and animals.	*0.73*	-0.03	0.10	0.55	0.45			
M4-I would like to go out in nature and observe insects and animals.	*0.66*	0.06	-0.26	0.51	0.47			
M19- Animal pictures in books attract my attention a lot.	*0.64*	0.12	0.03	0.42	0.40	2.97	23.85	0.75
M5- Instead of playing games on the computer. I would like to go to nature and watch insects.	0.62	0.12	-0.06	0.41	0.39			
M6- I examine an animal I see in detail.	*0.55*	-0.01	-0.22	0.40	0.36			
M2- Robots often look like animals.	-0.08	*0.76*	0.06	0.58	0.47			
M8- I think that vehicles and machines have similar aspects to living things in nature.	0.11	*0.73*	-0.16	0.57	0.51			
M14- The bucket part of the bucket truck. which is a construction machine. is similar to a human hand.	0.03	*0.65*	-0.06	0.43	0.43	1.81	14.92	0.78
M9- When I see a vehicle or machine. I think that it is inspired by living things in nature.	0.34	*0.65*	-0.07	0.54	0.45			
M11- I scream when a fly lands on me. (R)	-0.10	-0.10	*0.74*	0.57	0.50			
M10- I am afraid of animals and insects. (R)	-0.08	-0.20	*0.74*	0.59	0.51			
M13- If I see any butterfly or spider-like insect in our house. I will run away screaming. (R)	-0.04	-0.12	*0.67*	0.46	0.42	1.65	13.66	0.76
M15- I do not like to touch animals in nature. (R)	-0.08	0.27	*0.62*	0.47	0.36			

*Com= Communalities, **Cor= Corrected Item-Total Correlation, R= Reverse

As a result of the EFA, it was observed that the factor loads of the scale items took values between 0.55 and 0.76. The three-factor structure explained 52.43% of the total Variance. According to this value, approximately half of the hallucination variable was explained. This result indicated that the representative power of the items was high. The first, second, and third factors were named interest, bonding, and fear.

Exploratory Factor Analysis Results

According to the EFA results, the IFNS has a three-factor structure. Confirmatory factor analysis was applied to determine the compatibility of the three-factor structure of the measurement tool with the collected data. Analysis was performed using the Maximum Likelihood Estimation method. The fit values calculated for the three-factor model are given in Table 2.

Table 2. Calculated Accordance Values

Criterion	Good Fit	Acceptable Fit	Obtained Values	Resource
(χ^2/sd)	≤ 3	≤ 4-5	1.85	Byrne, 1989
RMSEA	≤ 0.05	0.06-0.08	0.05	Browne ve Cudeck, 1993
SRMR	≤ 0.05	0.06-0.08	0.06	
GFI	≥ 0.90	0.85-0.90	0.88	Tanaka and Huba, 1985 Jöreskog ve Sörbom,1984
AGFI	≥ 0.90	0.80-0.90	0.84	
CFI	≥ 0.95	0.90-0.94	0.96	
TLI	≥ 0.95	0.90-0.94	0.95	Bollen, 1989
IFI	≥ 0.95	0.90-0.94	0.96	

When Table 2 is examined, it can be seen that the three-factor structure of the Inspiration from Nature Scale is generally well-matched with the available data, according to the calculated fit value. This result indicates that the three-factor structure of the measurement tool has been confirmed. The three-factor model tested is shown in Figure 1. All path coefficients shown in the model are statistically significant at p<0.001 level (Table 3).

Table 3. Values Obtained as a Result of Confirmatory Factor Analysis

			β	SE	t
M18	<---	Interest	0.54		
M4	<---	Interest	0.65	0.26	6.24***
M19	<---	Interest	0.50	0.20	5.53***
M5	<---	Interest	0.50	0.25	5.54***
M6	<---	Interest	0.46	0.22	5.29***
M2	<---	Bonding	0.53		
M8	<---	Bonding	0.69	0.17	6.45***
M14	<---	Bonding	0.50	0.16	5.64***
M9	<---	Bonding	0.64	0.17	6.35***
M10	<---	Fear	0.66		
M13	<---	Fear	0.71	0.16	7.10***
M11	<---	Fear	0.52	0.10	6.37***
M15	<---	Fear	0.41	0.11	5.25***

***p<0,001

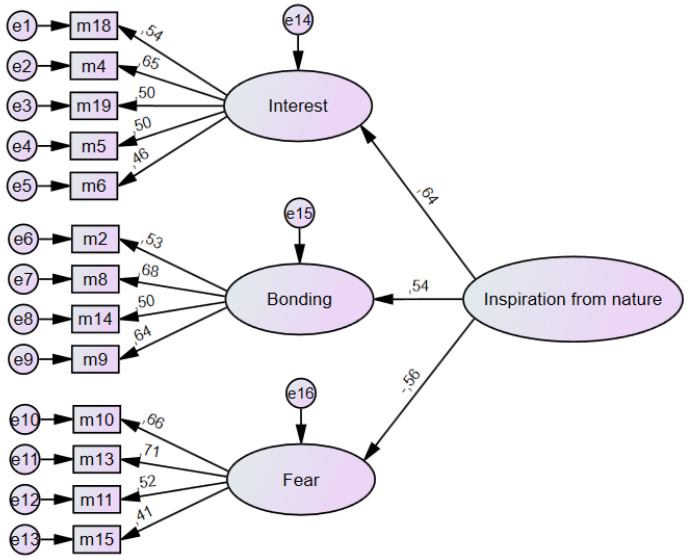

Figure 1. Confirmatory Factor Analysis Diagram, Chi-square=114.89, Df=62, p<0.001

Cronbach Alpha coefficients were calculated to determine the reliability of the IFNS. Values between 0.60-0.80 indicate that the measurement tool is highly reliable, and values between 0.81-1.00 indicate that the measurement tool is highly reliable (Özdamar, 2004). The alpha coefficients calculated for interest, bonding, and fear were 0.75, respectively, 0.78, and 0.76. The coefficients obtained showed that the internal consistency reliability of the measurement tool was at a sufficient level.

Item Analysis Results

The scale scores were ranked from highest to lowest to assess the discriminant validity of the measurement tool. Then, the participants with the highest scores (27%) were assigned to the upper group, and those with the lowest scores (27%) were assigned to the lower group. The groups' mean scores from each scale item were compared using the independent group's t-test (Table 4).

Table 4. Mean Scores by Lower and Upper Groups, Standard Deviations and Independent Groups t-Test Results

	Item no	Lower group (n=92)		Upper Group (n=92)		t
		M	Sd	M	Sd	
Interest	M4	2.20	0.87	2.89	0.40	6.97***
	M5	1.61	0.84	2.86	0.43	12.71***
	M6	1.96	0.88	2.91	0.32	9.84***
	M18	2.48	0.82	2.97	0.11	6.11***
	M19	2.16	0.94	2.94	0.13	8.53***
Bonding	M8	1.71	0.73	2.92	0.27	14.86***
	M9	1.54	0.64	2.91	0.26	19.08***
	M2	1.35	0.60	2.79	0.51	17.56***
	M14	1.76	0.86	2.96	0.21	12.95***
Fear	M10	1.09	0.28	2.74	0.55	25.38***
	M11	1.01	0.10	1.92	0.97	8.98***
	M13	1.04	0.21	2.74	0.61	25.16***
	M15	1.01	0.10	2.37	0.90	14.39***

***p<0,001

When the table is examined, it is understood that the mean scores obtained from the scale items show a significant difference according to the groups ($p<0.001$). The mean score of the upper group for each of the scale items is significantly higher than the mean score of the lower group. These results indicated that each of the thirteen items on the scale was distinctive.

Test-Retest Reliability Results

The IFNS was applied to the same group twice, with an interval of two weeks. Then, the correlation coefficients between the scores obtained from these two applications were calculated. The obtained correlation coefficients were accepted as reliability indicators. The high correlation coefficients calculated from the Test-Retest method show stability between the scores obtained from the two applications (Tavşancıl, 2005). In order to obtain a total score from the scale, the items in the "Fear" dimension must be reversed. The correlation coefficients calculated in this study are given in Table 5.

Table 5. Pearson Correlation Coefficients of the Relationship Between First and Last Application Scores

Test	Implementation	N	M	Sd	r
Interest	First	112	2.38	0.32	0.64*
	Last	112	2.58	0.45	
Bonding	First	112	2.20	0.62	0.69*
	Last	112	2.46	0.55	
Fear	First	112	1.91	0.60	0.72*
	Last	112	1.68	0.71	
Total score	First	112	2.70	0.39	0.73*
	Last	112	2.46	0.43	

*p<0,05

When the table is examined, it is understood that despite a specific time difference, the average scores obtained from the first and last applications are close. The first and final application scores for interest ($r=0.55$, $p<0.05$), attachment ($r=0.54$, $p<0.05$), fear ($r=0.72$, $p<0.05$), and aggregation ($r=0.73$, $p<0.05$) have moderate to high correlations. The results obtained showed that the measuring instrument had a stable structure.

Criterion Validity Results

A criterion validity study was carried out to ensure the Inspiration from Nature Scale's external validity and determine its degree of serving its purpose. In this direction, the scale of being inspired by nature and the scale of attitude towards the environment was applied to the participants in a single session. The environmental Attitude Scale (Peker, 2020) was developed to measure primary school students' attitudes toward the environment. It consists of a total of 15 items. The scale scoring was designed as a 3-point Likert (with options agree-, partially agree, and disagree). The relationships between the scores obtained from the scales were calculated and examined (Table 6).

Table 6. Pearson Correlation Coefficients of the Relationships between Inspiration from Nature Scale Scores and Environmental Attitude Scale Scores

Variables	Attitude towards the environment
Interest	0.55**
Bonding	0.42**
Fear	-0.38**
Total Score	0.47**

**p<0,01; N=50

When the table is examined, it is understood that there are moderate positive and negative relationships between environmental attitude scores and interest (r=0.55; p<0.01), bonding (r=0.42; p<0.01), fear (r=-0.38; p<0.01), and total (r=0.47; p<0.01) scores. As the positive attitudes towards the environment increase, the total scores of interest, bonding, and scale increase while the fear score decreases. The results showed that the external validity of the IFNS was provided, and the scale served its purpose.

Discussion, Conclusion and Recommendations

Since the scale aims to measure taking from nature as a whole, it aims to measure the sub-dimensions of interest in being inspired by nature, linking nature with technological structures, and fear of structures in nature. Regarding student success, one of the first factors that come to mind is interest (Demir & Kılıç, 2010; Ilgar, 2004). J. Holland considers a person's interest and desire for any profession as a reflection of that individual's personality (Holland, 1997). Personality traits and professional interests are two crucial, non-cognitive areas of individual differences in psychology. Spiritual qualities are important because they influence many outcomes associated with work and life success (Mount et al., 2005). Namely, it affects the choices about which tasks and activities individuals will perform, how much effort they should put into these tasks, and how long they should stay (Uğur & Devcar, 2018). For this reason, students' ability to be inspired by nature is closely related to their interest in structures related to nature.

The second sub-dimension of the Inspiration from Nature Scale links nature and technological structures. Connecting is a prerequisite process for meaningful learning and discovery. Meaningful learning is an educational-scientific concept expressing the ability to connect, articulate, associate, appropriate, update and use new information with existing information to acquire knowledge. Thus, meaning; is a result of the relationship between ideas, events, concepts, and objects (Ausubel, 2000). Suppose the student is not aware of this relationship. In that case, he cannot integrate and connect what he has learned with the old knowledge in his mind, or if there is not enough knowledge and experience in mind to establish a relationship between them, it is not easy to achieve meaningful learning. For this reason, being inspired by nature and connecting with the structures in nature and technology were considered essential sub-dimension. The sub-dimension of connecting nature and technological structures was included in this scale.

It is necessary not to be afraid of nature and elements such as insects, animals, and plants in nature to be interested in being inspired by its structures and to establish a connection between technological structures and elements in

nature. Ecophobia has taken its place in the literature in the sense of fear of the natural world (Kaşot, 2014). Ecophobia, called fear of nature, also means the fear of deterioration in natural life and ecological disaster (Kocalar, 2015). Entomophobia/arachnophobia is also the fear of insects and is considered among the most severe psychological problems that require treatment (Shahriari-Namadi, Tabatabaei, & Soltani, 2018). In the modern world, especially people living in cities, their contact with nature is minimal. The disconnection of people from nature threatens society's future and nature's future. Today, ecophobia is beginning to emerge in primary school children (McKnight, 2010). Children can only see plants, insects, and animals in nature on television, the internet, or in books. This causes children to stay away from nature and to be afraid (Sobel, 2014). For this reason, while measuring the features related to being inspired by nature, it was also desired to determine the issues related to fear of nature.

Reliability analyses of the scale were performed using Cronbach Alpha, item analysis, and test-test-retest. Cronbach's Alpha values were .75 for the concern dimension, .78 for the bonding dimension, and .76 for the fear dimension. The item analysis results based on comparing the lower and upper 27% slices showed that they significantly separated the two groups from each other in the context of all items. Tezbaşaran (2008) states that a scale that distinguishes the lower and upper groups from each other meaningfully is reliable in terms of discrimination. The results obtained from the test-retest method indicate that the reliability of both measures of the test was similar and positively correlated. The obtained correlation values vary between .54 and .73. All three of the methods used to test the reliability show that the reliability values of the IFNS are high. The validity and reliability features of the scale were tested with different techniques; it provided controls with multiple measurements and strengthened the scale's psychometric properties. These psychometric properties indicate that the IFNS is a valid and reliable measurement tool.

The construct validity of a scale is essential in terms of being able to be used scientifically and revealing the feature it wants to die for in wholeness (Büyüköztürk, 2018). The construct validity of the IFNS was calculated, and the sub-dimensions of interest in being inspired by nature 5; It was observed that the sub-dimension of establishing a connection between nature and technological structures and fearing the structures in nature consisted of 4 items. According to the EFA results of the scale, the total explained variance rate was determined as 52.43%. In the total Variance explained, the dimension of interest in being inspired by nature was 23.85%; Making a connection between nature and technological structures contributed 14.92%, and the sub-dimension of fear of structures in nature contributed 13.66%. The fit indices values obtained as a result of the CFA performed showed that the structure reached by the EFA was confirmed and worked similarly in a different data set. For example, Gupta & Geetika (2020) stated that 53.679% explained total Variance was sufficient in the Academic Self-Handicapping Scale they developed. Accordingly, it can be said that the factor loads explained by the sub-dimensions of IFNS are sufficient. It can be said that these values are sufficient to create a structural whole between the sub-dimensions of a scale and the whole (Büyüköztürk, 2018; Orçan, 2018).

In order to determine the criterion validity of the scale, the significant relationships between the total score of the "Attitudes towards the Environment Scale" (Peker, 2020) and the sub-score and total score of the IFNS were examined. In the findings obtained, the scale items showed highly distinctive features; This measurement tool was

reliable, highly stable, and valid. Considering all these examples, it can be said that the IFNS is a reliable scale. The validity and reliability values obtained from the analysis results and both the explained variance rates, factor scopes, and reliability coefficients reached as a result of the scale studies in the literature (Büyüköztürk, 2018; Erkuş, 2012; Deniz, 2007; Orçan, 2018) indicates that it is a measurement tool. The validity and reliability of this measurement tool can be tested in different samples. An interdisciplinary education form can be developed to develop students' attitudes of being inspired by nature by evaluating the results of the three sub-factors of the scale, namely, interest in being inspired by nature, linking nature and technological structures, and fear of structures in nature. The IFNS can be used as an assessment tool in biomimicry education. It is a preliminary preparation for the biomimicry training to be applied to improve the levels of inspiration from nature starting from primary school and an assessment tool throughout the process.

References

Ausubel, D. P. (2000). *The acquisition and retention of knowledge: A cognitive view*. Springer Science Business Media Dordrecht (e-book version).

Ayçiçek, B., & Yanpar Yelken, T. (2021). Classroom Life Perception Scale: A Scale Development Study. *International Journal of Instruction, 14*(1), 253-264. https://doi.org/10.29333/iji.2021.14115a

Bashir, H., & Bala, R. (2018). Development and validation of academic dishonesty scale (ADS): Presenting a multidimensional scale. *International Journal of Instruction, 11*(2), 57-74. https://doi.org/10.12973/iji.2018.1125a

Benyus, JM. (1997). *Biomimicry: innovation inspired by nature*. Harper Collins: New York.

Biomimicry Institute. Çevrimiçi erişim adresi: Biomimicry.org (Erişim tarihi: 12 Haziran, 2022).

Bollen, K. A. (1989). A new incremental fit index for general structural equation models. *Sociological Methods & Research, 17*(3), 303-316.

Browne, M. W., & Cudeck, R. (1993). Alternative ways of assessing model fit. *Sage focus editions, 154*, 136-136.

Buo, C. (2021). *On leptin and learning: Investigating the interaction of leptina signaling and learning in zebrafish* (Doctoral dissertation, The University of Akron).

Büyüköztürk, Ş. (2018). *Sosyal bilimler için veri analizi el kitabı*. Pegem Akademi.

Byrne, B. (1989). *A Primer of LISREL, Basic Assumptions and Programming for Confirmatory Factor Analysis Models*. New York: Springer.

Can, A. (2018). *SPSS ile bilimsel araştırma sürecinde nicel veri analizi*. Pegem Akademi.

Cohen, R. J., & Swerdlik, M. E. (2018). *Psychological testing and assessment* (9th ed.). McGraw-Hill Education.

Comrey A. L., & Lee H. B. (1992). Interpretation and application of factor analytic results. In: *A First Course on Factor Analysis*, 2nd edn. Hillsdale, NJ: Lawrence Erlbaum, 250–254

Demir, İ., & Kılıç, S. (2010). Using PISA 2003, examining the factors affecting students' mathematics achievement. *Hacettepe Ün. Eğitim Fakültesi Dergisi, 38*(38), 44-54.

Deniz, Z. (2007). Psikolojik ölçme aracı uyarlama, *Ankara Üniversitesi Eğitim Bilimleri Fakültesi 40*(1), 1-16.

Devellis, R. F. (2012). *Scale development theory and applications* (Third Edition), SAGE Publications, Inc.

Didari, A., & Mengüç, M. P. (2018). A biomimicry design for nano-scale radiative cooling applications inspired by Morpho didius butterfly. *Scientific Reports, 8*(1), 1-9.

Erkuş, A. (2012). *Psikolojide ölçme ve ölçek geliştirme-1: Temel kavramlar ve işlemler*. Ankara: Pegem Akademi.

Field, A. (2013). *Discovering Statistics Using IBM SPSS* (4th ed.). London: Sage Publications.

Goss, J. (2009). *Biomimicry: Looking to nature for design solutions*. Corcoran College of Art and Design.

Gupta, S., & Geetika, M. (2020). Academic Self-Handicapping Scale: Development and Validation in Indian Context. *International Journal of Instruction, 13*(4), 87-102. https://doi.org/10.29333/iji.2020.1346a

Haryanti, N. H., & Susilawati, I. O. (2022, February). Biomimicry of greater club rush (Scirpus grossus Lf) and water mimosa (Neptunia oleracea Lour): Wetland plants inspiring innovative modular design. In IOP Conference Series: *Earth and Environmental Science* (Vol. 976, No. 1, p. 012062). IOP Publishing.

Holland, J.L. (1985), *Making Vocational Choices: A Theory of Vocational Personalities and Work Environments*. Englewood Cliffs, NJ: Prentice-Hall.

Ilgar, Ş. (2004). Motivasyon aktiviteleri ve öğretmen. *Hasan Ali Yücel Eğitim Fakültesi Dergisi, 1*(2), 211-222.

Iouguina, A., Dawson, J. W., Hallgrimsson, B., & Smart, G. (2014). Biologically informed disciplines: A comparative analysis of bionics, biomimetics, biomimicry, and bio-inspiration among others. International *Journal of Design & Nature and Ecodynamics, 9*(3), 197-205.

Jamei, E., & Vrcelj, Z. (2021). Biomimicry and the built environment, learning from nature's solutions. *Applied Sciences, 11*(16), 7514.

Jöreskog, K. G., ve Sörbom, D. (1993). *LISREL 8: Structural equation modeling with the simplis command language*. Lincolnwood: Scientific Software International, Inc.

Karabetça, A. R. (2018). Biyomimikri destekli tasarım ölçütleri ile yenilikçi mekanlar yaratılması. *Turkish Online Journal of Design Art and Communication, 8*(1), 104-111.

Kennedy, S. (2004). *Biomimicry/biomimetics: General Principles and Practical Examples.* The Science Creative Quarterly.

Lawniczak, A. T., Ernst, J. B., & Di Stefano, B. N. (2014, May). Biomimicri based cognitive agent and its simulator. In *2014 IEEE 27th Canadian Conference on Electrical and Computer Engineering* (CCECE) (pp. 1-7). IEEE.

Meena, A. K., D'Costa, D., Bhavsar, S., Kshirsagar, M., & Kulkarni, S. (2021). *Applications of Biomimicry in Construction and Architecture: A Bibliometric Analysis*. Library Philosophy and Practice, 1-17.

Menon, C. Broschart, M. and Lan, N. (2007). *Biomimetics and robotics for space applications: challenges and emerging technologies*. IEEE International Conference on Robotics and Automation-Workshop on Biomimetic Robotics.

Moses, K. C. (2020). *Biomimicry of the Hawk Moth, Manduca sexta (L.): Forewing and Thorax Emulation for Flapping-Wing Micro Aerial Vehicle Development* (Doctoral dissertation, Case Western Reserve University).

Mount, M. K., Barrick, M.bR., Scullen, S. M., & Rounds, J. (2005). Higher-order dimensions of the big five personality traits and the big six vocational interest types. *Personnel Psychology, 58*, 447-478.

Orçan, F. (2018). Açımlayıcı ve doğrulayıcı faktör analizi: İlk hangisi kullanılmalı. Eğitimde ve Psikolojide *Ölçme ve Değerlendirme Dergisi, 9*(4), 413-421.

Özdamar, K. (2004). *Paket programlar ile istatistiksel veri analizi (çok değişkenli analizler)*. Kaan Kitabevi, Eskişehir.

Öztoprak, Z. (2020). Yaşamın İlkeleri ile Kenti Yeniden Düşünmek: Biyomimikri Temelli Bir Yaklaşım. *İdealkent, 11*(Kentleşme ve Ekonomi Özel Sayısı), 1180-1204.

Peker, R. (2020). *İlkokul dördüncü sınıf öğrencilerinin çevre algıları ile çevreye yönelik tutum ve davranışlarının değerlendirilmesi.* Yayımlanmamış Doktora Tezi, Mehmet Akif Ersoy Üniversitesi, Burdur.

Ramezani, A. Chung, SJ. and Hutchinson, S. (2017). A biomimetic robotic platform to study flight specializations of bats, *Science Robotics, 2*(3), eaal2505.

Seçer, İ. (2018). *Psikolojik test geliştirme ve uyarlama süreci: SPSS ve LISREL uygulamaları*. Anı yayıncılık.

Shahriari-Namadi, M., Tabatabaei, H. R., & Soltani, A. (2018). Entomophobia and arachnophobia among school-age children: a psychological approach. *Shiraz E-Medical Journal, 19*(7).

Speck, O., Speck, D., Horn, R., Gantner, J., & Sedlbauer, K. P. (2017). Biomimetic bio-inspired biomorph sustainable? An attempt to classify and clarify biology-derived technical developments. *Bioinspiration & Biomimetics, 12*(1), 011004.

Surastina, & Dedi, F. S. O. (2018). Examining academic writing motivation of prospective indonesian language teachers using exploratory factor analysis. *International Journal of Instruction, 11*(2), 15-24. https://doi.org/10.12973/iji.2018.1122a

Tanaka, J. S., & Huba, G. J. (1985). A fit index for covariance structure models under arbitrary GLS estimation. *British Journal of Mathematical and Statistical Psychology, 38*(2), 197-201.

Tavşancıl, E. (2005). *Tutumların ölçülmesi ve SPSS ile veri analizi*. Nobel Yayıncılık, Ankara.

Tezbaşaran, Ata. (2008). *Likert tipi ölçek geliştirme kılavuzu*. Üçüncü baskı, Türk Psikologlar Derneği Yayını, Ankara.

Uğur, S. S., ve Devcar, M. A. (2018). Girişimcilik özellikleri ile Holland'ın kişilik tipleri arasındaki ilişki üzerine nitel bir çalışma. *Girişimcilik İnovasyon ve Pazarlama Araştırmaları Dergisi, 2*(4), 98-110.

Wahl, D. C. (2006). *Bionics Vs. Biomimicry: From Control of Nature to Sustainable Participation in Nature*. Design and Nature III: Comparing Design in Nature with Science and Engineering, Vol. 87

Yakışan, M. & Velioğlu, D. (2019). İlkokul 4. sınıf öğrencilerinin biyomimikri algılarına yönelik yaptıkları çizimlerin analizi. *Gazi Üniversitesi Gazi Eğitim Fakültesi Dergisi, 39*(2), 727-753.

Doğadan İlham Alma Ölçeği (Inspiration from Nature Scale-Turkish Form)

Sevgili öğrenciler,

Aşağıda bitki ve hayvanlarla ilgili düşüncelerinizin yer aldığı bazı cümleler vardır. Bu cümlelerin kesin doğru ya da yanlış cevapları yoktur. Cümlenin karşısındaki hangi ifade size uygunsa onu işaretleyiniz. Görüşleriniz özellikle sizin görüşünüz olmalıdır. Bu yüzden aile ve arkadaşlarınızın görüşleri sizi etkilemeden kendinize uygun durumu işaretleyiniz. Cevaplarınız bir bilimsel araştırma için kullanılacak olup hiç kimseye gösterilmeyecektir. Sorunuz olursa öğretmeninize sorunuz. Cümleleri acele etmeden dikkatlice okuyup işaretleyiniz. Katkınız için teşekkür ederim.

		Katılıyorum	Kararsızım	Katılmıyorum
1.	Bitki ve hayvanlarla ilgili bir dersim olsun isterdim.			
2.	Doğaya çıkıp böcek ve hayvanları gözlemeyi isterim.			
3.	Kitaplarda hayvan resimleri çok dikkatimi çeker.			
4.	Bilgisayarda oyun oynamak yerine doğaya gidip böcekleri izlemek isterim.			
5.	Gördüğüm bir hayvanı ayrıntılı incelerim.			
6.	Robotlar genellikle hayvanlara benziyor.			
7.	Araç ve makinaları doğadaki canlılara benzer yönleri olduğunu düşünürüm.			
8.	İş makinesi olan kepçenin kürek kısmı insan eline benzer.			
9.	Araç ve makinaları doğadaki canlılara benzer yönleri olduğunu düşünürüm.			
10.	Üzerime sinek konduğunda çığlık atarım.			
11.	Hayvanlardan ve böceklerden korkuyorum.			
12.	Evimizde herhangi bir kelebek, örümcek benzeri bir böcek görsem bağırarak kaçarım.			
13.	Doğada hayvanlara dokunmaktan hoşlanmam.			

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A Systematic Review of 21st-Century Chemistry Laboratory Experiments and Classroom Instructions Facilitated/Aided With Digital Technologies and E-Resources

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Abstract

The study is a systematic review that looked at several technological tools used by academics to support 21st-century chemistry classroom instruction and lab experiments. Different databases, search engines, journals, and libraries were searched to obtain the most recent and relevant studies conducted from 2012 to 2022. The result reveals that the VR2E2C system, Authentic Intelligent Robotics for Chemistry (AIR-Chem), and LEGO-based automation device were the robotics tools used by researchers to facilitate classroom instruction of chemical concepts, including inorganic and general chemistry. It also reveals that the type of web resource that is integrated with an LMS, such as Google Classroom, Edmodo, Mooc, Moodle, and others, is the one that is utilized most frequently. Furthermore, the findings reveal that the virtual laboratories used for facilitating chemistry instruction include the Virtual Reality Multisensory Classroom (VRMC), Blackboard Learning System (BLS), PhET interactive simulation, ChemVLab+, and Interactive Molecular Dynamics in Virtual Reality (iMD-VR). Other findings reveal that computer and mobile device software applications used by researchers include Elements 4D, MoleculAR, iMolview Lite, MATLAB, Courseware, and CHEMTrans. The study concluded that technological advancement in the twenty-first century revolutionized chemistry instruction, making it more realistic than abstract.

Keywords: Chemistry, Instruction, Technology, 21st century, Experiment, Classroom.

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Introduction

As computers, tablets, smartphones, and other forms of technology are used more frequently in classrooms, researchers are interested in investigating and researching digital technologies' effectiveness in education and formative assessment. Interactive computer simulations are becoming increasingly influential teaching aids for chemistry nowadays. Students are learning through exploration in the simulations' animated, interactive, and game-like worlds. The simulations are easily accessed online and are made to be versatile tools to suit a variety of implementation techniques and instructional situations.

Many developing technologies have found widespread uses in the field of chemical education, including robotics, learning analytics, virtual reality (VR), and augmented reality (AR) (Chiu, 2021). For example, modern chemistry education places much emphasis on hands-on activities in the classroom, visualizing and interacting with chemical structures, and using virtual chemistry labs. While engaging and enjoyable for students and teachers, technology offers flexible access to several representations, makes the unseen visible, stimulates inquiry, and enables safe and quick access to numerous trials.

Psychologically, an experiment is an investigation in which a hypothesis is scientifically tested by manipulating an independent variable (the cause) while the dependent variable (the effect) is measured. Thus, experimentation is the manipulation of variables to establish cause-and-effect relationships. This experiment is mainly conducted in laboratories, hence the name laboratory experiment. Generally, laboratory experiments are a research method by which researchers create controllable environments to test hypotheses. A chemistry laboratory experiment is conducted under highly controlled conditions where accurate measurements, observations, and extractions are possible. Chemistry laboratory experiments are easy to replicate because standardized procedures are mostly utilized (Aliyu, 2022). Thus, a chemistry laboratory experiment is an experiment that uses a carefully controlled setting and standardized procedure to accurately measure how a change in the independent variable (the variable that changes) affects the dependent variable (the variable measured).

According to An et al. (2020), many educators have argued that, given their significance, laboratory experiences must be an essential component of science instruction. They listed the objectives of laboratory experiments as including (i) piquing and maintaining students' interest in science; (ii) encouraging original thought and conceptual understanding of the subject; (iii) advancing the science process and practical skills; and (iv) developing the study's inquiry skills. Interestingly, most chemical concepts are learned through laboratory experimentation and modeling. Thus, learning chemistry, whether in the classroom or the laboratory, requires effectively planned instruction. Instruction means the efforts of somebody superior in knowledge, skills, and attitude to plan, design, implement, and evaluate the teaching-learning process to benefit the recipients (learners). A classroom is a room in a school or college where instruction occurs. Classroom instruction means training in a setting where individuals receiving training are assembled and learn through organized formal education techniques (Muchtar et al., 2021). Traditionally, schools delivered classroom instruction with chalk and board. However, the demand for 21st-century skills and knowledge and the challenges brought by the COVID-19 pandemic force teachers to use technology to facilitate classroom instruction. Today, teachers systematically plan,

design, implement, and evaluate the total process of teaching and learning based on specific instructional objectives, using available human and non-human elements (such as digital technology) to improve the quality of instruction. Today, web-based applications, virtual laboratory tools, and other digital technologies are predominantly used by chemistry educators to facilitate classroom instructions and laboratory experiments in the teaching and learning of chemistry at both secondary and tertiary education levels.

Learning of Chemistry Concepts in the 21st Century

Chemistry demands students to understand chemistry at the macroscopic, microscopic, and symbolic levels. To complete this task, students must employ both highly abstract verbal and nonverbal thinking capabilities and subject-specific thinking abilities. As a result, in a "normal" classroom setting, teachers attempt to convert abstract chemical information into a teachable form, primarily through vocal explanations supplemented by parallel symbolic representations of information on the board. Students must focus on both the verbal cues and the visual input simultaneously to integrate them and make sense of them (Marchak et al., 2021). This demonstrates that the metacognitive processes necessary to comprehend and use an idea in any problem-solving are fundamentally based in chemistry.

Visual comprehension is a conceptual competency that relies on verbally mediated sense-making processes because it impacts how the subject's theoretical and experimental notions are learned and taught. It is impossible to ignore the importance of these representational skills in creating accurate mental models and giving the correct meaning to abstract chemical material through visualization. The fundamental premise behind traditional teaching methods is that the information humankind has amassed in the past must be transmitted to students in its current state. Therefore, lecturing has long been the primary method of achieving this goal, and as a result, learners have developed a passive attitude, both physically and cognitively.

Problem Statement

Researchers (Binti Ibrahim & Hj. Iksan, 2018 and Zoller, 2012) have found that learning chemistry can be challenging for various reasons, including complex concepts and misconceptions. According to certain studies (Luxford & Bretz, 2013 and Vladušić et al., 2016), students cannot distinguish between ionic and covalent bonding, while other studies (Taber, 2013) show that they are unaware of the chemical bond's electrostatic nature. Additionally, students conflate intramolecular and intermolecular forces, according to Luxford & Bretz (2013) and Uyulgan et al. (2014), while having misconceptions regarding the geometrization and polarity of molecules. These demonstrated the claim by Nahum et al. (2004) that students had trouble seeing and comprehending abstract concepts like chemical bonding.

Recently, reports show that the most challenging topic in chemistry is chemical bonding. This was a result of a study conducted to investigate (i) the problems encountered by the students and lecturers during the teaching and learning of matriculation chemistry subject, (ii) the most challenging topics in the matriculation chemistry syllabus, and (iii) the needs for the development of the teaching and learning module. That is why the report, after

analyzing how the chemical bond is taught, that traditional instruction contributes to learning difficulties. As a result, they proposed a new method of teaching chemical bonds based on current scientific knowledge, new pedagogical content knowledge and technological integration in chemistry teaching and learning. Inorganic and organic chemistry's understanding of reactivity and analytical chemistry's comprehension of spectroscopy depend on an understanding of chemical bonding (Vladušić et al. (2016). This is because it is focused on particle combinations, and the type of particle bonding can be used to explain a substance's chemical and physical properties.

According to Lee (2022), chemical bonding is currently the most challenging area of chemistry. This report was the outcome of a study conducted to assess (I) the issues that both learners and instructors encountered while learning and teaching chemistry, (ii) the most difficult topics on the syllabus, and (iii) the requirements for the development of the teaching and learning module. In the cause of a similar problem, Nahum et al. (2010) claimed that traditional training exacerbates learning issues after investigating how the chemical bond is taught. They consequently put up a fresh approach to teaching chemical bonds based on modern pedagogical content knowledge, current scientific understanding, and technological integration in chemistry teaching and learning.

Educational processes in Technology Enhanced Learning Environments (TELE) are mainly constructivist inquiries that foster an understanding of science and technology concepts and develop research skills. In such environments, the students construct knowledge in science and technology through practice in creating and operating technological tools. Digital technology in the 21st century is regarded as an effective tool for innovation in learning systems. Learning environment adopting digital technology positively contributes to students' cognitive and affective processes, which can finally result in a high attitude toward learning (Nababan et al., 2019).

Objectives of the Study

Because of the difficulties that both students and teachers have had in learning, understanding, and teaching chemical concepts that are either macroscopic, submacroscopic, or symbolic, many researchers have turned their attention to using technologically advanced tools to facilitate classroom instruction and laboratory experiments. Thus, the study examined several forms of technology academics utilize to facilitate chemistry classroom instruction and laboratory experiments in the 21st century.

The study is intended to pull out any relevant digital software tools used in the 21st century to ease the teaching and learning of chemical concepts at home, in the classroom, or the laboratory. The study's findings will categorically indicate chemical concepts taught to the students by chemistry educators when teaching with the aid of specific digital technology. Thus, this will help chemistry teachers understand technological tools that could be used to address specific chemical concepts. If effectively used, the problem of complex concepts and misconceptions in chemistry caused by textbooks, chemical models, or even teachers themselves can be easily overcome.

Method

The study adopted a systematic review of related work executed by scholars between 2010 and 2022. It is believed that during this period of 12 years, a lot has changed regarding the instructional approach for teaching and learning chemistry at both secondary and tertiary levels of education. Many databases and journals were visited to source relevant information for the study, including Google Scholar, Elsevier, ScienceDirect, Web of Science, SAGE journals, Springer, Semantic Scholar, the Journal of Chemical Education, and the International Journal of Interactive Mobile Technologies. The keywords searched include "chemistry and technology," "chemistry and mobile learning," "virtual chemistry laboratories," "chemistry and robotics," "chemistry and learning management systems," "chemistry and digital games," and "chemistry and web-based learning."

The search results, amounting to over 22,169 articles, were scrutinized and screened through set criteria. The first criterion is screening out those articles intended for areas other than the teaching and learning of chemistry. This criterion excludes articles from consideration for laboratory and clinical research. Secondly, articles not related to the teaching and learning of chemistry specifically were also eliminated. Further exclusion and inclusion are represented in Figure 1, which reveals that 58 articles qualified for the review.

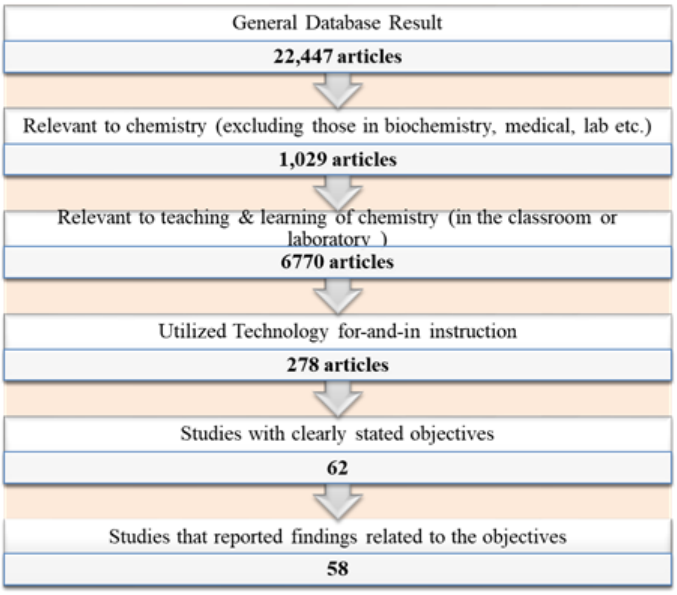

Figure 1. Criteria for Screening Qualified Research Work

Result and Discussion

Over the years, several technological resources were used by researchers and chemistry teachers to facilitate classroom instruction and laboratory experiments, especially during the COVID-19 pandemic. The outcome of this review demonstrated the variety of electronic resources and digital technologies used for facilitating the learning and teaching of various chemical concepts concerning the objective intended to be addressed. Thus, the analysis is hereby presented to address different forms of technologies and e-resources used by the researchers, including robotics, learning management systems, virtual laboratories, computer and mobile software

applications, videos, and digital games.

Robotics for Chemistry Instructions

For more than a decade, a combination of robotic automation and artificial intelligence (AI) has made great advances in chemistry to improve yields and reproducibility, cut costs, prevent health hazards, and accelerate the discovery of new materials. Most of the relevance here indicated is associated with advancement in the industrial sector. Despite claims that many schools train students to employ automation technology while some have already discontinued teaching traditional manual techniques, very few robotics (indicated in Table 1) are created to facilitate chemistry classroom instruction and laboratory research (Verner & Revzin, 2019). Robotic technologies are thought to be able to increase the effectiveness and accessibility of laboratory experimentation, offering considerable educational benefits, particularly in supporting constructivist inquiry-based learning and in developing students' higher-order thinking skills.

Table 1. Robotics Used by Chemistry Instruction by Researchers

SN	Authors	Publishers	Software application	Scope of chemical activities
1	Lu et al. (2021)	Journal of Chemical Education	VR^2E^2C system	General chemistry experiment: the synthesis of gold nanocrystals (AuNCs)
2	Li et al., (2018)	Journal of Physical Chemistry	Authentic Intelligent Robotics for Chemistry (AIR-Chem)	Inorganic chemistry
3	Verner & Revzin (2019)	Springer	LEGO-based automation device	Inorganic chemistry

As indicated in Table 1, while two studies are related to inorganic chemistry, one concerns general chemistry. Thus, researchers use robotics to facilitate the learning of general and inorganic chemistry. This does not limit other experts from utilizing robotics in other areas of chemistry, including analytical and physical chemistry. Researchers (Li et al., 2018; Lu et al., 2021; Verner & Revzin, 2019) report that robotics was interesting and engaging and contributed to significant outcomes in learning chemistry. There is no specific robotics designed for chemistry education. Teachers need to determine more relevant tools that fit their students' intellectual development and ensure the attainment of instructional objectives.

Web-Based Learning Resources for Chemistry Education

The web-based learning resources are categorized into learning management systems and virtual laboratories. Thus, this section is divided into two sub-sections, including (a) web-based learning via learning management systems and (b) a virtual laboratory in chemistry education.

Web-Based Learning Via Learning Management Systems

The software used to deliver, monitor, and process training and learning is a learning management system (LMS).

Similarly, creating teaching materials for learning that use the LMS application is thought to pique students' desire and interest more, fostering a positive attitude toward chemistry and enhancing their metacognition abilities (Nababan et al., 2019). According to Putro et al. (2022), it is envisaged that the learning management system (LMS) for chemistry teaching will consist of a collection of resources, virtual lessons, quizzes and practice problems, and a collection of formulas, as well as extra animations and virtuals to make it easier to grasp. As indicated in Table 2, some of the LMS used in teaching and learning include Edmodo, Moodle LMS, Google Classroom, Teachmint, TalentLMS, iSpring Learn, TalentCards, Eduflow, Skillcast LMS, 360 Learning, Gurucan, Sakai, Xperiencify, GyrusAim, Tovuti LMS, LearnWorlds etc.

Table 2. Web-Based Technologies Used in Chemistry Instruction

SN	Authors	Publishers	Software application	Scope of chemical activities
1	Agnello et al., (2020)	Journal of Chemical Education	ULg Spectra	Spectrometry (organic chemistry experiment)
2	Marchak et al. (2021)	Journal of Chemical Education	Framework	General chemistry
3	Hagos et al. (2022)	Journal of Chemistry Education Research	Technology Integrated Formative Assessment (TIFA)	chemical equilibrium
4	Fosu et al. (2019)	Technology Integration in Chemistry Education and Research (TICER)	Twitter and a campus-based learning management system (LMS)	General chemistry
5	Putro et al. (2022)	Journal of Physics: Conference Series	Moodle LMS	General chemistry
6	Imaduddin & Astuti (2022)	Bulletin of Community Engagement	Google Classroom	microscopic concepts i.e. sub macroscopic concepts like atom, radioactivity etc.
7	Hsiung (2018)	Journal of Interactive Mobile Technologies	Moodle e-Learning platform	General chemistry
8	Al-nawaiseh & Alwraikat (2020)	European Journal of Business and Management	e-learning made from LMS	General chemistry
9	Siqueira de Oliveira & Nichele (2020)	14th International Technology, Education and Development Conference	Facebook as a Learning Management System (LMS)	Organic chemistry
10	Muchtar et al. (2021)	Jurnal Pendidikan Kimia	Google Classroom	General chemistry
11	Wolfa et al. (2012)	Proceedings of the SPDECE-2012. Ninth Nultidisciplinary Symposium on the Design and Evaluation of Digital Content for Education	ILIAS-learning software	Practical chemistry (organic & inorganic)
12	Kurniawan et al. (2021)	2nd Annual Conference on Blended Learning, Educational Technology and Innovation (ACBLETI 2020)	Moodle	General chemistry
13	Suherman et al. (2022)	International Journal of Educational Research & Social Sciences	Learning management system	General chemistry
14	Rohyami & Huda (2020)	AIP Conference Proceedings	Google classroom	Analytical Chemistry (stoichiometric aspects of volumetric analysis)
15	Flynn (2015)	Chemistry Education Research and Practice	Blackboard Learning system	organic chemistry and spectroscopy
16	Napitupulu et al. (2020)	International Journal of Mobile Technology	LMS Schoology	Metal Inorganic Chemistry
17	Varela & Leal (2015)	Proceedings of the 5th International Technology, Education and Development Conference (INTED)	Moodle	Carbon compounds; Chemical reactions; Separation processes from mixtures; Chemical bond; etc.
18	Fakngern et al. (2022)	Asia Research Network Journal of Education	online Chemistry learning management	General chemistry
19	Parbuntari & Ikhsan (2014)	International Conference On Research, Implementation And Education Of Mathematics And Sciences	Edmodo	Acid Base Chemistry
20	Nababan et al. (2019)	AIP Conference Proceedings	Thermochemistry-based Learning Management System (LMS)	General chemistry

As can be seen from Table 2, there were about eight general chemistry studies, four organic and inorganic chemistry studies, two analytical chemistry studies, one radioactivity study, and one physical chemistry study conducted by researchers with the aid of a web-based learning management system or as an instructional tool. Since web-based learning tools are employed to reciprocate face-to-face instruction, researchers focus on the chemistry curriculum's theoretical (non-practical) aspects, like general, organic, and inorganic chemistry. Experts

mostly use web-based resources to address certain educational or instructional objectives. As a result, the type of web resource that is integrated with an LMS, such as Google Classroom, Edmodo, Mooc, Moodle, and others, is the one that is utilized the most frequently..

The findings of review studies emphasize the advantage of web-based learning resources in developing/enhancing/encouraging student motivation (Fosu et al., (2019; Hagos et al., 2022; Hsiung, 2018; Kurniawan et al., 2021 and Parbuntari & Ikhsan, 2014), learning outcomes (Rohyami & Huda, 2020 and Wolfa et al., 2012), attitude of students toward learning (Nababan et al., 2019), metacognition of the learner (Hagos et al., 2022; Nababan et al., 2019), user satisfaction (Muchtar et al., 2021), and scientific thinking & process skills (Agnello et al., 2020 and Al-nawaiseh & Alwraikat, 2020). Other web resources include ChemTeach & ChemSage, Discovery and Naming of the Chemical Elements, Khan Academy, VIAS Library GenChem, LibreTexts Chemistry, General Chemistry Online, Mark Bishop's Introduction to Chemistry, Virtual Chembook, General Chemistry Virtual Textbook, Chemogenesis Webbook, WikiBooks, AUS-e-TUTE, ChemPaths, KnowledgeDoor, ChemCollective, Doc Brown's Chemistry Clinic, Wyzant, etc.

Virtual Laboratory in Chemistry Education

A "virtual laboratory" is a three-dimensional, realistic virtual environment created using cutting-edge technologies including high-resolution screens, multi-sensor interaction, artificial intelligence, multimedia, and three-dimensional graphics production. Modern sensors that are integrated with technology, as well as high-performance computer hardware and software, are all completely utilized (Geng & Wu, 2021). As indicated in Figure 2. users can replicate their hearing, touch, vision, and other senses to observe items in three dimensions as if they were physically there.

Figure 2. An Analogue of Virtual Chemistry Laboratory

(Retrieved from https://www.labster.com/simulations/introductory-lab/)

Students can obtain a more realistic experience and achieve better learning results while engaging in interactive virtual learning or performing a simulation experiment in a virtual laboratory (Geng & Wu, 2021). Thus, as shown

in Table 3, researchers focus on utilizing various distinct virtual laboratories to fulfill varying aims for understanding related chemical processes.

Table 3. Virtual Laboratory Used in Chemistry Instruction

SN	Authors	Publishers	Software application	Scope of chemical activities
1	Winkelmann et al. (2017)	Journal of Chemical Education	Second Life (SL) created and operated by Linden Lab	General chemistry
2	Edwards et al. (2018)	Virtual Reality,	Virtual Reality Multisensory Classroom (VRMC)	Organic chemistry
3	Soong et al. (2021)	Journal of Chemical Education	open-source remote titration unit	Analytical chemistry (titration)
4	Ferrell et al. (2019)	Journal of Chemical Education	interactive molecular dynamics in virtual Reality (iMD-VR)	Molecular chemistry
5	Dunnagan et al., (2020)	Journal of Chemical Education	VR laboratory experience	Spectrometry (organic chemistry lab experiment)
6	Davenport et al. (2018)	Journal of Chemical Education	ChemVLab+	General chemistry
7	Clark & Chamberlain (2014)	Journal of Chemical Education	PhET interactive simulation	General Chemistry laboratory
8	Lancaster et al. (2013)	ACS Symposium Series	PhET interactive simulation	General Chemistry laboratory ((e.g. atoms, photons, electrons))
9	Wright & Oliver-Hoyo (2021)	Journal of Chemical Education	Hydrogen Nuclear Magnetic Resonance MoleculAR Application	Spectrometry energy levels, symmetry, molecular geometry, chemical bonding, reaction mechanisms, etc.
10	Moore et al. (2011)	Journal of Chemical Education	PhET interactive simulation	General Chemistry laboratory
11	Moore (2016)	Journal of Chemical Education	PhET interactive simulation	General Chemistry Instruction
12	Aguirre & Selampinar (2020)	Journal of Chemical Education	Blackboard Learning System (BLS)	General Chemistry laboratory
13	Buchberger et al. (2020)	Journal of Chemical Education	Blackboard Collaborate Ultra	analytical chemistry
14	Dunnagan et al. (2019)	Journal of Chemical Education	VR laboratory experience created using WondaVR	analytical chemistry
15	Tatli & Ayas (2013)	Educational Technology & Society	virtual chemistry laboratory (VCL)	Physical Chemistry (chemical changes)

As you can see from Table 3, there are seven general chemistry studies, five analytical chemistry studies, one organic chemistry study, one molecular chemistry study, and one physical chemistry study conducted via a virtual learning platform. This result reveals that chemistry teachers most often use virtual laboratories to convey laboratory activities involving general and analytical chemistry. These concepts (general and analytical chemistry) are important content of the secondary and undergraduate curriculum that learners must cover, learn, and gain skills before graduating. For example, secondary school chemistry curriculum and assessments frequently prioritize numerical problem-solving activities and practice with symbolic operations, such as balancing chemical equations and building Lewis structures. These steps assume students will learn chemistry fundamentals by manipulating numbers and symbols. By assisting students in drawing links to real-world situations, realistic and context-based instruction via virtual laboratories fosters deep learning of chemical processes.

Another example of the importance of virtual laboratories is their animated and interactive interface, which allows for the exploration of various atomic models, including Dalton's billiard ball, Thomson's plum pudding model, Rutherford's classical solar system model, the Bohr and de Broglie models, and finally Schrödinger's quantum mechanical model. Some of the most frequently used virtual laboratories include the Virtual Reality Multisensory Classroom (VRMC), Blackboard Learning System (BLS), PhET interactive simulation, ChemVLab+, and Interactive Molecular Dynamics in Virtual Reality (iMD-VR).

The advantages of virtual laboratories for students operating and experimenting with chemical and physical processes include promoting student's motivation, interest, and learning (Edwards et al., 2018; Lancaster et al., 2013), encourages intuitive interaction (Lancaster et al., 2013), overcoming learning difficulties (Davenport et al., 2018), learner satisfaction (Ferrell et al., 2019; and Winkelmann et al., 2017), student's self-efficacy (Ferrell et al., 2019), minimizes cognitive load (Lancaster et al., 2013), enhancement of student's performance (Ferrell et al., 2019; and Winkelmann et al., 2017), development of manipulative and science process skills (Chabra 2020 and Clark & Chamberlain, 2014), allow students to connect learning to real-world situations (Lancaster et al., 2013). Virtual environments let students observe the process in more detail, compared to board and chalk activities of the traditional classroom or partially completed experiments in a real laboratory environment (Tatli & Ayas, 2013). Other significant virtual chemistry laboratories not found in this review include Reactor Lab, Virtlab, ScienceMedia, Model ChemLab, and Model ChemLab.

For example, Model ChemLab is a real-time two-dimensional simulation of a chemistry lab in which the user interacts with animated lab equipment in a large number of experiment modules, including Charles' Law, Acid-Base Titration, Atomic Weight of Magnesium, Bond, Cation, and Anion Reactions, Determination of Specific Heat, Electrochemical Cell, Flame Chemistry, Fractional Crystallization, Gas Compression, Gravimetric Analysis of Chloride, Reaction Kinetics, Iron (II) Redox Titration, LeChatelier's Principle, Oxidation and reduction, Nuclear Chemistry, and Paper Chromatography.

Computer and Mobile Software Applications in chemistry instruction

Some software applications are designed to operate on computer devices and mobile phones due to their portability and numerousness. Today, almost every grown individual in this 21st-century society has, if not both, at least a computer device or a mobile phone used for business, leisure, or education. As a result of that, there are many software applications (indicated in Table 4) that run on computers and mobile phones to facilitate the teaching and learning of chemical concepts.

Table 4. Computer and Mobile Software Applications for Chemistry Instruction

SN	Software/Application	Publishers	Scope of chemical exploration	Authors
1	Elements 4D	Journal of Chemical Education,	Periodicity (General chemistry)	Yang et al. (2018)
2	MoleculAR, available in Android and iOS stores	Journal of Chemical Education,	Spectrometry (Analytical chemistry)	Wright & Oliver-Hoyo (2021)
3	iMolview Lite, available in Android and iOS stores	Journal of Chemical Education,	Organic chemistry	Toscanini et al., (2021)
4	Mathematica and MATLAB programming environments	Journal of Chemical Education	Spectrometry (Analytical chemistry)	Jones et al. (2021)
5	Matlab framework.	Journal of Chemical Education	Spectrometry (Analytical chemistry)	Fisher (2019)
6	CHEMTrans	Journal of Chemical Education	Chemical equations	Li et al., (2022)
7	Courseware	2018 IEEE 10th International Conference on Engineering Education (ICEED)	Acid-Based chemistry	Talib et al. (2018)

As indicated in Table 4, while three studies related to analytical chemistry are executed with the aid of computer and mobile software applications, two general, one inorganic, and one organic chemistry use similar technological resources. Some applications and software researchers use include Elements 4D, MoleculAR, iMolview Lite,

MATLAB, Courseware, and CHEMTrans. Most of these methods are used by researchers to encourage students' creativity while facilitating active learning, which shows that the activity assists students in absorbing chemical concepts more thoroughly. Some of the reported by researchers include the development of a positive user experience (Wright & Oliver-Hoyo, 2021), a positive attitude toward learning (Yang et al., 2018), gain a deeper understanding of the chemical concept (Fisher, 2019; Jones et al., 2021; Li et al., 2022 and Toscanini et al., 2021).

Other chemistry-specific apps include AutoChrom, Katalyst D2D, Luminata, Method Selection Suite, MS Fragmenter & NMR Predictors, Spectrus JS, ChemOffice (the new version includes ChemDraw Ultra, Chem3D Ultra, E-Notebook Ultra, ChemFinder, CombiChem, Inventory, BioAssay, and The Merck Index), Spectrus Processor, Gaussian, Structure Elucidator Suite, ChemSketch, Hyperchem, Betwixt, Odyssey, ChemBuddy, Monte Carlo Gas Simulator, SAVANT Laboratory Training, Atomic orbitals CD-ROM, Chemical Thesaurus, CHEM-IT, Newbyte, WinTorg, CHEMIX School, Kintecus.

Video-Based Learning Technology in Chemistry Instructions

Videos can be used to support chemistry lessons if they are appropriately integrated with crucial elements that help teaching and learning (Gallardo-Williams et al., 2020). Videos are frequently used in chemistry to describe chemical processes and demonstrate instruments, procedures, and skills pertinent to the lab. In order to instruct experiments to people learning the practical parts of chemistry, movies are frequently employed. As demonstrated by using problem-solving videos for general chemistry, learners can learn at a self-regulated pace. They may review the content whenever necessary with video technology. Managing the cognitive load of the video, maximizing the engagement of the video, and fostering active learning from the video are three factors that instructors should consider when using video as a teaching method (Brame, 2016). Videos may be a powerful educational tool because they are often the foundation of blended learning strategies. Various techniques and delivery methods are used in video-based chemistry laboratories, such as straightforward video footage, storylines lab compilations, and real-time delivery (Karayilan et al., 2021).

Table 5. Video-based Technology in Chemistry Instruction

SN	Authors	Publishers	Scope of chemical activities
1	Altowaiji et al. (2021)	Chemistry Education Research and Practice	General chemistry
2	Box et al. (2017)	Journal of Chemical Education,	Organic Chemistry
3	Cresswell et al. (2019)	Journal of Chemical Education,	Organic and analytical chemistry
4	Pulukuri & Abrams (2020)	Journal of Chemical Education,	Solubility
5	Jones et al. (2021)	Journal of Chemical Education	General chemistry laboratory courses (CHEM 1211, 1212, & 1310)
6	Nadelson et al. (2015)	Journal of Science Education and Technology	Organic Chemistry
7	Howitz et al. (2020)	Journal of Chemical Education	General & Organic Chemistry
8	Demissie et al. (2013)	American Journal of Chemistry Education	General & Organic Chemistry
9	Ranga (2017)	Journal of Chemical Education	General Chemistry
10	Delaviz & Ramsay, (2018)	Proc. 2018 Canadian Engineering Education Association (CEEA-ACEG18) Conf	engineering chemistry

The authors employed videos to facilitate instructions in several chemistry topics, as shown in Table 5. According to this review, researchers use five video technologies related to general chemistry, four to organic chemistry, one to analytical chemistry, one to physical chemistry, and one to engineering chemistry.

It is obvious that most teachers use videos for common practical and non-practical areas of the curriculum, like general and organic chemistry. For example, a video-modified platform called “Edpuzzle” was used by Pulukuri & Abrams (2020) to teach the concept of solubility in a chemistry classroom at Boston University. Moreover, Nadelson et al. (2015) researched to determine the influence of the addition of instructional videos on student preparation, performance, and achievement associated with their engagement in organic chemistry laboratory activities with the aid of instructional videos. Furthermore, at the University of California, Irvine (UCI), Howitz et al. (2020) replaced general & organic chemistry experimental work with videos.

The findings of studies involved in this review reveal that videos improve the comprehension ability and performance of students in the subject (Demissie et al., 2013), deep learning and improve students' ability (Box et al., 2017), better prepare for the laboratory activities (Altowaiji et al., 2021); highly suitable for teaching purposes (Cresswell et al., 2019)

Digital Game-Based E-Resources for Chemistry Instruction

Using games to teach ideas or impart skills to students who would otherwise struggle in a regular classroom is known as game-based learning (GBL). Students can study a subject, review the rules, and locate patterns based on the correctness or errors in their responses when games help them understand complex concepts (Gupta, 2019). The easiest games to make and utilize for teaching and learning are physical ones, such board games, puzzle games, and card games. These games can be created with common things and require little technical expertise. For people of all ages, digital gaming has become one of the most exciting types of entertainment. Video games and computer-based games' elements are combined in digital educational games, which are software programs. Digital educational games are a fundamental education innovation that can improve students' learning and skill development.

The reasons why people find digital educational games appealing include their entertaining elements combined with a pleasant environment, their aesthetic quality (graphics, effects, and music), the presence of a structured framework, their learning objectives (also presented as problems requiring solutions), and the presence of the gaming element (also causing the strong participation of the learner). Digital educational games don't make having fun and enjoyment their primary goal, but its setting incorporates educational material in a pleasant and challenging style that encourages active learning.

As shown in Table 6, the review studies facilitated learning and teaching chemical topics using Kahoot!, Molebots, and the Symperid board game. Chemical symbols, nomenclature, elemental periodicity, Molecular weight, elemental quantum chemistry, acid-base and reduction-oxidation equilibrium, colligative properties of solutions, and reaction kinetics are some ideas. The results show that including game elements in lessons results in learner satisfaction, motivation, and interest stimulation, offering an alternative method of presenting subject matter and inspiring students regardless of their gender, age, or educational level (Aliyu, 2022; Aliyu et al., 2021; and Gupta, 2019).

Table 6. Game Element in Learning/Teaching of Chemistry Concepts

SN	Authors	Publishers	Technological Resources	Scope of Exploration
1	Aliyu (2022)	4th International Göbeklitepe Scientific Research Congress. Organized by International Science and Art Research Center (ISARC)	Kahoot!	Philosophy of Chemistry
2	Gupta (2019)	ACS Symposium Series	Molebots	Nomenclature, or naming chemical compounds
3	Aliyu et al. (2021)	International Journal of Asian Education,	Symperiod Board Game	chemical symbols and periodicity of elements
4	Murciano-Calles (2020)	Journal of Chemical Education	Kahoot!	elemental quantum chemistry, acid-base and reduction-oxidation equilibrium, colligative properties of solutions, and reaction kinetics
5	Sanga Lamsari Purba et al. (2019)	Jurnal Pendidikan Kimia	Kahoot!	General chemsitry
6	Youssef (2022)	Journal of Chemical Education	Kahoot!	General chemistry
7	María et al. (2018)	4th international conference on higher education advances (HEAD'18)	Kahoot!	General chemistry
8	Ghawail & Yahia (2022)	Procedia Computer Science	Kahoot!	Molecular weight

Other instructional games that can facilitate learning of chemical concepts include ChemCompete, Chemistry Gears, Build a Molecule (Molecularium), ChemCaper, CheMoVEr, Bingo, Old Pro, Common Sense Media, and Sheppard.

Conclusion

The study is a systematic review that looked at several technological tools used by academics to support 21st-century chemistry classroom instruction and lab experiments. Different databases, search engines, journals, and libraries were searched to obtain the most recent and relevant studies from 2012 to 2022. The result reveals that the VR2E2C system, Authentic Intelligent Robotics for Chemistry (AIR-Chem), and LEGO-based automation device were the robotics tools used by researchers to facilitate classroom instruction of chemical concepts, including inorganic and general chemistry. It also reveals that the type of web resource that is integrated with an LMS, such as Google Classroom, Edmodo, Mooc, Moodle, and others, is the one that is utilized most frequently. Furthermore, the findings reveal that the virtual laboratories used for facilitating chemistry instruction include the Virtual Reality Multisensory Classroom (VRMC), Blackboard Learning System (BLS), PhET interactive simulation, ChemVLab+, and Interactive Molecular Dynamics in Virtual Reality (iMD-VR). Other findings reveal that computer and mobile device software applications used by researchers include Elements 4D, MoleculAR, iMolview Lite, MATLAB, Courseware, and CHEMTrans. The study concluded that technological advancement in the twenty-first century revolutionized chemistry instruction, making it more realistic than abstract.

Recommendations

The study recommends that all chemistry teachers learn how to use these online resources for the instruction of laboratory concepts to supplement if not completely replace, face-to-face or direct laboratory experiments in

school laboratories. Moreover, researchers need to test other digital software tools yet to be presented in academic journals and databases. Some could be more relevant and effective in facilitating classroom instructions or laboratory experiments.

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References

Agnello, A., Vanberg, S., Tonus, C., Boigelot, B., Leduc, L., Damblon, C., & Focant, J. F. (2020). Introducing Molecular Structural Analysis Using a Guided Systematic Approach Combined with an Interactive Multiplatform Web Application. *Journal of Chemical Education*, *97*(12), 4330–4338. https://doi.org/10.1021/acs.jchemed.0c00329

Al-nawaiseh, A., & Alwraikat, M. (2020). Impact of Using Developed Learning Management System on Student ' s Scientific Thinking Skills : Applied Study on 10th Grade Chemistry Class. *European Journal of Business and Management*, *12*(5), 94–102. https://doi.org/10.7176/EJBM/12-5-11

Aliyu, H. (2022). Implementing Formative Assessment In Chemistry Education Classroom Instruction Using Kahoot! Online Resources. *4th International Göbeklitepe Scientific Research Congress. Organized by International Science and Art Research Center (ISARC)*.

Aliyu, H., Raman, Y., & Talib, C. A. (2021). Enhancing Cognitive Development in Learning Chemical Symbol and Periodicity through Instructional Game. *International Journal of Asian Education*, *2*(3), 285–295.

Altowaiji, S., Haddadin, R., Campos, P., Sorn, S., Gonzalez, L., Villafañe, S. M., & Groves, M. N. (2021). Measuring the effectiveness of online preparation videos and questions in the second semester general chemistry laboratory. *Chemistry Education Research and Practice*, *22*(3), 616–625. https://doi.org/10.1039/d0rp00240b

An, J., Poly, L. P., & Holme, T. A. (2020). Usability Testing and the Development of an Augmented Reality Application for Laboratory Learning. *Journal of Chemical Education*, *97*(1), 97–105. https://doi.org/10.1021/acs.jchemed.9b00453

Binti Ibrahim, N. H., & Hj. Iksan, Z. B. (2018). Level of Chemophobia and Relationship with Attitude towards Chemistry among Science Students. *Journal of Educational Sciences*, *2*(2), 52. https://doi.org/10.31258/jes.2.2.p.52-65

Box, M. C., Dunnagan, C. L., Hirsh, L. A. S., Cherry, C. R., Christianson, K. A., Gibson, R. J., Wolfe, M. I., & Gallardo-williams, M. T. (2017). Qualitative and Quantitative Evaluation of Three Types of Student-Generated Videos as Instructional Support in Organic Chemistry Laboratories. *Journal of Chemical Education*, *94*(2), 164–170. https://doi.org/10.1021/acs.jchemed.6b00451

Brame, C. J. (2016). Effective Educational Videos: Principles and Guidelines for Maximizing Student Learning from Video Content. *CBE—Life Sciences Education*, 1–6. https://doi.org/10.1187/cbe.16-03-0125

Chabra, J. (2020). Using a Cooperative Hands-On General Chemistry Laboratory Framework for a Virtual

General Chemistry Laboratory. *Journal of Chemical Education*. https://doi.org/10.1021/acs.jchemed.0c00780

Chiu, W.-K. (2021). Pedagogy of Emerging Technologies in Chemical Education during the Era of Digitalization and Artificial Intelligence: A Systematic Review. *Education Sciences*, *11*, 1–24.

Clark, T. M., & Chamberlain, J. M. (2014). Use of a PhET Interactive Simulation in General Chemistry. *Journal of Chemical Education*, *91*(8), 1–5.

Cresswell, S. L., Loughlin, W. A., Coster, M. J., & Green, D. M. (2019). Development and Production of Interactive Videos for Teaching Chemical Techniques during Laboratory Sessions. *Journal of Chemical Education*, *96*(5), 1033–1036. https://doi.org/10.1021/acs.jchemed.8b00647

Davenport, J. L., Rafferty, A. N., & Yaron, D. J. (2018). Whether and How Authentic Contexts Using a Virtual Chemistry Lab Support Learning. *Journal of Chemical Education*, *95*(8), 1250–1259. https://doi.org/10.1021/acs.jchemed.8b00048

Delaviz, Y., & Ramsay, S. D. (2018). Student Usage of Short Online Single-Topic Cideos in a First-Year Engineering Chemistry Class. *Proc. 2018 Canadian Engineering Education Association (CEEA-ACEG18) Conf*, 8–11.

Demissie, T., Ochonogor, C. E., & Engida, T. (2013). Effects of Technology Driven Pedagogy Application on the Comprehension of Comprehension of Complex and Abstract Concepts of Chemical Equilibrium. *American Journal of Chemistry Education*, *3*(2), 57–75.

Dunnagan, C. L., Dannenberg, D. A., Cuales, M. P., Earnest, A. D., Gurnsey, R. M., & Gallardo-Williams, M. T. (2020). Production and Evaluation of a Realistic Immersive Virtual Reality Organic Chemistry Laboratory Experience: Infrared Spectroscopy. *Journal of Chemical Education*, *97*(1), 258–262. https://doi.org/10.1021/acs.jchemed.9b00705

Edwards, B. I., Bielawski, K. S., Prada, R., & Cheok, A. D. (2018). Haptic Virtual Reality and Immersive Learning for Enhanced Organic Chemistry Instruction. *Virtual Reality*, *23*(4), 363–373. https://doi.org/10.20944/preprints201804.0065.v1

Fakngern, S., Chapoo, S., & Chanunan, S. (2022). Online Chemistry Learning Management Model Promoting Students ' Scientific Communication in the Special Program Classroom on Science , Mathematics , and Technology , and Environment during the Pandemic Covid-19 Situation. *Asia Research Network Journal of Education*, *2*(2), 110–117.

Ferrell, J. B., Campbell, J. P., McCarthy, D. R., McKay, K. T., Hensinger, M., Srinivasan, R., Zhao, X., Wurthmann, A., Li, J., & Schneebeli, S. T. (2019). Chemical Exploration with Virtual Reality in Organic Teaching Laboratories. *Journal of Chemical Education*, *96*(9), 1961–1966. https://doi.org/10.1021/acs.jchemed.9b00036

Fisher, A. A. E. (2019). An Introduction to Coding with Matlab: Simulation of X-ray Photoelectron Spectroscopy by Employing Slater's Rules [Product-review]. *Journal of Chemical Education*, *96*, 1502–1505. https://doi.org/10.1021/acs.jchemed.9b00236

Flynn, A. B. (2015). Structure and Evaluation of Flipped Chemistry Courses: Organic & Spectroscopy, Large and Small, First to Third Year, English and French. *Chemistry Education Research and Practice*, *16*(2), 198–211.

Fosu, M. A., Gupta, T., & Michael, S. (2019). Social Media in Chemistry: Using a Learning Management System

and Twitter To Improve Student Perceptions and Performance in Chemistry. In *Technology Integration in Chemistry Education and Research (TICER)* (pp. 185–208). American Chemical Society.

Gallardo-Williams, M., Morsch, L. A., Paye, C., & Seery, M. K. (2020). Student-generated video in chemistry education. *Chemistry Education Research and Practice*, *21*(2), 488–495. https://doi.org/10.1039/C9RP00182D

Geng, J., & Wu, X. (2021). Application of Virtual Reality Technology in University Education. *Journal of Physics: Conference Series*. https://doi.org/10.1088/1742-6596/1972/1/012023

Ghawail, E. A. Al, & Yahia, S. Ben. (2022). Using the E-Learning Gamification Tool Kahoot! to Learn Chemistry Principles in the Classroom. *Procedia Computer Science*, *207*(Kes), 2667–2676. https://doi.org/10.1016/j.procs.2022.09.325

Gupta, T. (2019). Game-Based Learning in Chemistry: A Game for Chemical Nomenclature [Chapter]. *ACS Symposium Series*, 65–79. https://doi.org/10.1021/bk-2019-1318.ch005

Hagos, T., Andargie, D., Studies, B., & Ababa, A. (2022). Technology Integrated Formative Assessment: Effects on Students' Conceptual Knowledge and Motivation in Chemical Equilibrium. *Journal of Chemistry Education Research*, *6*(1), 26–43.

Howitz, W. J., Thane, T. A., Frey, T. L., Wang, X. S., Gonzales, J. C., Tretbar, C. A., Seith, D. D., Saluga, S. J., Lam, S., Nguyen, M. M., Tieu, P., Link, R. D., & Edwards, K. D. (2020). Online in no time: Design and implementation of a remote learning first quarter general chemistry laboratory and second quarter organic chemistry laboratory. *Journal of Chemical Education*, *97*(9), 2624–2634. https://doi.org/10.1021/acs.jchemed.0c00895

Hsiung, W. Y. (2018). The Use of E-Resources and Innovative Technology in Transforming Traditional Teaching in Chemistry and its Impact on Learning Chemistry. *International Journal of Interactive Mobile Technologies*, *12*(7), 86–96.

Imaduddin, M., & Astuti, A. P. (2022). Strengthening Chemistry Teachers' Technological Pedagogical Content Knowledge through the Introduction of Augmented Reality and Learning Management Systems. *Bulletin of Community Engagement*, *2*(1), 21–31.

Jones, O. A. H., Stevenson, P. G., Hameka, S. C., Osborne, D. A., Taylor, P. D., & Spencer, M. J. S. (2021). Using 3D Printing to Visualize 2D Chromatograms and NMR Spectra for the classroom. *Journal of Chemical Education*, *98*(3), 1024–1030. https://doi.org/10.1021/acs.jchemed.0c01130

Jones, E. V., Shepler, C. G., & Evans, M. J. (2021). Synchronous Online-Delivery: A Novel Approach to Online Lab Instruction. *Journal of Chemical Education*, *98*(3), 850–857. https://doi.org/10.1021/acs.jchemed.0c01365

Karayilan, M., McDonald, S. M., Bahnick, A. J., Godwin, K. M., Chan, Y. M., & Becker, M. L. (2021). Reassessing Undergraduate Polymer Chemistry Laboratory Experiments for Virtual Learning Environments. *Journal of Chemical Education*. https://doi.org/10.1021/acs.jchemed.1c01259

Kurniawan, A. F., Sanga, L., Purba, L., & Novita, F. (2021). Utilization of Moodle in Increasing Motivation of Learning Chemistry Students. *2nd Annual Conference on Blended Learning, Educational Technology and Innovation (ACBLETI 2020)*, 182–188.

Lancaster, K., Moore, E. B., Parson, R., & Perkins, K. K. (2013). Insights from using PhET's design principles for interactive chemistry simulations. *ACS Symposium Series*, *1142*, 97–126. https://doi.org/10.1021/bk-

2013-1142.ch005

Lee, T. T. (2022). The Development of Matriculation Chemistry Module : Needs Analysis. *Central Asia and the Caucasus*, *23*(1), 2086–2099. https://doi.org/https://doi.org/10.37178/ca-c.21.5.082

Li, J., Lu, Y., Xu, Y., Liu, C., Tu, Y., Ye, S., Liu, H., Xie, Y., Qian, H., & Zhu, X. (2018). AIR-Chem: Authentic Intelligent Robotics for Chemistry [Research-article]. *The Journal of Physical Chemistry A*, *122*, 9142–9148. https://doi.org/10.1021/acs.jpca.8b10680

Li, J., Yang, M. A., & Xue, Z. H. (2022). CHEMTrans: Playing an Interactive Board Game of Chemical Reaction Aeroplane Chess. *Journal of Chemical Education*, *99*(2), 1060–1067.

Lu, Y., Xu, Y., & Zhu, X. (2021). Designing and Implementing VR 2 E 2 C, a Virtual Reality Remote Education for Experimental Chemistry System. *Journal of Chemical Education*, 2720–2725. https://doi.org/10.1021/acs.jchemed.1c00439

Luxford, C. J., & Bretz, S. L. (2013). Moving beyond definitions: What student-generated models reveal about their understanding of covalent bonding and ionic bonding. *Chemistry Education Research and Practice*, *14*(2), 214–222. https://doi.org/10.1039/c3rp20154f

Marchak, D., Shvarts-Serebro, I., & Blonder, R. (2021). Teaching Chemistry by a Creative Approach: Adapting a Teachers' Course for Active Remote Learning. *Journal of Chemical Education*, *98*(9), 2809–2819. https://doi.org/10.1021/ACS.JCHEMED.0C01341/SUPPL_FILE/ED0C01341_SI_001.PDF

María, A., Jesús, M., & Javier, F. (2018). Results of the use of Kahoot! gamification tool in a course of Chemistry. *4th International Conference on Higher Education Advances (HEAD'18)*, 1215–1222.

Muchtar, Z., Sari, S. A., Rahmah, S., Zubir, M., Selly, R., & Damanik, M. (2021). The implementation for natural science online lecture with chemistry education base at Nurul Fadhillah school Bandar Setia. *Jurnal Pendidikan Kimia*, *13*(1), 85–93. https://doi.org/10.24114/jpkim.v13i1.24212

Murciano-Calles, J. (2020). Use of Kahoot for Assessment in Chemistry Education: A Comparative Study. *Journal of Chemical Education*, *97*(11), 4209–4213. https://doi.org/10.1021/acs.jchemed.0c00348

Nababan, K., Hastuti, B., & Yunita, N. (2019). Blended learning in high school chemistry to enhance students' metacognitive skills and attitudes towards chemistry : A need analysis. *AIP Conference Proceedings*, *2194*(1), 020068.

Nadelson, L. S., Scaggs, J., Sheffield, C., & McDougal, O. M. (2015). Integration of Video-Based Demonstrations to Prepare Students for the Organic Chemistry Laboratory. *Journal of Science Education and Technology*, *24*(4), 476–483. https://doi.org/10.1007/s10956-014-9535-3

Nahum, T. L., Hofstein, A., Mamlok-Naaman, R., & Bar-Dov, Z. (2004). Can Final Examinations Amplify Students' Misconceptions in Chemistry? *Chem. Educ. Res. Pract.*, *5*(3), 301–325. https://doi.org/10.1039/b4rp90029d

Nahum, T. L., Mamlok-Naaman, R., Hofstein, A., & Taber, K. S. (2010). Teaching and learning the concept of chemical bonding. *Studies in Science Education*, *46*(2), 179–207. https://doi.org/10.1080/03057267.2010.504548

Napitupulu, M., Walanda, D. K., Poba, D., & Pulukadang, S. H. V. (2020). Ace Chemistry Classroom Management with LMS Schoology. *International Journal of Mobile Technology*, *14*(12), 179–185.

Parbuntari, H., & Ikhsan, J. (2014). The Use of Hybrid Multimodal Learning on Chemistry at Senior High School To Improve Students' Motivation. *International Conference On Research, Implementation And Education*

Of Mathematics And Sciences, 18–26.

Pulukuri, S., & Abrams, B. (2020). Incorporating an Online Interactive Video Platform to Optimize Active Learning and Improve Student Accountability through Educational Videos. *Journal of Chemical Education*, *97*(12), 4505–4514. https://doi.org/10.1021/acs.jchemed.0c00855

Putro, T. I., Utomo, S. B., & Indriyanti, N. Y. (2022). High School Students ' Experience Using Learning Management System on Chemistry In Age of Pandemic High School Students ' Experience Using Learning Management System on Chemistry In Age of Pandemic. *Journal of Physics: Conference Series*, *1842*(1), 012024 IOP Publishing. https://doi.org/10.1088/1742-6596/1842/1/012024

Ranga, J. S. (2017). Customized Videos on a YouTube Channel: A Beyond the Classroom Teaching and Learning Platform for General Chemistry Courses. *Journal of Chemical Education*, *94*(7), 867–872.

Rohyami, Y., & Huda, T. (2020). The effect of flipped classroom cooperative learning on learning outcomes in the analytical chemistry course. *AIP Conference Proceedings*, *2229*(1), 020008. https://doi.org/10.1063/5.0002664

Sanga Lamsari Purba, L., Sormin, E., Harefa, N., & Sumiyati, S. (2019). Effectiveness of use of online games kahoot! chemical to improve student learning motivation. *Jurnal Pendidikan Kimia*, *11*(2), 57–66. https://doi.org/10.24114/jpkim.v11i2.14463

Siqueira de Oliveira, J. C., & Nichele, A. G. (2020). Students' Impressions about the use of Facebook as a Learning Management System to Learn Organic Chemistry in English Language. *14th International Technology, Education and Development Conference*, 7375–7381. https://doi.org/doi: 10.21125/inted.2020.1965

Soong, R., Jenne, A., Lysak, D. H., Biswas, R. G., Adamo, A., Kim, K. S., & Simpson, A. (2021). Titrate over the Internet: An Open-Source Remote-Control Titration Unit for All Students. *Journal of Chemical Education*, *98*(3), 1037–1042. https://doi.org/10.1021/acs.jchemed.0c01096

Suherman, D., Warta, W., & Barlian, U. C. (2022). Learning System Management To Improve The Quality Of Learning Chemistry On Students Of State 8 Sma Negeri 8 Bekasi And Taman Students High School Of Bekasi. *International Journal of Educational Research & Social Sciences*, *3*(5), 1927–1934.

Taber, K. S. (2013). Three levels of chemistry educational research. *Chemistry Education Research and Practice*, *14*(2), 151–155. https://doi.org/10.1039/c3rp90003g

Talib, C. A., Aliyu, H., Malik, A. M. A., Siang, K. H., & Ali, M. (2018). Interactive Courseware as an effective strategy to overcome misconceptions in Acid-base Chemistry. *2018 IEEE 10th International Conference on Engineering Education (ICEED)*, 240–245.

Toscanini, M. A., Angelini, A. A. R., Troncoso, M. F., & Curto, L. M. (2021). A mobile device application as a tool that promotes the understanding of protein structure and function relationship. *Journal of Chemical Education*, *98*(5), 1808–1813. https://doi.org/10.1021/acs.jchemed.0c01173

Uyulgan, M. A., Akkuzu, N., & Alpat, Ş. (2014). Assessing the students' understanding related to molecular geometry using a two-tier diagnostic test. *Journal of Baltic Science Education*, *13*(6), 839–855. https://doi.org/10.33225/jbse/14.13.839

Varela, M. M., & Leal, J. P. (2015). Moodle - A way of Teaching Chemistry in the 21st century. *Proceedings of the 5th International Technology, Education and Development Conference (INTED)*, 4064–4066.

Verner, I. M., & Revzin, L. B. (2019). Robotics in School Chemistry Laboratories Robotics in School Chemistry

Laboratories. In *Robotics in education* (pp. 127–136). Springer, Cham. https://doi.org/10.1007/978-3-319-42975-5

Vladušić, R., Bucatb, a R. B., & Ožićc, M. (2016). Understanding ionic bonding – A scan across the Croatian education system. *Royal Society of Chemistry*, *17*(4), 685–699. https://doi.org/10.1039/C6RP00040A

Vygotsky, L. S. (1978). Mind in Society: The Development of Higher Psychological Processes. Harvard University Press

Winkelmann, K., Keeney-kennicutt, W., & Fowler, D. (2017). Learning gains and attitudes of students performing chemistry experiments in an immersive virtual world. *Journal of Chemical Education*, *94*(7), 849−858. https://doi.org/10.1021/acs.jchemed.6b00733

Wolfa, K., Hafferb, S., Geutherc, A., Barthc, H., & Waitz, T. (2012). The Application of Learning Management Systems in Chemistry Teacher Trainees' Practical Courses. *Proceedings of the SPDECE-2012. Ninth Nultidisciplinary Symposium on the Design and Evaluation of Digital Content for Education*, 149–159.

Wright, L., & Oliver-Hoyo, M. (2021). Development and Evaluation of the H NMR MoleculAR Application. *Journal of Chemical Education*, *98*(2), 478–488. https://doi.org/10.1021/acs.jchemed.0c01068

Yang, S., Mei, B., & Yue, X. (2018). Mobile Augmented Reality Assisted Chemical Education: Insights from Elements 4D. *Journal of Chemical Education*, *95*(6), 1060–1062. https://doi.org/10.1021/acs.jchemed.8b00017

Youssef, M. (2022). Assessing the Use of Kahoot! in an Undergraduate General Chemistry Classroom. *Journal of Chemical Education*, *99*(2), 1118–1124. https://doi.org/10.1021/acs.jchemed.1c00799

Zoller, U. (2012). Science education for global sustainability: What is necessary for teaching, learning, and assessment strategies? *Journal of Chemical Education*, *89*(3), 297–300. https://doi.org/10.1021/ed300047v

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Exploring the Impact of Covid-19 on Higher Education in India: A Systematic Review of Online Teaching –Learning and Examination Practices

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Abstract

The Covid-19 pandemic has affected every sphere of the society. The sector of education & especially higher education is not an exception from this. Facing and resolving problems and issues can help us gain competence and knowledge through the learning experience they offer. So the Covid-19 Pandemic also forced us to be empowered with new technologies, which will serve our purpose soon and at present. When it started, all the higher education institutions in India were closed, and the online teaching-learning system commenced. From 2020 to 2022, we were in the crisis of the Pandemic. In between that period, many research reports on online teaching-learning and online examination have been published. Therefore, now the need of the time is to analyze the impact of the Pandemic on teaching-learning & also online examination as it was new for us. So the paper aims to give a comprehensive report of the scenario of online teaching-learning & online examination during Covid-19 in Higher Education in India. The result of the study will be helpful for researchers and education stakeholders to understand the state of the crisis and the measures taken to address it, including the strategies to mitigate the situation.

Keywords: Covid-19, Online teaching-learning, Online examination, Higher education.

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Introduction

Before 2019 all sectors such as education, economy, politics, the overall lifestyle, and ways of the human being and society were ordinary. However, when the Pandemic came, then it made all the ways of doing things abnormal. As it was an infectious disease, all instructions were given to keep social distance. Therefore, according to these conditions the education of the students is very much affected in all levels such as primary, secondary and higher. All institutions worldwide that offer face-to-face instruction have been forced to close because of the COVID-19 pandemic. In the Pandemic, the UGC in India ordered all of its colleges offering conventional courses to offer online courses (Mishra & Mohanty, 2021).

This Pandemic has impacted all facets of society, and the educational system is no exception. In this emergency time all the people of the world, including educationists, scientist thought about what to do and how we can provide education? Then we have only one way to deal with the situation, i.e. technology. We were not completely unknown and not fully competent at that time but we adopted some of the ways of teaching online.

Then all the institutions all over India and abroad followed the online teaching and learning platform. They have also used platform like Google meet, Zoom cloud meeting etc. As we know, our country is a developing country and is now facing problems with technological infrastructure and access to technology, so education during the Pandemic had greatly affected. Hence, the time needs to consider and analyze the techniques we managed the situation and what we experienced by providing online education and examination. So the present paper focuses deeply on the teaching-learning scenario and the examination scenario amid Covid-19 in India by considering the previous published studies of India in various journals. Therefore, the main aims of the study are to find out the effect of the Pandemic on India's higher education system and also what are the effects of the Pandemic on teaching-learning, as well as online examination. Hence, the following research questions were raised by the investigator:

Research Questions

1. What is the impact of Covid-19 on online teaching-learning in terms of its benefits and challenges?
2. What is the impact of Covid-19 on online examination regarding its feasibility and challenges?

Related Studies

Due to Covid-19 Pandemic the whole world faced the challenges related to teaching-learning and examination. Some related researches on the above aspects show how higher education institutions have taken measures to tackle the crisis situation. By reviewing online teaching and learning practices in teacher education from January 2000 and April 2020. Carrillo and Flores (2020) purposed to explore why and how online teaching and learning in teacher education takes place. The review brought attention to the complexity of the online teaching-learning model by talking about concerns with social learning, cognitive learning, and teaching, as well as the necessity for a thorough understanding of the pedagogy of online technology-based education utilised to assist teaching and learning (Carrillo & Flores, 2020).

From the previous literature, Di Pietro et al. (2020) examined how Covid-19's effects on education included the following: learning is anticipated to experience an average setback, the effect on academic performance is likely to vary with socio-economic status, inequality in socio-economic status may manifest as an emotional response because those from less privileged backgrounds may be under more environmental stress; and the widening social gap may persist and have long-term implications (Di Pietro et al., 2020). Studies also show that immediate implementation of online learning has posed many challenges like poor pedagogy, privacy, its effect on students' lives and best practices (Hodges et al., 2020; Harwell, 2020).

Another review study by Bansal and Pruthi (2023) has identified the student engagement strategies in online learning during the Pandemic like "team-based learning, problem-based learning, design your exam, gamified flipped learning etc. Mseleku, (2020) conducted a literature review on "E-Learning and E-Teaching in the Era of Covid-19 Pandemic" and found some challenges like difficulties in adjusting by "lectures, internet connectivity issues, unconducive physical environment, mental health related issues, lack of basic needs, lack of teaching and learning resources". Some opportunities also explored like innovation and capacity building. Additional study like "Learning during COVID-19 pandemic: A systematic literature review" by (Kurnia et al., 2022) explored that education institution was not ready for online education at that time and other problems are poor internet connection as well as infrastructural problems.

A review study on students' motivation, engagement, and acceptance in online learning (Mohtar & Yunus, 2022) found that "the primary factors influencing motivation and acceptance are a sense of ownership and accessibility." Studies focused on online examination by (Mahbub et al., 2022) explored that there are five types of online examinations practices, "remote online delivery and time-limited remote examinations were used most, whereas automated student-centered assessment, interim presentation, and video assessment were used less frequently" as well as fifteen challenges of assessment faced by the stakeholders in online learning like "lack of preparedness, lack of students' interest, challenging online assessment, facilitating cheat, importing marking system, lack of students' mental preparedness, dissatisfactory examination system, and limited time had high frequency. On the other hand, external distraction, family interference, internet issue, item leakage, lack of government preparedness, limited resources, and test anxiety had the least frequency." A study on "Adoption of online proctored examination by university students" (Raman et al., 2021) explored that "relative advantage, compatibility, ease of use, trialability, and observability were found to be positively related to acceptance of OPE."

Montenegro-rueda et al. (2021) conducted a systematic literature review on "Assessment in higher education during Covid-19". They found some challenges & opportunities like lack of training of students and teachers related to the online system of examination, students misconduct during the exam, internet disconnection, power outage, family emergency, and privacy issues. However, on the other hand, it had some benefits, like it promotes motivation of the students, satisfaction, and skills. Another study, "Online Assessment in Higher Education: A Systematic Review, "conducted by (Heil & Ifenthaler, 2023), explores that there are "four main categories of online assessment modes: peer, teacher, automated, and self-assessment. The synthesis of findings supports the assumption that online assessments have promising potential in supporting and improving online learning

processes and outcomes. A summary of success factors for implementing online assessments includes instructional support as well as clear-defined assessment criteria."

The researcher has gone through much-related research on this theme and found that there is a lack of research in terms of online teaching-learning and online examination during the Covid-19 pandemic crisis, which explores its impact regarding its benefits and challenges faced by students and teachers of higher education. This study explores how and in which way students and teachers of higher education in India tackle the Pandemic and which factors affect them during online teaching-learning and online examination. Therefore, this study systematically analyses the existing literature regarding online teaching-learning and online examination and looks into its benefits & challenges with particular reference to the Indian higher education context.

Purpose & Importance

The importance of this article lies in its potential to provide insights into how educators and institutions can adapt to the new realities of online teaching and learning in higher education. With the COVID-19 pandemic forcing a rapid shift to online instruction, many educators and institutions have struggled to deliver quality education and assessment remotely in the world and in India. This article can help educators and institutions better understand their challenges and develop effective strategies for online teaching, learning, and assessment.

This article will benefit many stakeholders, including educators, administrators, policymakers, students, and researchers. Educators and administrators can benefit from the insights provided by this article to develop effective strategies for online teaching-learning & examination, to ensure that students continue to receive a quality education in the face of the Pandemic. Policymakers can use this article to inform their decisions regarding allocating resources and support for online education. Students can benefit from this article by better understanding the challenges faced by their educators, and by learning about the best practices and strategies employed to deliver quality online education. Finally, researchers can use this article to identify gaps in the existing literature and to develop further research on online teaching–learning & online examination during the COVID-19 pandemic in Indian higher education.

Online Teaching-Learning

The high spread of Covid-19 impacted education institutions at all levels, like-primary, secondary, and higher-to close and search for alternate teaching and learning methods (Liguori & Winkler, 2020). While traditional classroom-based instruction is forbidden under COVID-19 regulations, higher education institutions worldwide are urged to experiment with e-learning (Demuyakor, 2020; Ratten, 2020). Most governments have mandated that in-person instruction end immediately, forcing students and educators to quickly switch to online learning and virtual education (Daniel, 2020).

The delivery of educational content via the Internet while facilitating communication between teachers and geographically distant students is known as online teaching (Simonson, Smaldino & Zvacek, 2015, p.34). Online

learning is also related to the concept of e-learning. Online learning is education that occurs partially or wholly online and makes information or knowledge accessible to users regardless of time constraints or proximity to the instructor (Sun et al., 2008).

Online teaching, also known as virtual learning, cyberlearning, and e-Learning, is a type of education in which students are not physically present in a classroom and in which the majority of the instruction and information are delivered via the Internet (Schwirzke et al., 2018; Thoms & Eryilmaz, 2014). In formal post-secondary educational contexts, the use of interactive telecommunications platforms to link students, resources, and instructors has increased the prevalence of online learning (Simonson, 2003, as cited in Simonson et al., 2009). Over the past 20 years, online teaching and learning have developed due to technological improvements, including its ubiquity and flexibility. Its acceptance by several higher education institutions worldwide as well as to a lesser but growing level in the K–12 educational system, is the result of this (Barbour, 2018).

Online learning helps distance education students by using the Internet, computer, and other devices (Sindre & Vegendla, 2015). UNESCO argued that making online learning and evaluation (examinations) available should not be disregarded because tertiary institutions (universities) serve as a training ground for students' intellectual, social, and psychological growth. Online education for higher-education students is a helpful way to advance research and scholarship (Manathunga, 2005). Therefore, during Covid-19, it played a significant role by providing education to all.

Online Examination

One of the critical components of the transition to higher education is student assessment. Giuseppad'Aostino de Cersosimo (2007) states that educational evaluation is viewed as a process intended to confirm the effectiveness and quality of all the components that come together to create the educational event to evaluate this level against reference parameters and make decisions regarding what to do about it. In developed countries, the online examination is efficient as they have better internet accessibility and proctored system functions (Mohammad, 2015; Sunar et al., 2015; Amigud et al., 2017). The development of evaluation mechanisms that are fragmented or disconnected from the teaching modality poses a severe didactic danger because assessment is an essential component of the educational process. When this occurs, evaluation becomes burdensome for learning and assumes a punishing tone that is inconsistent with its original intent (De Vincenzi, 2020).

Online platforms help build collaborative and authentic assessments (McVey, 2016). However, research has emphasized complex assessment issues, including homework and formative evaluation in online education (Amasha et al., 2018; Eichler & Peeples, 2013; Espasa & Meneses, 2010; Tinoca & Oliveira, 2013). Teaching and assessment are very closely intertwined, according to Anderson (1998), who relates teachers' choice of assessment procedures to their teaching-centeredness. More recently, a conceptual framework for assessment in an online setting based on four dimensions—authenticity, consistency, transparency, and practicality—was presented by Pereira et al. (2010, as mentioned in Tinoca & Oliveira, 2013).

To make online assessment effective, teachers must use regular and more assessment techniques (Dipietro et al., 2008). Student diversity and inclusion should be addressed in the online assessment (Barril, 2018; Loertscher & Koechlin, 2013). To improve interaction with the course materials, the online examination must add quizzes and innovative assessment techniques like immediate feedback, peer assessment, self-assessment, portfolio, and projects (Gaytan & McEwen, 2007). Teachers can conduct formative assessments by using the online platforms such as LMSs. Furthermore, prompt feedback is linked to greater student performance and happiness (Espasa & Meneses, 2010). This is essential for teachers to reflect on their online practises and for students to achieve their learning goals (Faber et al., 2017).

Eichler and Peeples (2013) claim that adaptive learning systems—generally called technology that gives students immediate feedback while engaged in a learning activity—have improved student performance. The authors also point out that adaptive systems can differentiate instruction by changing the tempo and degree of difficulty of the work assigned to advanced and challenged students. In contrast, responsive systems include learners in the same set of exercises while giving them feedback, tutorials, or tips. It is encouraging to see that prestigious testing organizations, including the GMAT (Graduate Management Admission Test), TOEFL (Test of English as a Foreign Language), AIMA MAT (All India Management Association Management Aptitude Test), NLAT (National Law Admission Test), and others, have adopted OPE. Online exams that are not proctored are not credible, according to the research by Alessio et al. (2017). As a result, university distance learning programs increasingly use Online Proctored Examinations (OPE) for assessment and evaluation. During the Pandemic, all the higher education institutions conducted the examination online. For some institutions it was new, and they experienced it when fully implementing it. They faced some challenges and also learned technological skills about online examinations.

Method

Design of the Study

In the present study, to find out the results of the above research questions, the investigator has employed the systematic literature review (SLR) method (Abu et al., 2021) by following the PRISMA technique, which includes three essential stages like search, eligibility, data collection and extraction (Moher et al., 2015). The researcher has gone through some systematic stages to conduct this study, like in the first stage, research questions raised by the researcher. In the second phase, the researcher collected the relevant articles which have been published & significant for the current topic. After this, exclusion and inclusion norms were applied to downloaded papers for selection according to the need of the research questions. In the next stage, the result is extracted from selected papers by going through it thoroughly. In the last stage, the extracted results have been synthesized meaningfully in terms of the need for research questions. The following steps comprehensively define the strategy of the present paper.

Framing the Research Questions

The present paper aims to explore the impact of Covid-19 on online teaching-learning & online examination in higher education in India. Therefore, to find this, the following research questions were raised by the researcher:

1. What is the impact of Covid-19 on online teaching-learning in terms of its benefits and challenges?
2. What is the impact of Covid-19 on online examination regarding its feasibility and challenges?

Searching relevant works

In this stage, relevant research articles have been searched by the help of the above research questions and by making keywords from this. Keywords synonymous with the research questions' terms are also included in the search. Google Scholar was used for the searching of relevant articles which has been published between 2020 to 2022 by using the keywords and their variations with Boolean operators like: “Covid-19 OR Pandemic” AND “Impact” OR “Effects” AND “Higher Education” “Online teaching” OR “Online learning” OR “e-learning” OR “Digital learning” OR “Virtual learning” AND “India.” “Covid-19” OR “Pandemic” AND “Online examination” OR “e-assessment” OR “e-exam” OR “e-test” AND “higher education” OR “university education” OR “tertiary education” AND “India” etc. The total number of articles, around 200-300, from the search varied according to the keywords.

Sorting and Selecting the Relevant Studies

From these 200-300 results based on varied keywords, only 20 articles for the online teaching-learning and 09 articles for the online examination have been selected to find the research questions based on the inclusion and exclusion criteria listed below.

Table1. Inclusion and Exclusion Criteria

Criteria	Inclusion	Exclusion
Study type	Empirical	Not empirical
Language	English	Not English
Publication year range	2020 -2022	Before and after the range
Region	India	Outside India
Context	Covid-19	Not Covid-19
Education type	Higher education	Other than higher education
Main focus	Online Teaching-learning & Online examination	Teaching-learning which not include online context

The above inclusion and exclusion criteria have been applied to answer the research questions. The researcher has gone through each article to check its eligibility in terms of the need for the research questions.

Interpreting the Result

The total 20 articles for online teaching-learning and 09 for the online examination have been interpreted by extracting the result. The following Table no 2 reports the review in a comprehensive way about its title, method, and results.

Reporting the Review

Table 2. Impact of Covid-19 on Online Teaching and Learning

Study & Authors	Method	Results
"Students' perception and preference for online education in India during COVID-19 pandemic" (Muthuprasad et al., 2021)	Quantitative	Study revealed that 70% of the respondents are ready for online classes and majority of students favoured to use Smartphone but they faced internet connectivity in rural areas for online classes. Teaching practical subjects in online was difficult for teachers.
"Experiences of teachers on online teaching at higher education level during covid-19 pandemic" (Mishra & Mohanty, 2021)	Quantitative	Found benefits of online classes i.e., reduce course covering time and give students more exposure to "collaborative technology" while also improving their "presentation, communication, and interpersonal skills".
"Impact of Covid-19 and its opportunities and challenges" (Mukharjee & Kuri, 2021)	Quantitative	Found online learning as second alternative but could not achieved cent percent aim of e-learning. Absence of face-to-face classes created some problems like "digital divide, learning gap, lack of digital literacy etc".
"Attitudes of teachers towards virtual teaching" (Kar, 2021)	Quantitative	Revealed attitude towards online teaching is not satisfactory, Male teachers have a more positive attitude than female. Also found that "more experienced teachers show less interest in virtual teaching-learning than less experienced teachers."
"Teachers' perception on online teaching during Covid-19" (Gurung, 2022)	Quantitative	Found that online teaching develops all round efficiency of teachers (technology skills) and also found that

		motivating students in online is very challenging.
"Attitude of undergraduate students on online classes" (Sungjeminla, 2022)	Quantitative	Most students (77%) disliked the online platform of instruction because of "poor mobile network connectivity (79%), electricity outages (81%) and causing eye problems (64%)." But (91.83%) preferred using their Smartphone over other devices to access online courses.
"Challenges faced by B.Ed. Student-teachers in online classes during Covid-19 in Nadia and Murshidabad district of west Bengal" (Mondal & Das, 2022)	Quantitative	Found some challenges i.e., internet connectivity, difficulty in focusing, technological difficulties, problems with time management, and a lack of desire for online classes. Some students were delighted with online classes despite the difficulties they encountered.
"Perception of student teacher on online learning and taking online learning as panacea" (Saha, Bagchi & Bairagya, 2022)	Quantitative	Due to the complete lack of physical interaction with their peers and teachers, students and teachers are feeling lonely. Some people struggle to pay the internet fees required for online programmes because they lack the necessary computer abilities. Positive influences include those who are satisfied with online programmes and have digital abilities. However, more than half of the student teachers have trouble understanding the material when learning online and lack of practical experience as well.
"Pre-service trainee teachers' experiences on computer-mediated learning during the Covid-19 Pandemic" (Roy & Mohaptra, 2022)	Quantitative	About one-third (30.6%) of pre-service trainee instructors were unsure about online classes, while more than one-third (36.6%) said that online classes were a bad method of instruction.

"Self-regulated online learning self-efficacy & Covid-19: a higher education perspective" (Shrama & Chintalapati, 2022)	Quantitative	Students who engage in online self-regulated learning still experience difficulties with task management and goal planning. They find it very challenging to set both short-term and long-term learning objectives. The main challenges students have are their struggles to put their learning strategies into practise, such as taking handwritten notes while learning online, finding it difficult to pay attention, asking questions, and getting immediate answers to their questions.
"Impact of Covid-19 on higher education in India" (Jena, 2020)	Quantitative	Found some impacts i.e., it increased the gap between rich and underprivileged students, for example, by promoting personalised learning, lowering student attendance, reducing national and international student mobility for higher education. Blended learning may take the lead, according to the researcher. It is anticipated that the unemployment rate will rise, etc.
"Challenges and Opportunities for Higher Education amid COVID-19 Pandemic" (Ramola, 2021)	Quantitative	Revealed that it was difficult for all academic staff and students to engage in online teaching and learning. Students frequently grumble, despite the best efforts made by colleges and universities. About 30% of students expressed dissatisfaction over not having internet connection or the proper equipment (Computer/Smartphone) for online learning.
"Impact of Digital Social Media on Indian Higher Education: Alternative Approaches of Online Learning during COVID-19 Pandemic Crisis in online classes" (Dutta, 2020)	Quantitative	Found that adopting social media as an alternate online learning technique is beneficial for over 80% of the study's student participants.

"Impact of Covid-19 on Indian Higher Education in India" (Kantipudi et al., 2021)	Quantitative	Revealed that there is lack of computer, internet facility in village. Some positive as well as negative impacts are: it reduces the effort on international education, passive learning, unprepared teachers for virtual class and low students enrolment and as a result of virtual class there is the rise of blended learning, strengthening of LMS, collaborative teaching and retention of knowledge.
"Online Teaching and Learning of Higher Education in India during COVID-19 Emergency Lockdown" (Naik et al., 2021)	Quantitative	Study revealed that lack of infrastructure, technological tools, and internet access are hurdles in online classes during Covid-19.
"Online Teaching amidst COVID-19 in India: An Outlook" (Joshi, 2020)	Qualitative	When instructing students online, teachers faced a number of challenges, such as a lack of technology resources, family disturbances, a lack of training, a lack of clarity and direction, a lack of technical experience, etc.
"Higher Education in India in the Time of Pandemic" (Roy & Brown, 2022)	Quantitative	Revealed that institutional leadership and readiness are lacking.
"Higher Education in India: Challenges and Opportunities of the COVID-19 Pandemic" (Gope et.al., 2020)	Quantitative	The study found that a hybrid (online and offline) teaching mode is the students' preferred option for weaker or poorer students who lack access to computers or the Internet. 81.4% of students support conducting instruction offline.
"Covid -19 Lockdown-Challenges to Higher Education" (Harsha & Bai, 2020)	Qualitative	The student's internet connectivity was the first problem, strong internet connectivity even in urban areas, problems in teaching practical subjects in online.

"Students' perception towards e-learning and effectiveness of online sessions amid Covid-19 Lockdown Phase in India: An analysis" (Nagar, 2020)	Quantitative	Found smart phones are being used. Some challenges faced by students are internet connectivity, the availability of the right equipment, comfort with technology, and the availability of the necessary infrastructural facilities have been highlighted as the main factors to determine the efficiency of e-learning in India.

Results

The result indicates the above outcome of the total collected reviews related to the online teaching-learning and online examination during Covid-19. All the studies focused on how the students and teachers faced the Covid-19 pandemic and the challenges encountered while shifting the teaching-learning from offline to online mode as well as online examination. Papers are also finding that teachers and students experienced some improvements in their technological skills, which greatly empowered them. Therefore, researchers are naming it as an opportunity to shift teaching-learning and examination modes. The results of this paper are discussed in terms of research questions, which are discussed below. The above literature shows the common essence is the teaching-learning process during Covid-19. The researcher has discussed the result of the first research question below:

1. What is the impact of Covid-19 on online teaching-learning in terms of its benefits and challenges?

a) Impact of Covid-19 on Online teaching-learning

When the covid-19 came and the educational institutions closed, everybody started to think how to run the educational process. Then online classes started as per the UGC's (University Grants Commission) guidelines. As we were novice to the sudden adoption of online mode of education, we faced many problems & challenges with that. It not only led us into a problematic situation, but also empowered us with the new technologies in educational technology. The merits and common problems faced by the teacher & students of higher education in India due to online classes during Covid-19 are as follows:

Merits of Online Teaching-Learning

Let's have focus on the various advantages of the effect of the sudden adoption of online classes.

It Saves Time

Studies show that online teaching-learning saves time regarding course coverage (Mishra & Mohanty 2020). The result of the study revealed that some students have satisfied with online classes as it saves time (Sungjeminla, 2022; Mishra & Mohanty, 2020). With virtual classes, students no longer have to spend hours traveling to attend lectures, which has freed up more time for studying, research, and other important activities. Lectures and other

course materials were available online, and students could access them at any time, from anywhere. This has enabled students to manage their time better and prioritize their work during Covid-19 Pandemic.

Increase Skill of Communication

With online teaching-learning, students have used digital communication tools such as email, chat, video conferencing, and discussion forums to communicate with their peers and teachers. This has helped students to become more proficient in using these tools and communicating effectively in a digital environment (Kantipudi et al. 2021; Sungjeminla, 2022). According to Mishra and Mohanty (2020), students developed their communication skills through online presentations.

Strengthens LMS (Learning Management System)

Higher education institutions as well as students and teachers have been forced to rely more heavily on LMS during the Pandemic, which has led to an increased focus on improving the functionality and features of these systems. LMS has become more integrated with other educational technologies, such as video conferencing platforms, assessment tools, and digital libraries due its huge use during the Pandemic (Kantipudi et al. 2021).

Collaborative Teaching-Learning as well as Personalised Learning

Literature focused that both collaborative and personalised teaching-learning has been taken place during the Pandemic. Online education platforms and Learning Management Systems (LMS) have enabled virtual collaboration tools that allow students and instructors to work together in real-time. These tools include video conferencing, chat, online whiteboards, and collaborative document editing. Through these tools, students could collaborate with their peers and instructors to share knowledge, brainstorm ideas, and complete group assignments during the Pandemic (Kantipudi et al. 2021). By using e-learning materials as well as LMS students studied according to their own pace during the Pandemic (Jena, 2020).

Improvement of Technological Skills

With the shift to online education, students have had to develop digital literacy skills. These skills include basic computer skills, the ability to use different software applications and online tools, and the ability to navigate different online learning platforms. The integration of technology in online education has enabled students to develop skills in the use of various software and applications such as Learning Management Systems (LMS), video conferencing platforms, collaborative tools, and online assessment tools.

As we practically saw that the sudden forced adoption made us empowered, learned and now we are more aware about the E-learning as well as also given the exposure to varieties of materials and also increased the common technology skills. We all know that a circumstance has both the sides such as positive and negative, so the Covid-19 and online teaching-learning has its own pros and cons in the field of higher education.

Problems & Challenges of Online Teaching and Learning

We have seen the above merits experienced by teachers and students of higher education during the Covid-19 Pandemic in teaching and learning. All the studies are giving a relative result which is aligning with each other. They have come up with the problems and the positive impacts of the Pandemic and online teaching-learning in higher education in India.

Digital Divide

One of the most significant challenges of online learning in India is the digital divide, where students from low-income families or rural areas may not have access to the necessary technology, such as laptops or stable internet connectivity, to participate in online classes. This divide has widened the gap in education and further marginalized students who were already at a disadvantage. As study reports that by the effort of both central & state governments we could not achieve 100% e-learning. The absence of offline classes has some effects such as gap among students & digital divide (Mukharjee & Kuri, 2021).

Lack of Motivation among Students

Online learning has resulted in a lack of motivation among some students due to the lack of face-to-face interaction and a sense of isolation. Students may find it challenging to stay motivated and engaged, especially when they were studying from home and are easily distracted by other activities or responsibilities. It is also found that male teachers have favourable attitude than the female towards online teaching, lack of motivation among students & also less concentration also found (Kar, 2021; Sungjeminla, 2022).

Technological Challenges

Online teaching-learning also posed technological challenges during the Pandemic, such as internet connectivity issues, electricity problems, eye problem, lack of digital skills and training , lack of devices such as computers, internet facility, high data consumption at home in villages, high internet charges software compatibility, and limited technical support. (Gurung, 2022; Mondal & Das, 2022: Dutta, 2020; Kantipudi et al. 2021; Joshi 2020; Roy & Brown 2022 & Mishra & Mohanty, 2020). These challenges can hinder the learning process and created frustration among both students and teachers.

Time Management by Students and Teachers

The sudden shift from offline to online mode of teaching-learning affected in time management of both students and teachers in higher education. Online learning requires a significant amount of self-discipline and time management skills from students and teachers. Students could not balance their study time with other responsibilities, such as household chores, while teachers could not manage their online classes, grading, and communication with students (Sungjeminla, 2022).

Lack of Training: Many teachers may not have received adequate training to deliver online classes effectively, which can lead to ineffective teaching practices and a lack of engagement among students (Mishra & Mohanty, 2020).

Passive Learning: Online classes can create a passive learning environment, where students may not actively engage with the content or participate in discussions. This passive learning could hinder the development of critical thinking and problem-solving skills that are essential for a quality education (Roy & Brown 2022). Gope et al. (2020) in his study finds that 84.4 % of students are in support of conducting offline mode of teaching for weaker section students. Reviews in relation to online examination has been reported in the following Table 3.

Table 3. Studies on Online Examination System

Study & Authors	Method	Results
"Experiencing e-assessment during COVID-19" (Kundu & Bej, 2021)	Quantitative	Showed that students' perceptions of e-assessment were generally of a moderate level and that these perceptions varied depending on their gender, academic standing, the type of stream they were studying, and their financial situation. Students performed better in the perceived utility, perceived ease of use, compatibility, subjective norms, and self-efficacy domains of the eight researched areas, but they did poorly in the awareness, resource facilitation, and information technology (IT) support domains. Their comments made it clear that COVID-19 played a key role in increasing their interest in e-assessment.
"Learners' Perspective towards e-Exams during COVID-19 Outbreak: Evidence from Higher Educational Institutions of India and Saudi Arabia" (Khan et al. 2021)	Quantitative	Found that online examination is advantageous, some obstacles faced in online examination were concerning validity , security, and impartiality.
"A survey on Online examination during Covid-19 Pandemic: Perception of Management Students" (Phadke et al.,2020)	Quantitative	Revealed that all pupils are prepared to embrace an online format in the future because students opined that it ensures accuracy, there is very rare chances of fraudulence, saves time, money and energy also.

“Adoption of online proctored examinations by university students during COVID-19: Innovation diffusion study” (Raman et al.,2021)	Quantitative	Found that 55% of students had a favourable opinion of Online Proctored Examination (OPE). According to the findings of our study, the adoption of OPE was favourably correlated with innovation features including relative advantage, compatibility, ease of use, trial-ability, and observe-ability.
“Open Book Examination and Higher Education During COVID-19: Case of University of Delhi” (Ashri & Sahoo,2021)	Quantitative	Revealed that students typically perform better on Open Book Examination than on closed-book exams.
“Experience of Conducting Online Test During COVID-19 Lockdown: A Case Study of NMIMS University” (Idnani et al.,2021)	Qualitative	The results demonstrate that the online computer-based test operates well, and the pupils' overall test scores have improved.
"Online Exams in the Time of COVID-19: Quality Parameters" (Wahid & Farooq, 2020)	Qualitative	Most educators believe it is feasible to evaluate the students in one part after a spoken exam or other type of engagement with the online exam when various assessment methods are employed, objective and subjective questions are combined, and random blocks of one question paper are generated. Interactive, continuous, innovative, and alternative evaluation throughout the semester is another technique to defend students' performance on online tests.
"Post-graduate exams during COVID-19 pandemic” (Gupta, Mohammad, & Kapur,2020)	Qualitative	Found that candidate's experience making a diagnosis without physically inspecting a patient was difficult and unpleasant, and that it is very difficult for the examiner to gauge the student's practical expertise. The main problems are a network problem and improper IT department operation. The researcher added that taking exams online is less stressful.
"A survey on online assessment during COVID 19 pandemic: Perception of Management Students" (Tilak et al.,2020)	Quantitative	Revealed that majority of students think that pre-exam preparations involve more work than traditional exam procedures, especially when using the online examination system. However, the majority also believes that the benefits of online testing exceed the disadvantages. Online testing would not only save time

		but also provide prompt and reliable results.

The process of formal education consists the instructional objectives, teaching-learning, & achievement of the learning outcomes. On the basis of that, examination plays a vital role as it is a part of the measurement and evaluation. Hence, due to this big pandemic crisis, the examination in the entire sector of education also been affected as reported by the various studies in India in the following discussion.

1. What is the impact of Covid-19 on online examination, regarding its feasibility and challenges?

Online Examination during Covid-19 in Higher Education of India

As we know, during Covid-19, we faced some exam problems and challenges. According to the existing studies, the, online exams has both positive and negative impact. The findings from the existing literature have been discussed in the following points.

Moderate Perception of Students

Studies reveal that higher education students have a moderate perception of online exams & also viewed that online exam is more advantageous than conventional exams (Kundu & Bej, 2021). Due to some challenges and personal benefits students have moderate views, in appearing in the exam during the Pandemic.

Essential for Formative Assessment

Another benefit of online assessment, as found by the studies, is that online examination is essential for formative assessment because teachers can use these exams to identify areas where students may be struggling and provide targeted support to help them improve. Additionally, students can receive immediate feedback on their performance, which can help them better understand the material and adjust their studying habits (Khan et al. 2021).

Flexibility

Online examination conducted during the Pandemic was flexible as opined by the students and has authenticity and security also (Khan et al. 2021). It reduces stress of the students also. Online examinations offer greater flexibility than traditional paper-based exams. Students can take the exam from any location with an internet connection, which can be especially beneficial for those who live far from campus or have other scheduling constraints during the Pandemic. Additionally, online exams can be taken at any time, which can be helpful for students who work or have other commitments outside of the institution. It also saves time, money and energy (Phadke et al.,2020).

Better for Pandemic Like Situation

Online examinations have proven to be a valuable tool during the Pandemic. With many schools and universities closed or offering remote learning, online exams have allowed for continuity of learning and assessment. However, online exams eliminate the need for in-person contact, which can help to reduce the spread of the virus at the time of the Pandemic.

Reduce Stress

Online examinations can help to reduce stress among students. Students can take the exam from the comfort of their own homes, which can help to reduce test anxiety. In addition, online exams are typically timed, which can help reduce the stress of having to complete the exam within a specific time frame. Overall, online examinations can be a valuable tool for both students and teachers, offering flexibility, convenience, and increased accuracy in assessment.

Open Book Examination

The open book examination was emphasized and practiced during the pandemic due to its significance. Students also get high marks in open-book exams than in closed-book exams. 55% of students have a positive attitude toward open book exams because of compatibility, ease of use etc. (Ashri & Sahoo, 2021). These are some benefits that higher education students utilised during the Pandemic; it is only one way to tackle that situation. However, the sudden application of the online examination created some problems, and also we faced some challenges, as revealed by the existing literature. Therefore, online examinations have become necessary during the COVID-19 pandemic, as educational institutions have been forced to adapt to remote learning. However, online examinations have also presented several challenges, including:

Network Issue

One of the main challenges of online examinations was network issues. Students have experienced internet connectivity problems or interruptions during the exam, which could cause them to lose precious time or even result in a loss of answers. Similarly, if the exam platform or servers experience network problems, students may lose access to the exam or experience technical issues (Gupta, Mohammad, & Kapur, 2020).

IT Problems

Another challenge is the possibility of IT problems during the examination. This could include issues with the exam platform, software compatibility issues, or technical glitches during the exam. Students may also face challenges with logging in or accessing the exam due to IT-related issues (Tilak et al., 2020).

Poor Invigilation

Another challenge is the issue of poor invigilation during online examinations. It can be challenging for teachers to monitor students and ensure they are not cheating, especially when the exam is being taken remotely. This can lead to questions about the integrity of the examination and the validity of the results. It is challenging for the examiner to gauge the student's practical expertise in online examinations (Tilak et al., 2020).

Affordability

Online examination has posed financial challenges for some students. Not all students may have access to a computer or a stable internet connection at home, which could impact their ability to take the exam due to the digital divide. It is also not suitable for science subjects that have practical examinations (Gupta, Mohammad, & Kapur, 2020).

Infrastructural Facilities

Finally, online examinations may pose infrastructural problems for educational institutions. Educational institutions must ensure they have the necessary infrastructure and resources to conduct online examinations successfully. This includes investing in online examination platforms, training invigilators to conduct online exams, and ensuring that students have the necessary infrastructure to take the exam remotely (Kundu & Bej, 2021).

Overall, online examinations have presented several challenges during the COVID-19 pandemic, including network issues, IT problems, poor invigilation, affordability, and infrastructural problems. Educational institutions need to work towards addressing these challenges to ensure that online examinations are a fair and reliable mode of assessment. However, the Pandemic has allowed us to tackle this type of problem to be more empowered in technological application in education. So overall, we have seen that moderately the online exam is good for the Pandemic, like a situation with various problems. However, we have to strengthen ourselves by giving training learning and improving the infrastructure relating to educational technology.

Discussion

In the present study, students are better managing their time and prioritizing their work during Covid-19 Pandemic. Lectures and other course materials were available online, and students could access them at any time, from anywhere. This result aligned with the study of (Sungjeminla, 2022; Mishra & Mohanty, 2020), who found that students have satisfied with online classes as it saves time. Results found that during covid-19, students have used various communication tools to develop their communication skills. These results aligned with (Kantipudi et al. 2021; Sungjeminla, 2022; Mishra & Mohanty, 2020), who found that students become more proficient in using tools such as email, chat, video conferencing, discussion forums and communicating effectively in a digital environment.

Higher education teachers and students faced challenges like digital divide (not having digital devices), affecting e-learning during Covid-19 (Mukharje & Kury, 2021). Due to the sudden shift of face to face to online classes, students faced many problems that affected their motivation to concentrate on online learning (kar, 2021& Sungjeminla, 2022) and also the result shows that we faced various technological challenges during Covid-19, such as; internet connectivity, electricity, lack of digital skill, training etc. which supported by (Gurung, 2022; Mondal & Das, 2022: Dutta, 2020; Kantipudi et al. 2021; Joshi 2020; Roy & Brown 2022 & Mishra & Mohanty, 2020). Therefore, due to this problem, learning became passive, and also study found that more students are supported by offline classes who are from weaker sections, which result is similar (Roy & Brown, 2022; Gope et al., 2020).

During the Covid-19 situation, higher education institutions adopted online examinations, and we faced both positive and negative impacts. And due to its new adoption, students found to be have moderate perception towards it found by (Kundu & Bej, 2021) & it is also found that online examination is suitable for formative assessment and it is flexible by saving time, money & energy (Khan et al., 2021; Phadke et al., 2020). Open book examination became popular as found by (Ashri &Sahoo, 2021) due to its compatibility. Students and teachers of higher education encounter some challenges in conducting online examinations like, network problem, IT problem, poor invigilation, affordability, lack of infrastructure etc. (Gupta, Mohammad, and Cappor, 2020; Tilak et al., 2020; Kundu and Bej,2021)

Conclusion

This study, “Exploring the Impact of Covid-19 on Higher Education in India: A Systematic Review of Online Teaching–Learning and Examination Practices,” concludes that maximum review studies of India concerning higher education show the negative aspects of online teaching & learning rather than positive. Various studies show that less number of students are in favor of online teaching-learning as it saves time and they have the necessary devices for online classes & accessibility also. Many studies also revealed that redesign the curriculum into a project-based curriculum will make it activity-based. As per the survey result, 38 % of Indian use the internet. So we can assume that we are now struggling to access technology. Also, the literature informs that India's higher education needs to adopt the blended learning format. Some studies reported that the smartphone is more used in conducting the online classes.

During the Pandemic, the online examination was conducted in the Indian higher education context & the overall result shows that the students have positive attitudes towards online exams but, to some extent, have negative attitudes due to the problems mentioned above. Therefore, in India, the covid-19 crisis has very much affected both teaching-learning and examination as it has both positive and negative impacts with more and less. The quality of online teaching-learning and examination is a question mark in higher education in India during Covid-19 like pandemic situation because the Pandemic has dramatically affected the education sector of India. The result of the study will be helpful to for researchers and education stakeholders to understand the state of the crisis and the measures taken to address it, including the strategies to mitigate the situation.

Recommendations

As it is found from the existing literature that in India, we face many problems related to online teaching-learning & examination, like the digital divide, lack of technical training, and internet connectivity, therefore steps need to be taken by government and policymakers to eradicate these challenges through providing different facilities and giving training also. Further research may need to be conducted using more sources to arrive at a better conclusion. The present review has been taken by taking two dimensions, i.e., online teaching-learning and examination. Future research can be undertaken by various dimensions like students' learning experience, academic achievement, academic procrastination etc., during the Pandemic. Future studies can be conducted by taking other aspects of online teaching-learning & examination like teachers' and students' preparedness, job burnout, invigilation, and assessing quality parameters of online teaching-learning & examination. This study is limited to only twenty-nine articles drawn from Google Scholar, but the study can be carried out by taking many articles from different databases.

References

Abu, M., Anissa, T., & Razan, M. B. (2021). Analytical study on the impact of technology in higher education during the age of COVID-19 : Systematic literature review. *Education and Information Technologies*, 6719–6746. https://doi.org/10.1007/s10639-021-10507-1

Alessio, H. M., et al. (2017). Examining the effect of proctoring on online test scores. *Online Learning, 21*(1). https:// doi. org/ 10. 24059/ olj. v21i1. 885.

Amasha, M. A., Abougalala, R. A., Reeves, A. J., & Alkhalaf, S. (2018). Combining online learning & assessment in synchronization form. *Education and Information Technologies, 23*(6), 2517–2529. https://doi.org/10.1007/s10639-01 8-9728-0

Amigud, A., Arnedo-Moreno, J., Daradoumis, T., & Guerrero-Roldan, A. E. (2017). Using learning analytics for preserving academic integrity. *International Review of Research in Open and Distributed Learning, 18*(5), 192-210. https:// doi. org/ 10. 19173/ irrodl. v18i5. 3103.

Anderson, R. S. (1998). Why talk about different ways to grade? The shift from traditional assessment to alternative assessment. *New Directions for Teaching and Learning, 1998*(74), 5–16. https://doi.org/10.1002/tl.7401

Ashri, D., & Sahoo, B. P. (2021). Open Book Examination and Higher Education During COVID-19: Case of University of Delhi. *Journal of Educational Technology Systems, 50*(1), 73–86. https://doi.org/10.1177/0047239521013783

Bansal, R., & Pruthi, N. (2023). A Systematic Literature Review on Student Engagement in Online Learning Amid COVID-19. January. https://doi.org/10.4018/978-1-6684-7639-0.ch011

Barbour, M. K. (2018). A history of K-12 distance, online, and blended learning worldwide. In *Handbook of research on K-12 online and blended learning*, (pp. 21–40). ETC press

Barril, L. (2018). Assessment for culturally inclusive collaborative inquiry-based learning. In *Handbook of distance education*, (pp. 311–320). Routledge.

Carrillo, C., & Flores, M. A. (2020). COVID-19 and teacher education: a literature review of online teaching and learning practices. *European journal of teacher education, 43*(4), 466-487.

Daniel, J. (2020). Education and the COVID-19 Pandemic. *Prospect 49*, 91-96. https://doi.org/10.1007/s11125-020-09464-3

De Vincenzi, A. (2020). Del aula presencial al aula virtual universitaria en contexto de pandemia de COVID-19. Avances de una experiencia universitaria en carreras presenciales adaptadas a la modalidad virtual. *Debate Univ. 8*, 67–71.

Di Pietro, G., Biagi, F., Costa, P., Karpiński, Z., & Mazza, J. (2020). The likely impact of COVID-19 on education: Reflections based on the existing literature and recent international datasets. In publica- tions Office of the European Union, Luxembourg: Vol. EUR, 30275(Issue JRC121071). https:// doi. org/ 10. 2760/ 126686.

Dipietro, M., Ferdig, R. E., Black, E. W., & Preston, M. (2008). Best practices in teaching K-12 online: Lessons learned from Michigan Virtual School teachers. *Journal of Interactive Online Learning, 7*(1), 10–35

Dutta, A. (2020). Education: Alternative approaches of online learning during COVID-19 pandemic crisis. *International Journal of Scientific and Research Publications, 10*(5), 604-611.

Eichler, J. F., & Peeples, J. (2013). Online homework put to the test: A report on the impact of two online learning systems on student performance in general chemistry. *Journal of Chemical Education, 90*(9), 1137–1143.

Espasa, A., & Meneses, J. (2010). Analysing feedback processes in an online teaching and learning environment: An exploratory study. *Higher Education, 59*(3), 277–292. https://doi.org/10.1007/s10734-009-9247-4

Faber, J. M., Luyten, H., & Visscher, A. J. (2017). The effects of a digital formative assessment tool on mathematics achievement and student motivation: Results of a randomized experiment. Computers & Education, 106,83–96.

Gaytan, J., & McEwen, B. C. (2007). Effective online instructional and assessment strategies. *American Journal of Distance Education, 21*(3), 117–132. https://doi. org/10.1080/08923640701341653

Giuseppad'Aostino de Cersosimo (2007). *Aspectos teóricos de la evaluación educacional*. EUNED: San José, Costa Rica.

Gope, P. C., Gope, D., & Gope, A. (2021). Higher Education in India: Challenges and Opportunities of the COVID-19 Pandemic. *Asian Journal of Distance Education, 16*(1), 54-73.

Gupta, V. S., Kapur, M., Naik, M., & Mohammad, A. (2020). Post-graduate exams amidst COVID-19 Pandemic: Our experience. *Indian journal of ophthalmology, 68*(11), 2630–2631.

Gurung, S,. (2022). Study of teachers' perception about online teaching during the covid-19 Pandemic. *The Online Journal of Distance Education & E-learning, 10*(1), 11-18.

Harsa, R & Bai, T. (2020). Covid -19 Lockdown-Challenges to Higher Education. An International Multidisciplinary Double-Blind Peer-reviewed Research Journal, 2(4). Retrieved from https://capecomorinjournal.org.in/Special-issue-view-abstract?Id=82

Harwell, D. (2020). Mass school closures in the wake of the coronavirus are driving a new wave of stu- dent surveillance. Washington Post. Retrieved March 2020, from https:// www. washi ngton post. com/ techn ology/ 2020/ 04/ 01/ online- proct oring- colle ge- exams- coron avirus/

Heil, J., & Ifenthaler, D. (2023). Online Assessment in Higher Education: A Systematic Review. *Online Learning, 27*(1), 187-218. DOI: 10.24059/olj.v27i1.3398

Hodges, C., Moore, S., Lockee, B., Trust, T., & Bond, A. (2020). *The difference between emergency remote teaching and online learning*. Retrieved March 2021, from https:// er. educa use. edu/ artic les/ 2020/3/ the- diffe rence- betwe en- emerg ency- remote- teach ing- and- online- learn ing

Idnani, D., Kubadia, A., Jain, Y., & Churi, P. P. (2021). Experience of Conducting Online Test During COVID-19 Lockdown: A Case Study of NMIMS University. *Int. J. Eng. Pedagog.*, *11*(1), 49-63.

Jena, K. (2021). Impact of Covid-19 on higher education in India. *International Journal of Advanced Education and Research*, *5*(3), 77-81.

Joshi, A., Vinay, M., & Bhaskar, P. (2020). Online Teaching amidst COVID-19 in India: An Outlook. *Asian Journal of Distance Education, 15*(2), 105-111. https://doi.org/10.5281/zenodo.4294477

Kantipudi,. et al. (2021). Impact of Covid-19 on Indian Higher Education. *Library Philosophy and Practice e-journal*, 4991. Retrieved from https://digitalcommons.unl.edu/libphilprac/4991

Kar, S,. (2021). Teachers' attitudes towards virtual teaching during covid-19 Pandemic. *The Online Journal of Distance Education & E- learning, 9(*4), 491-496.

Khan,. et al. (2021).Learners' Perspective towards E-Exams during COVID-19 Outbreak: Evidence from Higher Educational Institutions of India and Saudi Arabia. *International Journal of Environmental Research and Public Health, 18*(12), 6534. Retrieved from https://doi.org/10.3390/ijerph18126534

Kundu, A., & Bej, T. (2021). Experiencing e-assessment during COVID-19: an analysis of Indian students' perception. *Higher Education Evaluation and Development, 15*(2), 114-134. https://doi.org/10.1108/HEED-03-2021-0032

Nasution, A. K. P., Nasution, M. K., Batubara, M. H., & Munandar, I. (2022). Learning during COVID-19 Pandemic: A systematic literature. *Int J Eval & Res Educ, 11*(2), 639-648.

Ibna Seraj, P. M., Chakraborty, R., Mehdi, T., & Roshid, M. M. (2022). A systematic review on pedagogical trends and assessment practices during the COVID-19 pandemic: Teachers' and students' perspectives. *Education Research International*, *2022*, 1-13.

Manathunga, C. (2005). Early warning signs in postgraduate research education: A different approach to ensuring timely completions. *Teaching in Higher Education, 10*(2), 219–33. https:// doi. org/ 10. 1080/ 13562 51042 00033 7963

McVey, M. (2016). Preservice teachers' perception of assessment strategies in online teaching. *Journal of Digital Learning in Teacher Education, 32*(4), 119– 127. https://doi.org/10.1080/21532974.2016.1205460.

Mishara, S,. & Mohanty, A. (2021).Experiences of teachers on online teaching at higher education level during covid-19 Pandemic. *The Online Journal of Distance Education & E-learning, 9*(4), 434-442.

Mishra, L., Gupta, T., & Shree, A. (2020). Online teaching-learning in higher education during lockdown period of COVID-19 pandemic. *International Journal of Educational Research Open*, https://doi.org/10.1016/j.ijedro.2020.100012

Mishra, S., & Mohanty, A. K. (2020). Status of online teaching at higher education level during Covid-19 pandemic. *University News*, *58*(35), Retrieved from https://www.aiu.ac.in/documents/aiu_publications/university_news/university%20news%20vol-58,%20no-35,%20august%2031-september%2006,%202020.pdf

Mohammad, H. (2015). Choice-based credit system in India: Pros and cons. *Journal of Education and Practice, 6(*25), 30-33.

Mohtar, M., & Md Yunus, M. (2022). A systematic review of Online Learning during COVID 19: Students' motivation, Task Engagement and Acceptance. *Arab World English Journal (AWEJ)* 2nd Special Issue on Covid, 19.

Mondal, N. & Das, A. C. (2022). Challenges faced by B.Ed. Student-teachers in online classes during Covid-19 in India and Murshidabad district of West Bengal. *The Online Journal of Distance Education & E-learning, 10*(1) 62-68.

Montenegro-Rueda, M., Luque-de la Rosa, A., Sarasola Sánchez-Serrano, J. L., & Fernández-Cerero, J. (2021). Assessment in higher education during the COVID-19 pandemic: A systematic review. *Sustainability, 13*(19), 10509.

Moore, M. G., & Kearsley, G. (2012). *Distance education: A systems view of online learning* (3rd ed.) Wadsworth.

Mseleku, Z. (2020). A Literature Review of E-Learning and E-Teaching in the Era of Covid-19 Pandemic. *International Journal of Innovative Science and Research Technology, 5*(10), 588-597.

Mukherjee, A., & Kuri, P. K. (2021). Impact of covid-19 on education system in India: challenges, opportunities and task ahead. *The Online Journal of Distance Education & E- learning, 9*(4), 461-470.

Muthuprasad, T., Aiswarya, S., Aditya, K. S., & Jha, G. K. (2021). Students' perception and preference for online education in India during COVID-19 pandemic. *Social Sciences & Humanities Open, 3*(1), 100101.

Nagar, S (2020). *Students' perception towards e-learning and effectiveness of online sessions amid Covid-19 Lockdown Phase in India: An analysis*. Retrieved from https://www.fergusson.edu/upload/document/86850__Dr.ShrutiNagar(IMDR).pdf

Naik, G. L., Deshpande, M., Shivananda, D. C., Ajey, C. P., & Manjunath Patel, G. C. (2021). Online teaching and learning of higher education in India during COVID-19 emergency lockdown. *Pedagogical Research, 6*(1), 1-14

Phadke, D. S. S. D., Hakim, D. S. S. K., Deshmukh, D. M., & Tilak, D. P. (2020). Comparison of Physiotherapy and Management Students' Perception Towards Online Examination Introduced During Covid-19 Pandemic. *International Research Journal of Engineering and Technology* (IRJET) eI SSN, 2395-0056.

Raman, R., Sairam, B., Veena, G., Vachharajani, H., & Nedungadi, P. (2021). Adoption of online proctored examinations by university students during COVID-19: Innovation diffusion study. *Education and Information Technologies, 26*(6), 7339–7358. https://doi.org/10.1007/s10639-021-10581-5

Ramola, R. C. (2021). Challenges and Opportunities for Higher Education amid COVID-19 Pandemic. *International Journal of Computer Engineering in Research Trends. 8*(2), 29-32.

Roy, A., & Mohapatra, A. K. (2021), Pre-service trainee teachers' experiences on computer-mediated learning during the covid-19 Pandemic revealed the need of revamping online pedagogy in India. *The Online Journal of Distance Education & E- learning. 10*(1), 119-133.

Roy, S., & Brown, S. (2022). Higher education in India in the time of pandemic, sans a learning management system. *AERA Open, 8*. https://doi.org/10.1177/23328584211069527

Saha, Bagchi & Bairagya,. (2021). Online learning as a panacea in Pandemic: perception of student-teachers. *The Online Journal of Distance Education & E- learning, 10*(1), 99-112.

Schwirzke, K., Vashaw, L., & Watson, J. (2018). A history of K-12 online and blended instruction in the United States. In Handbook of research on K-12 online and blended learning (pp. 7–20). Pittsburgh: ETC Press.

Sharma, G. S., & Chintalapati, N. (2021), Self-regulated online learning self-efficacy & covid-19: a higher education Perspective, *The Online Journal of Distance Education & E- learning*, *10*(1), 148-161.

Shen, R.; Tang, Y.Y.; Zhang, T.Z. The intelligent assessment system in Web-based distance learning education. In *Proceedings of the Frontiers in Education Conference*, 31st Annual, Reno, NV, USA, 10–13 October 2001.

Simonson, M. R., Smaldino, S., Albright, M., & Zvacek, S. (2009). *Teaching and learning at a distance: Foundations of distance education*, (4th ed.,). Boston: Allyn & Bacon/Pearson.

Simonson, M., Smaldino, S., & Zvacek, S. (2015). *Teaching and learning at a distance: Foundations of distance education* (6th ed.). Information Age Publishing

Sindre, G., & Vegendla, A. (2015). *E-exams and exam process improvement*, in UDIT 2015. Bibsys OJS:Ålesund. 13.

Smith, A. C., Warren, J. M., & Ting, S. M. R. (2018). Developing online learning in the helping professions: Online, blended, and hybrid models. New York: Springer Publishing Company.

Sunar, A. S., Abdullah, N. A., White, S., & Davis, H. C. (2015). Personalisation of MOOCs – The state of the art. In M. Helfert, M. T. Restivo, S. Zvacek, & J. Uhomoibhi (Eds.), *Proceedings of the seventh international conference on computer supported education (CSEDU'15)* (pp. 88–97). Setúbal: Science and Technology Publications.

Sungjeminla, (2022). Attitude of under graduate students towards online classes. *The Online Journal of Distance Education & E-learning*, *10*(1) 57-61. Retrieved from https://tojdel.net/journals/tojdel/articles/v10i01/v10i01-07.pdf

Thoms, B., & Eryilmaz, E. (2014). How media choice affects learner interactions in distance learning classes. *Computers and Education*, *75*, 112–126. https://doi. org/10.1016/j.compedu.2014.02.002

Tilak, P., Deshmukh, M., & Phadake, S. (2020). A survey on online examination during COVID 19 pandemic: Perception of Management Students. *Mukt Shabd Journal*, *9*(8), 285-290.

Tinoca, L., & Oliveira, I. (2013). Formative assessment of teachers in the context of an online learning environment. *Teachers and Teaching*, *19*(2), 214–227. https://doi.org/10.1080/13540602.2013.741836

Vonderwell, S., Liang, X., & Alderman, K. (2007). Asynchronous discussions and assessment in online learning. *Journal of Research on Technology in Education*, *39*(3), 309–328. https://doi.org/10.1080/15391523.2007.10782485.

Wahid, R. & Farooq, O. (2020). Online exams in the time of COVID-19: Quality parameters. *International Journal of Social Sciences and Educational Studies*, *7*(4), 13-21.

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Survey of Corruption and Falling Standard of Education in Tertiary Institutions in Rivers and Anambra States with Impact on Nigeria

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Abstract

All over the world, education is known as the bedrock for socio-economic development, but the reverse seems to be the case in Nigeria. This necessitated the "survey of corruption and falling standard of education in tertiary institutions in Rivers and Anambra States with impact on Nigeria." Two research questions and hypotheses guided the study. A descriptive survey research design was adopted. From the population of 2,500 lecturers, a sample size of 333 was drawn using the Krechie and Morgan Table of 1979. A four-point response options questionnaire validated by three experts was used. The instrument's reliability was established using Cronbach's alpha which yielded alpha coefficients of 0.84 and 0.80. Mean was used to answer the research questions, while one-way analysis of variance (ANOVA) and t-test were used to test the null hypotheses at a 0.05 significance level. Findings and others revealed that the impact of corruption practiced in tertiary institutions in Rivers and Anambra states on Nigeria was very high. Therefore, among other things, it was recommended that the fight against corruption in Nigeria's education system be reinvigorated by (ICPC) and (EFCC).

Keywords: Corruption, Survey of corruption falling standard of education, Tertiary institutions impact on Nigeria.

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Introduction

Education is transmitting and acquiring knowledge, experiences, and skills that positively change individuals and societies. Honesty, selflessness, tolerance, devotion, hard effort, and personal integrity are just a few of the traits and ideologies education encourages at all levels. It provides a favorable environment for raising future leaders who can solve social and economic issues. According to Asian School of India (2018), education is a tool that gives people the knowledge, skills, and capacities to understand their rights and duties to aid in finding solutions to the social and economic problems that their family and nation are now experiencing. According to Ukata (2019), Kingdom and Maekae (2013), education is the only means of arousing people's attention. Therefore, education's major goal is to create sensible, cooperative, enlightened people who follow the rules of the society in which they live.

Additionally, education is the overall process of training, learning specialised abilities, information, behaviours, and morals necessary for a person to be responsible while contributing to social progress by understanding right and wrong, which corruption may be a difficult for (Madaki, 2019). The influence of education on any nation during this time of globalisation cannot be over-looked because it also encourages social and cultural oneness by promoting a concept of societal partnership of awareness (Egbefo & Ibbu, 2012). However, Nigeria, which was among the wealthiest countries in the early 1970s, has declined to be. Due to corrupt practices, education in Nigeria has had significant difficulties (Madaki, 2019). According to Jacob, Josiah, and Solomon (2021), Ahmodu and Sofoluwe, 2018), corruption in the Nigerian education sector primarily takes the form of bribery, embezzlement, money laundering, financial misappropriation, falsification of academic records, non-remittance of tax or money collected, contract inflation, and ghost worker syndrome.

Review of Current Related Studies

Corruption

According to Ahmodu and Sofoluwe (2018), corruption refers to the abuse of public power for personal gain and a wide range of illegal activities, such as bribery, extortion, fraud, nepotism, grafting, and theft, embezzlement, falsifying academic transcripts, kickbacks, and influence peddling. According to the Socio-Economic Rights and Accountability Project, allegations of corruption were made in 2018 regarding the unfair distribution of grades, contract inflation, truncation of staff salaries on the payroll, hiring of unqualified staff, certificate scandal, examination malpractice, sexual harassment, and the issuance of results for expelled students to graduate in several federal universities (Punch 2020). Corruption is defined as "bribery, fraud, and other related offenses" by the Independent and Corrupt Practises Commission (ICPC) (Eshemitan, 2015). The World Bank has noted that when government officials accept. Ahmodu and Sofoluwe (2018) defined corruption as the abuse or exploitation of public power for personal gain, as well as a broad range of illegal behaviours, such as bribery, extortion, fraud, nepotism, grafting, theft, embezzlement, falsifying academic transcripts, kickbacks, and influence peddling. According to the Socio-Economic Rights and Accountability Project, allegations of corruption in several federal universities were made in 2018 regarding the unfair distribution of grades, contract inflation, truncation of staff members' pay on the payroll, employment of unqualified staff, certificate scandal, examination malpractice, sexual

harassment, and the issuance of results for expelled students to graduate. Corruption is defined by the Independent and Corrupt Practises Commission (ICPC) as "bribery, fraud, and other related offences" (Eshemitan, 2015).

According to the World Bank, corruption occurs when public officials knowingly solicit or demand bribes or when private actors actively pay bribes to get around laws and procedures for business or competitive advantage (Anti-Corruption Academy of Nigeria, 2017). The definition of "bribe," according to Chambers 21st Century Dictionary, is "a gift, usually money, offered to someone to induce them to perform an unlawful or improper act."

Bribery

Bribery takes place between the donor and the recipient. It creates a path for the provider to be favored in whatever he or she want, notwithstanding the policies and processes. Whether or not the giver merits it, the bribe recipient must comply with their request (Anti-Corruption Academy of Nigeria, 2017). According to the economic perspective of the Economic and Financial Crimes Commission (EFCC), corruption is defined as nonaggressive illegal and illegitimate behaviours by organizations and individuals that stimulate or produce illegal riches (Oladele, 2019). Corrupt behavior is defined by Transparency International (TI) as "the abuse of public office for private gain." Literally, it refers to unethical and illegal actions, particularly those displayed by those in positions of authority. The following three components—which also entail education—were shown to be present in corrupt public office practises: (1) That the activity must violate a law, rule, regulation, or ethical standard; (2) That it must include abusing the officer's position of authority; and (3) That the reward must be money or anything of value to be measured in money. The development of public administration and the discovery of oil and gas are two significant occurrences that are said to have contributed to the persistent growth in the incidence of corrupt behaviour in Nigerian public offices. Various countries have tried to reduce corruption by passing laws and enforcing integrity systems, but they have had little to no success. 2020 (Wikipedia).

Causes of Corruption in Education

According to Asiyai (2015), the causes of corruption in education include the moral decay of Nigerian culture, they want to become wealthy quick syndrome, a lack of respect for God, poor leadership, and poor management. She continued by noting that the love of money and material wealth in Nigerian society had led to a disregard for education that would foster excellence and character. According to Chinyere and Chukwuma (2017), bureaucratic factors, an excessive focus on certificates, late staff salary payments, environmental factors, moral decadence, poor leadership, materialism, and a disregard for ethical standards and values are all causes of corruption in higher education. Students, professors, non-academic workers, and administrators are all affected by corruption in some way. It is also thought that extravagant behaviour, customs, and attitudes of people contributed to corrupt practises. Tribalism and nepotism are additional core reasons. When friends and family ask for favors from officials, it puts pressure on their ethical character because they perceive government officials as having opportunities for their survival and wealth. Office ethics, especially the oath of office, appear to have been consistently ignored by many people in public office and Nigerian education, or better still, they appear to have been actively rejected (Okoye, 2012). It was a major breach of ethics in the education system to prosecute Prof. Lawrence Adedibu Ojerinde, a

former registrar of the Joint Admission and Matriculation Board (JAMB), along with his three sons and a daughter-in-law on new corruption accusations (Guardian Nigeria, 2023).

Additionally, concerns about corrupt practises in the education sector were raised by the high-profile multi-billion naira financial fraud and employment racketeering incident that rocked the National Board for Arabic and Islamic Studies and featured Prof. Muhammed Shafiu Abdullahi (Sahara Reporters, 2021).

Nigeria was listed as "one of the most corrupt countries in the world" in the Transparency International Corruption Perception Index of 1997, demonstrating the prevalence of corruption in the country (Nwaokugha&Ezeugwu, 2017). Unfortunately, this analysis shows that organised corruption is pervasive and deeply ingrained in the mindset of a major portion of the population, just as Tony Blair, a former British Prime Minister, once referred to Nigeria as being "fantastically corrupt" (Madaki, 2019). Unproductivity is bred through corruption, and the educational system is a stark example. This is demonstrated by the lack of walls, roofs, vacant workshops, outdated teaching materials, cheating on exams, and underpaid teachers in institutions, all of which have a negative impact on the calibre of graduates and the country's educational standards (Madaki, 2019; Egbefo, 2012).

Education Standards

Education standards are the standards that all stakeholders, including teachers, students, policymakers, and the government, are expected to meet. With a focus on the standards of curriculum development and execution, quality of availability and accessibility of teaching facilities, teacher and student achievement, management, and accreditation, this standard relates to the quality of teaching and learning. The quality of education also considers how students perform internally and externally in exams and how the global workplace is developing. According to the study (n.d.), the standard of education assesses students' proficiency using a set of standards, which are detailed expectations for what students should know and be able to perform to demonstrate mastery of a subject. Education standards have been conceptualized from different perspectives including standards in curriculum, teaching, teacher and student achievement, management, accreditation, and others. Similarly, the notion of quality is a multidimensional concept whose interpretation depends on the objectives of the different actors in the process and outcomes of the educational enterprise (Osuafor, n.d.). Teachers Without Borders looked at educational standards or standard of education from how schools' products (learners) can be measured in terms of outcome. That is, how school leavers contribute to the society in terms of cognitive, affective and psychomotor (Tanko, n.d.). So, the totality of these is the measures to know whether the standard of education is rising or failing. The quality of teaching and learning, with a focus on the standards of curriculum development and implementation, the quality of availability and accessibility of facilities for teaching and learning, teacher and student achievement, management and accreditation performances are all indicators of a falling standard of education when they fall short of expectations. The declining quality of education also affects how well students do overall internally and externally, in exams and the evolving global workplace. Due to the declining quality of education, school dropouts make minimal cognitive, emotional, and psychomotor contributions to society (Tanko, n.d.). These factors taken together provide evidence that the quality of education is declining. According to Duze (2011), modernity comes from progress away from the past. However, it requires food from the lower layers. As a result, a primary level

that is clearly "malnourished" will produce a secondary level that is "kwashiokored," which will then lead to a tertiary level that is "masrasmused." Poor funding for education, ineffective execution of educational plans and programmes, and a negative attitude towards schoolwork were the three main causes of the deteriorating standard of education. According to Duze (2011), educational standards are declining at all levels due to inadequate skill acquisition caused by poorly implemented school curriculum, poor availability, and inaccessibility of teaching and learning resources. Other issues include financial theft, inadequate funding, and others at all levels of education, including higher institutions in Rivers state. Nigeria's future appears to be badly impacted by corruption and declining educational standards in terms of learners' low skill acquisition, poor manpower production, breeding unemployed graduates, poverty, crimes, and criminalities.

Effects of Corruption on the Educational Field

According to Athanatius (2021), the overall effects of corruption on the educational field are immense and crippling. According to Suleiman and Aminul Karim (2015), corruption delays investments in private-public partnerships and diverts funds from planned projects to white elephant projects with exorbitant invoices. It also raises operating expenses for schools and distorts public spending. Additionally, it weakens the constancy of funding and grants. Corruption has made it difficult for Nigerian educational institutions to maintain their social, economic, and academic systems as is. According to Suleiman and Aminul Karim (2015), economic and political mismanagement and corruption have all contributed to instability, egregious power abuse, deteriorating infrastructure, inadequate staffing, subpar and failing educational standards, and the disappearance of grants, trust funds, loans, and entire projects without a trace. The gap between the rich and the poor has widened due to corruption in the educational sector. Due to this, a small group of callous individuals and their friends, including foreign collaborators, have gained undue control over Nigerian wealth and resources intended for creating capacity for sustained development (Athanatius, 2021).

Some academics find it simple to label schools as no longer places of learning but rather money-exchange agencies that aid students in passing exams and gaining admission to more prestigious colleges because of corruption in the educational system. According to Onwuka (2019), corruption in a country's political system is a tragedy, and corruption in the educational system is a double tragedy. Because the educational sector has such much potential for initiating change. Additionally, corruption has contributed to the underdevelopment of the educational sector because some ministers, commissioners for education, vice-chancellors, rectors, and provosts launder large sums of money through money laundering while owing staff in their countries several months' worth of areas of salaries and allowances (Athanatius, 2021). The quality of education from primary to tertiary level has been threatened by corruption, which affects teachers, school administrators, parents, students, and all other stakeholders (Ajol, n.d.). Corruption appears to have significantly contributed to Nigeria's declining standard of education. The effects of corruption on public education in Nigeria also include cuts to administrative funding, a lack of infrastructure, a staffing shortage, poor educational quality, systemic waste, increases in administrative costs, stifling of public university development, and a negative perception of public universities abroad (Jacob, Josiah, & Solomon, 2021).

Justification for and Moderating Variable of the Study

The study "Survey of Corruption and falling standard of Education in tertiary institutions in Rivers and Anambra States with Impact on Nigeria " was justified because it exposed the impact of the types of corruption practised in tertiary institutions in Rivers and Anambra states on Nigeria, the causes of those types of corruption practised in the tertiary institutions. Accordingly, even though there is literature related to this study, none of them has the same objectives and moderated variables, making this study a novel direction that will significantly contribute to the body of knowledge. The study's participants are male and female lecturers from state, federal, and state public institutions in Rivers and Anambra States who have varying degrees of education and years of teaching experience. Education level, institution ownership (federal and state), and years of teaching experience are the moderating variables. Federal and state tertiary institutions will own the institution. This is because instructors at federal institutions can be more familiar than those in the state with corruption, a declining educational standard, and how these things affect Nigeria's future. The degree of education a lecturer had acquired at the time of this inquiry is considered a moderating factor for educational attainment.

A National Diploma (ND), Higher National Diploma (HND), Bachelor of Science (B.Sc.), Bachelor of Education (B.Ed.), Master of Science (M.Sc.), Master of Education (M.Ed.), or Doctor of Philosophy (Ph.D.) may be included in this category. Governments at the federal and state levels on the institutes. Corruption may occur in these tertiary institutions in Rivers and Anambra states as the federal and state governments own them. The state institutions are Rivers State University (RSU), Ignatius Ajuru University of Education (IAUE), Odumegwu Ojukwu University, Kensaro Wiwa Polytechnic (KENPOLY), and Captain Elechi Amadi Polytechnic (CEAPOLY). In contrast, the federal institutions are the University of Port Harcourt, Nnamdi Azikiwe University, and Federal College of Education (Technical) Omoku (FCET- Omoku). The researcher chose these factors because they have a good chance of affecting the subject. For instance, a lecturer with a Ph.D. may be more knowledgeable than a lecturer with a Master's or Bachelor's degree in science about corruption, the decline of educational standards, and the effects on Nigeria's future. While lecturers at federal institutions might be more knowledgeable about the topic than those at state tertiary institutions, this could be due to financing, training, or other factors (Ukata and Udeh, 2022). According to Taiwo and Ade-Ajayi (2015), teachers' educational backgrounds can significantly impact perceived variables affecting the efficient teaching and learning of any curriculum. According to Taiwo and Ade-Ajayi (2015), teachers' educational backgrounds can affect their subject-matter knowledge, tool preferences, usage of suitable instructional tactics, and classroom management abilities. According to Top Education Degrees (2020), institutional ownership significantly influences knowing about problems plaguing institutions. This is because compared to state institutions, federal universities may offer better pay plans, educational environments, aids, laboratories, motivation, worker-friendly regulations, compensation, and staff development programmes.

Statement of the Problem

Education all over the world has been regarded as the bedrock for socio-economic development. The foundation of socio-economic growth is widely seen as being education, particularly in developing nations. The destiny of

every country is affected by the rising and lowering of education standards. The worry of losing the advantages of education has increased due to the current state of the country's educational system in Nigeria. Some have suggested that corruption is to blame for the argument that the Nigerian educational system produces unemployed, half-baked graduates, which has harmed the nation's socio-economic progress (Elem, 2019). The issue with this study is that, despite the apparent benefits of education for the growth of human capital, the creation of jobs and wealth, and national development, the future of Nigeria appears to be negatively impacted due to perceived corruption in the educational system. The study "Corruption and Falling Standard of Education in Tertiary Institutions in Rivers State: Impact on the Future of Nigeria" was conducted for this reason.

Purpose of the Study

The purpose of this study was to determine a survey of corruption and falling standard of education in tertiary institutions in Rivers and Anambra States with impact on Nigeria. The specific objectives of this study are to find out:

1. Impact of corruption practiced in tertiary institutions in Rivers and Anambra states in Nigeria.
2. Causes of the types of corruption practiced in tertiary institutions in Rivers and Anambra states

Research Questions

The following two research questions guided the study:

1. How does corruption practice in tertiary institutions in Rivers and Anambra states affect Nigeria?
2. What causes corruption in tertiary institutions in Rivers and Anambra states?

Hypotheses

The following null hypotheses were tested at a 0.05 level of significance

1. There is no significant difference in lecturers' mean ratings on the impacts of the types of corruption practiced in tertiary institutions in Rivers and Anambra states based on (Ph.D., M.Sc. /M.Ed., and B.Sc./B.Ed./HND).
2. Lecturers do not differ significantly in their mean ratings on the causes of corruption practiced in tertiary institutions in Rivers and Anambra states based on institution ownership (federal and state).

Method

Research Design, Population, and Sample Size

The purpose of this study is to investigate corruption and falling standard of education in tertiary institutions in Rivers State: Impact on the future of Nigeria. A descriptive survey research design was adopted. The study population was 2,500 lecturers from the nine public tertiary institutions (five universities, two polytechnics, and two colleges of education) in Rivers and Anambra States. The sample size was 333 using the Krechie and Morgan Table of 1979 for determining the sample of a known population of 2,500.

Instrument and Method of Data Collection

The instrument used for data collection was a self-designed four-point response options questionnaire titled, "Survey of corruption and falling standard of education with impact on Nigeria (SCF- SEIN)." It contains 19 and 21 items in sections 1 and 2 with a scale of very high level (4.50 - 500), high level (3.50 – 4.49), moderate level (2.50 – 3.49), and low level (1.50 – 2.49).

Validity and Reliability of the Instrument

The questionnaire was subjected to face and contents validation by three experts from the Faculty of Education at Nnamdi Azikiwe University, Awka, and Rivers State University. The measure of internal consistency method was used to establish the reliability of the instrument. The instrument was administered to 60 lecturers from the University of Uyo who were not part of the study population. Cronbach's alpha was applied to compute the reliability coefficient, which yielded alpha values of 0.84 and 0.80. These high-reliability coefficient values show that the instrument was reliable.

Administration and Data Collection Process

The researchers personally administered copies of the questionnaire to the respondents in their schools with the assistance of nine research assistants who were adequately briefed on the following modalities. The researchers first visited each tertiary institution and sought consent from the relevant Heads of Department for the study.

After that, the researchers and assistants visited each school and handed over the required number of copies of the instrument to the Heads of the Department to distribute to the lecturers for completion and revisited after five working days to retrieve the completed copies. Two hundred and ninety-five (295) copies of the instrument were correctly filled, retrieved, and used for data analysis.

Data Analysis

The arithmetic means, and standard deviation was used to answer the two research questions and ascertain how homogeneous or heterogeneous the respondents' opinions were relative to the questionnaire items and the aggregated mean. The one-way analysis variance (ANOVA) and independent sample t-test were used to test the two null hypotheses at a 0.05 significance level. The ANOVA was used for null hypothesis 1 because it measured one categorical independent variable with three levels. The independent sample t-test was used to test null hypothesis 2 because it contained one independent variable with only two levels. A null hypothesis was rejected where the calculated significant (Sig.) value (p-value) was greater than or equal to (≥) the alpha value of 0.05. Otherwise, the null hypothesis was not rejected. The data analysis used Statistical Package for Social Sciences (SPSS) version 25.

Results

Research Question 1: How does corruption practice in tertiary institutions in Rivers and Anambra states affect Nigeria?

Table 1. Respondents' mean ratings on the impacts of the types of corruption practiced in tertiary institutions in Rivers and Anambra states in Nigeria

S/N	**Impacts of the types of corruption practiced on the future of Nigeria**	$\bar{X}$	**SD**	**N = 295 Remarks**
1	Falling educational standards at all levels	4.50	0.65	Very high level
2	Poor implementation of school curricula	4.53	0.62	Very high level
3	Inadequate skills acquisition	4.67	0.85	Very high level
4	Poor inadequate/quality of facilities	4.73	0.64	Very high level
5	Poor funding of education,	4.50	0.59	Very high level
6	Poor quality of manpower production,	4.54	0.59	Very high level
7	Unemploybaility graduates breeding,	4.86	0.58	Very high level
8	Poverty	4.73	0.64	Very high level
9	Crimes and criminalities.	4.71	0.58	Very high level
10	White elephant projects heavily over invoiced	4.63	0.60	Very high level
11	Increases the costs of running the schools	4.53	0.62	Very high level
12	Distort public expenditures	4.67	0.85	Very high level
13	Defers private-public partnership investments	4.73	0.64	Very high level
14	Erodes the consistency for grants and funding.	4.50	0.59	Very high level
15	Instability and gross abuse of power,	4.53	0.62	Very high level
16	Decaying infrastructure	4.67	0.85	Very high level
17	Inadequate staffing,	4.73	0.64	Very high level
18	Poor leadership	4.50	0.59	Very high level
19	Wide gulf between the rich and the poor	4.53	0.62	Very high level
20	Concentration funds in hands of few	4.67	0.88	Very high level
21	Underdevelopment of the educational sector,	4.73	0.64	Very high level
	Aggregate Mean	**4.62**		**Very high level**

Table 1 shows that all 21 items on the impacts of the types of corruption practiced in tertiary institutions in Rivers and Anambra states have mean scores ranging from 4.50 to 4.86, which means that the types of corruption practiced in tertiary institutions in Rivers and Anambra states on Nigeria was at very high level. Correspondingly, the aggregate mean score of 4.62 shows that the impact of corruption practiced in tertiary institutions in Rivers and Anambra states on Nigeria was very high. The standard deviations for the 21 listed items ranged from 0.58 to 0.88, which shows that respondents were homogeneous in their opinions.

Research Question 2: What causes corruption in tertiary institutions in Rivers and Anambra states?

Table 2. Respondents' mean ratings on the causes of the types of corruption practiced in tertiary institutions in Rivers and Anambra states

				N = 295
S/N	**Causes of types of corruption practiced education system**	$\bar{X}$	**SD**	**Remarks**
1	Greed	4.50	0.59	Very high level
2	Ostentatious lifestyle	4.54	0.59	Very high level
3	Customs, and people's attitudes	4.86	0.56	Very high level
4	Tribalism and nepotism	4.73	0.64	Very high level
5	Friends and relatives seeking favour	4.71	0.58	Very high level
6	Refused to obey and practice office ethics	4.63	0.60	Very high level
7	Moral decadence of the Nigerian society	4.88	0.58	Very high level
8	Rich quick syndrome	4.73	0.62	Very high level
9	Lack of fear of God	4.50	0.65	Very high level
10	Poor management	4.53	0.62	Very high level
11	Desire to pass examination without hard- work	4.67	0.85	Very high level
12	Nigerian society worship for money and material wealth	4.73	0.64	Very high level
13	Bureaucratic Factors,	4.50	0.59	Very high level
14	Undue Emphasis on Certificates,	4.54	0.59	Very high level
15	Environmental Factors	4.86	0.58	Very high level
16	Failure of Leadership	4.73	0.64	Very high level
17	Deviation from Ethical Principles and Values.	4.71	0.58	Very high level
18	Weak government policies	4.63	0.60	Very high level
19	Low and lack of political will	4.86	0.58	Very high level
	Aggregate Mean	**4.67**		**Very high level**

Table 2 shows that all 19 items on the causes of the types of corruption practiced in tertiary institutions in Rivers and Anambra states have mean scores ranging from 4.50 to 4.88, which means that the causes of the types of corruption practiced in tertiary institutions in Rivers State were at a very high level. Similarly, the aggregate mean score of 4.67, which shows that the causes of the types of corruption practiced in tertiary institutions in Rivers and Anambra state was at a very high level. The standard deviations for the 19 listed items ranged from 0.56 to 0.85, which shows that respondents were homogeneous in their opinions.

Testing of Hypotheses

Table 3. ANOVA summary on significant difference in lecturers' mean ratings on the impacts of the types of corruption practiced in tertiary institutions in Rivers and Anambra states based on educational attainment

Sources of Variance	Sum of Squares	Df	Mean Square	F-cal.	Sig.	Decision
Between Groups	2.458	2	1.529	1.598	.793	Accept H_{O1}
Within Groups	47.357	293	.877			
Total	49.615	295				

Table 3 shows a calculated F-value of 1.59 with a significant (sig.) p-value of 0.79, which is greater than the alpha value of 0.05 (0.79 > 0.05) at degrees of freedom of 2 and 258. Therefore, the null hypothesis (HO3) was accepted. This means there is no significant difference in lecturers' mean ratings on the impacts of corruption practiced in tertiary institutions in Rivers and Anambra states based on educational attainment.

Table 4. The t-test on the causes of the types of corruption practiced in tertiary institutions in Rivers and Anambra states based on institution ownership

Ownership	N	Mean	SD	Df	t-value	Sig.	Decision
State	160	3.96	.99	258	.99	.64	Accept H_{O2}
Federal	100	3.93	.87				

Table 4 shows a calculated t-value of 0.99 with a significant (sig.) p-value of 0.64, which is greater than the alpha value of 0.05 (0.64 > 0.05) at 258 degrees of freedom. Therefore, null hypothesis two was accepted. This means that the lecturers do not differ significantly in their mean ratings on causes of corruption practiced in tertiary institutions in Rivers and Anambra states based on institution ownership.

Discussion

The study's results also revealed that the causes of the various forms of corruption that were prevalent in tertiary institutions in Rivers and Anambra states were at a very high level. The results support Okoye's (2012) assertion that the root causes of corrupt practices are high levels of avarice, extravagant lifestyles, conventions, and attitudes held by people. Accordingly, Asiyai (2015) identified the moral decay of Nigerian society as one of the root causes of corruption in education, along with the get-rich-quick syndrome, a lack of respect for God, poor management, a desire to pass exams without studying hard, worship of money and material possessions, and a disregard for excellence in education.

The causes of corruption in the educational system, according to Chinyere and Godwin (2017), include bureaucratic factors, an excessive emphasis on certificates, the failure to pay staff salaries on time, environmental factors, moral decadence, poor leadership, materialism, and departure from ethical principles and values

(Chukwuma, Okechukwu & Okafor 2014). The study's findings also revealed that, regardless of educational background, instructors' mean judgments of the many types of corruption practiced in tertiary institutions in Rivers and Anambra states are the same. The results support the assertions made by Taiwo and Ade-Ajayi (2015), who found that teachers' educational backgrounds might significantly impact perceived variables affecting the efficient teaching and learning of any curriculum. According to Taiwo and Ade-Ajayi (2015), teachers' educational backgrounds can affect their subject-matter knowledge, tool preferences, use of effective instructional strategies, and classroom management abilities when combined with other factors in the educational environment. The study's findings also revealed that, regardless of the institution's ownership, instructors' mean judgments' of the corruption practiced in tertiary institutions in Rivers and Anambra states do not differ considerably. The study's findings are consistent with those of Top Education Degrees (2020), which asserted that institution ownership plays a significant role in knowing about problems plaguing institutions. This is because, compared to state institutions, federal institutions may offer better staff-management relationships, salary packages, teaching environments, aids, laboratories, motivation, worker-friendly policies, compensation, and staff development programs with better information on current events.

Conclusion

Based on the findings of this study, it was concluded that the impacts of the types of corruption practiced in tertiary institutions in Rivers and Anambra state in Nigeria were at a very high level and that the causes of the types of corruption practiced in tertiary institutions in Rivers and Anambra state was at a very high level. It was further concluded that there is no difference in lecturers' mean ratings on the causes of the types of corruption practiced based on educational attainment and that lecturers do not differ in their mean ratings on causes of the types of corruption practiced based on institution ownership.

Recommendations

In light of the research findings, the following recommendations were developed.

1. The fight against corruption in Nigeria's education system should be reinvigorated by the Independent and Corrupt Practices Commission (ICPC) and the Economic and Financial Crimes Commission (EFCC). Any person or group caught should be adequately punished according to the law.
2. State and federal governments should establish financial monitoring and evaluation committees in the various tertiary institutions to help check spending and corruption.
3. teachers' salary payment should follow international best practices. If the teachers are well paid and on time, it will reduce corrupt practices on the part of the lecturers.
4. Employment of teachers should be on merit. Only qualified teachers should be employed in tertiary institutions to demonstrate competence.
5. The government should provide adequate teaching and learning materials owing any tertiary institutions (state or federal).
6. according to UNESCO recommendation of 26% of yearly budgetary allocation, Nigeria's educational system

should be adequately founded and equipped.

7. Enforcement of rules and regulations/examination ethics should be revived and taken seriously by tertiary institutions.

8. Various levels of Nigerian government and tertiary institutions administrators should display transparency, honesty, probity, accountability, purposefulness, and commitment to the good ideals of the society.

9. There should be a reward system of equitability enough for hard work and adequately compensated and recognized in all facets of our national life.

References

Ahmodu, O. L, & Sofoluwe, A. O. (2018) Combating Corruption in Nigerian Universities through Treasury Single Account Policy. *Research Journal of Business and Economic Management, 1* (2), 1-11.

Ahmodu, O. L., & Sofoluwe, A. O. (2018). Combating corruptionin Nigerian universities through treasury single account policy. *Research Journal of Business and Economic Management, 1*(3), 1-12.

Ajol (n.d.). *Corruption and Falling Standard of Education: Impact on the Future of Nigeria*. Retrieved from https://www.ajol.info/index.php/lwati/article/view/79352#:~:text=Three%20major%20reasons%20found%20were,poor%20attitude%20to%20school%2Dwork on 15 April, 2023.

Anti-Corruption Academy of Nigeria (2017). *Corruption Prevention Training Manual*. Retrieved from https://www.justice.gov/archives/ncfs/page/file/761076/download.

Asian School of India (2018, March 17). *Importance of Education in Life*. Retrieved from https://www.theasianschool.net/blog/importance-of-education/, on September 29, 2021.

Asiyai, R. I. (2015). School Administrators Strategies for Combating Corruptionin Universitiesin Nigeria. *Journal of Education and Learning, 4*(4), 160-167.

Athanatius, I. I. (2021). Corruption and Curriculum Implementation in the Nigerian Educational System: Effects and the Way. *Unizik Journal of Educational Research and Policy Studies, 6,* 278-293.

Chinyere, A. P., & Chukwuma, O. (2017) C*orruption and Administration of Higher Education Institutionsin Nigeria*.

Chukwuemeka, E. E., Okechuku, E., & Okafor, U. B. (2014). Foreign Aid to Nigeria and Domestic Obstacles: A Review of Anambra State Education Sector. *Africa's Public Service Delivery & Performance Review, 2*(2), 52-81.

Chukwuemeka, E. E., Okechuku, E., & Okafor, U. B. (2014). Foreign Aid to Nigeria and Domestic Obstacles: A Review of Anambra State Education Sector. *Africa's Public Service Delivery & Performance Review, 2*(2), 52-81.

Duze, C. O. (2011). Falling Standards of Education in Nigeria: An Empirical Evidence in Delta State of Nigeria. Journal of Contemporary Research, 8(3), 1-12.

Egbefo, D. O., & Ibbu, L. (2012) Corruption in the Nigerian Educational System: It's Implication in Manpower and National Development in the Age of Globalization. *Educationalists Nigeria, 1* (4), 56-63.

Elem, E. O. (2019). Impact of Corruption on Nigerian Educational Sector: Implications for Sustainable Socio-Economic Development. *African Journal of Politics and Administrative Studies, 12(1), 63-75.*

Eshemitan, J. (2015). *How the Media Can Effectively Help Fight Corruption? Independent Newspaper.* Retrieved from http://independent.ng/media-can-effectively-help-fight- corruption.

Federal Way Public School (n.d.). *What is Standards-Based Education*? Retrieved fromhttps://www.fwps.org/domain/807 on 20 April, 2023.

Guardian Nigeria (2023). *Alleged Corruption: Arraignment of JAMB Ex-Registrar, Three Sons, Daughter-In-Law Stalled*. Retrieved from https://guardian.ng/news/alleged-corruption-arraignment-of-jamb-ex-registrar-three-sons-daughter-in-law-stalled/ on the 25th March, 2023.

Ibietan, J., Chidozie, F., & Ujara, E. (2014). Poverty alleviation and the efficacy of development assistance models in Nigeria: An Appraisal. *International Journal of Humanities Social Sciences and Education (IJHSSE), 1*(4), 1-8.

Jacob, O. N., Josiah, H. F., & Solomon, A. T. (2021). Effects of corruption on public universities administration in Nigeria. *Emergent Journal of Educational Discovery and Lifelong*, *2*(7), 5-18.

Kazeem, Y. (2017). *Nigeria's whistle-blower plan to pay citizens to report corruption is off to a great start. Quartz Afric*a. Retrieved from htpp://qz.com/9090 on.

Kingdom, E. O., & Maekae, J. (2013). The Role of Education in National Development: Nigerian experience. *European Scientific Journal, 9*(28), 312 -321.

Madaki, A. K. (2019). The Effect of Corruption on the Educational System in Nigeria. *British Journal of Education, 7*(11), 41-49.

Madaki, A. K. (2019). The Effect of Corruption on the Educational System in Nigeria. British Journal of Education, *7*(11), 41-49.

Ogunode, N. J (2020). Administration of Public Universities in Nigeria: Problems and Solutions. *JournalSinestesia, 10*, (2), 86-96.

Okoye, R. (2012). *"Nigeria has lost $400bn oil revenue to corruption since Independence – Ezekwesili"*. Daily Post Nigeria. Retrieved from https://dailypost.ng/2012/08/31/nigeria-lost-400bn-oil-revenue-corruption-since-independence-ezekwesili/.

Oladele, S. (2019). Corruption in the educational sector in Nigeria. The continuous strike of the Academic Staff Union of Universities. GRIN Verlag.

Onwuka, E. Mary (2019) "Strategies for countering corruption in the Educational System: An Administrative overview". *International Journal of Forum for African Women*, *2*(4), 21-31.

Osuafor, A. (n.d.). *Standard of education in Nigeria: The role of teachers.* Retrieved from https://www.academia.edu/21672409/STANDARD_OF_EDUCATION_IN_NIGERIA_THE_ROLE_OF_TEACHERS.

Punch (2020). *Ending FG/ASUU perennial face-off*. Retrieved from https://punchng.com/ending-fg-asuu-perennial-face-off/

Sahara Reporters (2021). *Exclusive: Multi-Billion Naira Financial Fraud, Job Racketeering Scandal Rocks National Board for Arabic and Islamic Studies*. Retrieved from https://saharareporters.com/2021/06/09/exclusive-multi-billion-naira-financial-fraud-job-racketeering-scandal-rocks-national.

Study, (n.d.). *Standard-Based Education Overview and Importance*. Retried from https://study.com/academy/lesson/standard-based-education-definition-importance.html on 23 April, 2023.

Suleiman, M. N., & Aminul Karim, M. (2015). Cycle of bad governance and corruption: The rise of Boko Haram in Nigeria. *Sage Open, 5*(1), 2158244015576053.

Taiwo, A. E. & Ade-Ajayi, J. (2015). Teacher variables and school effectiveness in Ekiti State, Nigeria. *International Journal of Humanities and Social Science, 5*(7), 95-101.

Top Education Degrees (2020, January 25). *What is educational leadership?* Retrieved from https://www.topeducationdegrees.org/faq/what-is-educational-leadership/retrieved, on May 4, 2023.

Ukata, P. F., & Udeh, C. P. (2022). Utilization of new technologies by business education lecturers for teaching accounting courses in tertiary institutions in Rivers State. *International Journal of Innovative Information Systems & Technology Research 10*(2), 29-38.

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Basic Computing Knowledge of Students with Visual Impairments

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Abstract

This study investigated the computing knowledge of students with visual impairments in a Ghanaian university. Using the case study research design, 103 students were randomly sampled from a population of 118 students with visual impairments. A test instrument was used to collect data for the study. Descriptive statistical methods were used to analyze the data. The results of the study indicated that the participants were knowledgeable in some aspects of basic computer operations, while they were not competent in the use of software. The study concluded that students with visual impairments can gain knowledge and competence in basic computer operations and the use of software and applications if the necessary steps are taken. It was recommended that students with visual impairments should be given access to computers and training by competent ICT professionals who understand the technological needs of students with visual impairments.

Keywords: Covid Basic computing knowledge, Students with disabilities, Visual impairments, Software skills.

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Introduction

Computing knowledge is vital to the education of all individuals, especially those with special needs such as visual impairments. ICT integration in special education is a 21st-century global phenomenon. Article 9 of the UN Convention on the Rights of People with Disabilities (UNCRPD) requires signatories to: (1) “promote access for persons with disabilities to new ICTs and systems, including the Internet” and (2) “promote the design, development, production, and distribution of accessible ICTs and systems at an early stage, so that these technologies and systems become accessible” (Indongo & Mufune, 2011; UNESCO, 2015).

ICT tools have become the most critical resource for educational, social and economic development for students with disabilities. As noted by Hakkarainena et al. (2006), being able to use ICT tools is a prerequisite for human life quality. Thus, knowledge and competencies in the use of ICT is increasingly required for education and employment, as well as for many activities of daily life. The use of ICT in education has transformed teaching and learning (Rather & Kuraishy, 2015) and is projected to improve educational outcomes, quality, and effectiveness (Jaffer, Ng'ambi, & Czerniewicz, 2007). Elder and Koehn (2009) notes that lack of ICT knowledge and skills might impede learning and raise student’s frustration and dissatisfaction. Therefore, students with visual impairments must possess some basic ICT knowledge to succeed in school. For instance, being able to perform basic computer operations and being able to use appropriate computer software and applications are very important for students with visual impairments if they are to overcome educational barriers and succeed in life (Arslantas & Gul, 2022).

Although all students of the University of Education, Winneba, including students with disabilities are given ICT training as part of their education, it appears that the scope of computing knowledge of students with visual impairments in particular is very limited. This seems to be the cause of the averseness of majority of the students with visual impairments to adopt and use ICT for their academic work instead of relying on the traditional braille system. It is in this light that this study sought to investigate the basic computing knowledge of students with visual impairments.

Subdivide text into unnumbered sections, using short, meaningful sub-headings. Please do not use numbered headings. Please limit heading use to three levels. Please use 12-point bold for first-level headings, 10-point bold for second-level headings, and 10-point italics for third -level headings with an initial capital letter for any proper nouns. Leave one blank line (1.5 times spaced) before and after each heading. (Exception: no blank line between consecutive headings.) Please margin all headings to the left.

Literature Review

ICT knowledge is crucial for students with visual impairments to be successful in the ever-changing world of ICT (Teye, 2014). Computers have become a significant tool for broadening educational possibilities for students with visual impairments. ICT knowledge has changed the way students acquire knowledge, facilitated communication, increased access to information, and supported deeper understanding of issues by developing problem-solving

skills (Balavivekanandhan & Arulchelvan, 2015). Using ICT as a tool can broaden the lives and increase the independence of students with visual impairment. Being able to boot a computer, shut it down, create folders, save files, use the mouse effectively, master the keyboard, identify and locate icons on the desktop, would enable students with visual impairments to not rely on their sighted peers to access information that is not in Braille.

Usually, computer use by students with visual impairments is difficult for several reasons (Ampratwum, Offei, & Ntoaduro, 2016), including insufficient knowledge and skills (Bordbar, 2010; Peralta & Costa, 2007) and inadequate prior experience (Askar & Umay, 2001; Ozcelik & Kurt, 2007). A study by Douglas and Long (2003) on behaviors of persons with visual impairments in copy-typing reported that the participants were inefficient in touch-typing and the use of shortcut keys. Teye (2014) also investigated the computer competency of students with disabilities and found out that only 56.5% of the participants had some level of knowledge about computers. It is critical that students with visual impairments acquaint themselves with ICT knowledge to be able to cope with the rate of ICT integration in education and to grab the spreading of educational opportunities in the era of ICT use in the educational system (Vidhya & Meena-Kumari, 2015).

Students with visual impairments use software to enhance their academic and social life. Mishra, Sharma and Tripathi (2010) noted that the integration of persons with disabilities into the school setting and social life in general, may depend on the use of software such as Window-Eyes, JAWS, and NVDA. Knowledge on these systems is therefore crucial for the education of students with visual impairments. Similarly, knowledge on how to use the internet effectively is very important for students with visual impairments (Hafiar, Subekti, & Nugraha, 2019). This is because use of computers and the World Wide Web is increasingly required for education and employment, as well as for many activities of daily life (Chiang, Cole, Gupta, Kaiser & Starren, 2005).

However, while the advent and growth of the internet has improved society in many respects, they can also hinder the progress of students with visual impairments may have significant difficulty processing the visual cues presented by modern graphical user interfaces which are largely deployed on many websites on the internet (Chiang, et al., 2005). A web accessibility study conducted by Hackett and Parmonto (2006) showed that the persons with visual impairments were more satisfied with transformed website that offered alternative means of accessing contents on the internet. It is imperative therefore that students with visual impairments are knowledgeable in internet use to be able to navigate and retrieve important information that are needed for their educational purposes.

Method

Research Design

The case study design was adopted for this study because the study sought to investigate the basic computing knowledge of students with visual impairments. This design guaranteed that firsthand information was obtained through realistic and flexible engagements with the participants (Dampson & Danso-Mensah, 2012).

Sample Size and Sampling Technique

From a population of 118 students with visual impairments, 103 participants were randomly sampled for this study. The random sampling technique was adopted to ensure that pure chance dictated the selection of each participant and that the cases studied were representative of the larger population of interest (Taylor, Bogdan, & De Vault, 2016).

Instrumentation

A dichotomous test instrument, with two response levels (0 = No Knowledge; 1 = Knowledgeable) was developed for the purpose measuring the participants' knowledge in performing specific ICT tasks. The instrument contained 19 tasks which were grouped under two categories – Basic Computer Operations and Use of Software and Applications which forms part of the skillsets that are vital for any person who is to be considered as ICT literate (Apeanti & Essel, 2015; Uimueka, Altuna, & Ateu, 2010).

Validity and Reliability of the Instrument

To ensure validity, the instrument was developed based on specific criteria for assessing ICT literacy (Apeanti & Essel, 2015; Mat-jizat, 2013). Also, expert opinion was sought on the clarity of statements, appropriateness of language, and clarity of directions of the test items from the Department of ICT Education at the University. Suggestions offered by these experts were incorporated into the revision of the instrument.

Also, in ensuring the reliability of the instrument, a pilot test was conducted with a sample of 15 students with visual impairments who were not sampled to participate in the study. The reliability coefficient was calculated to determine the internal consistency of the items in the instrument. A Cronbach's alpha of .971 was obtained, which is greater than the standard value of .800 accepted for social science research (Field, 2009; Hof, 2012). Therefore, the instrument was deemed to be reliable to be used for this study.

Procedure for Data Collection

Permission was sought from the Resource Centre for Students with Special Needs (RCSSN) at the University of Education, Winneba, for the study to be conducted at the Centre. This is because the RCSSN is the most comfortable place for students with visual impairments in the University, and the researchers wanted to conduct the study at the comfort of the participants. Upon receiving the needed approval, the participants were informed about the intention and purpose of the research. The period and duration for the exercise was also agreed upon, after which participants were assured of the confidentiality and anonymity that will be given to any information gathered from them. Furthermore, the nature of the data collection was discussed and agreed upon between the researchers and the participants. The questionnaires were administered personally by the researchers, to help improve the collection and response rate. The items in the questionnaire were explained to the respondents to ensure that they understood what the items sort to find out. Communication among participants was not allowed,

to ensure that the responses of each participant were not affected by the views of others. The questionnaires were collected from the participants as soon as they were completed.

Data Analysis

The data analysis was done in two phases. In the first phase, the questionnaires were labeled serially for easy identification. This was followed by generating and assigning codes to each response option, after which the data was entered into IBM SPSS Software (version 26) for processing and analysis. A frequency table was generated to check for errors such as outliers and missing values in the dataset. The frequency table showed that the data was clean, hence the second phase of the analysis kicked in.

In the second phase, the demographic information was analyzed using frequencies and percentages, and the data on ICT knowledge was also analyzed using frequency, percentage and mean scores. For each test item, a mean score greater than or equal to 0.5 was interpreted as knowledgeable in performing that specific task, while a mean score less than 0.5 was interpreted as not knowledgeable in performing the task. The data was then presented using appropriate tables.

Results

Demographic Information of Participants

The study collected demographic information from the participants. This information included details on age, gender, and the type of visual impairment. Table 1 shows the breakdown of this information.

Table 1. Demographic Information of the Participants

Variable		Frequency	Percentage
Age	Below 20 years	6	6.3%
	20 – 30 years	81	78.4%
	31 – 40 years	16	15.3%
Gender	Male	65	63.1%
	Female	38	36.9%
Type of visual impairment	Low Vision	41	39.6%
	Blind	62	60.4%
Onset of visual impairment	Congenital	35	34.2%
	Adventitious	68	65.8%
Total		103	100.0%

Out of the 103 participants involved in the study, six (6.3%) were below 20 years, 81 (78.4%) were between 20 and 30 years, and the remaining 16 (15.3%) were between 36 and 40 years. Also, the result shows that there were 65 (63.1%) male and 38 (36.9%) female participants. Again, the results revealed that 41 (39.6%) of the participants

had low vision while 62 (60.4%) were blind. Finally, 35 (34.2%) of the participants had congenital visual impairments, while 68 (65.8%) had adventitious visual impairment. This result revealed that most participants were between 20 and 30 years old, which suggested that the participants were fairly young. It also shows that most of the participants were blind males who became visually impaired after birth.

Findings on Computing Knowledge

To determine the computing knowledge of students with visual impairments, the frequency, percentages, and mean scores of the responses were computed. Two areas of computing knowledge were measured. These are '*Basic Computer Operations'* and '*Use of Software and Applications*. The result for knowledge on Basic Computer Operations is presented in Table 2.

Table 2. Knowledge in Basic Computer Operations

Variable	Responses			
Basic Computer Operations	No Knowledge F (%)	Knowledgeable F (%)	Mean	Interpretation
1. Start or boot a computer	31 (30.3)	72 (69.7)	0.70	Knowledgeable
2. Restart a computer.	50 (48.5)	53 (51.5)	0.52	Knowledgeable
3. Shut down a computer.	44 (42.4)	59 (57.6)	0.58	Knowledgeable
4. Use the keyboard to scroll through a document.	37 (36.4)	66 (63.6)	0.64	Knowledgeable
5. Insert and eject removable drives from USB Ports.	47 (45.5)	56 (54.5)	0.55	Knowledgeable
6. Scan removable drives for viruses.	69 (67.4)	34 (32.6)	0.45	Not Knowledgeable
7. Format a removable drive (pen drive).	78 (75.8)	25 (24.2)	0.24	Not Knowledgeable
8. Determine the storage capacity of a drive.	81 (78.8)	22 (21.2)	0.21	Not Knowledgeable
9. Create and name files and folders.	78 (75.8)	25 (24.2)	0.24	Not Knowledgeable
10. Access files from different storage locations on a computer.	50 (48.5)	53 (51.5)	0.52	Knowledgeable
11. Delete files from a computer.	50 (48.5)	53 (51.5)	0.52	Knowledgeable

From the results in Table 2, 69.7% of the participants were knowledgeable in starting or booting a computer. Also,

with respect to knowledge on restarting a computer, 51.5% of the participants reported that they were knowledgeable. Again, 57.6% of the participants were knowledgeable in shutting down a computer. Also, on the use of the keyboard to scroll through a document, and the ability to insert and eject removable drives from USB ports, it was revealed that 63.6% and 54.5% of the participants were knowledgeable respectively. Again, it emerged that 51.5% of the participants are knowledgeable in accessing files from storage locations and deleting files from computers.

However, the results showed that majority of the participants were not knowledgeable in scanning removable drives for viruses (67.4%), as well as formatting a removable drive (75.8%). Also, 78.8% of the participants indicated that they were not knowledgeable in determining a drive's storage capacity, while 75.8% of participants lacked knowledge in creating and naming files and folders. In summary, the findings from Table 2 suggest that, the majority of participants were knowledgeable in many of the activities that were categorized under Basic Computer Operations. Still further, the result for knowledge in the Use of Software and Applications is presented in Table 3.

Table 3. Knowledge in the Use of Software and Applications

Variable	Responses			
Use of Software and Applications	No Knowledge F (%)	Knowledgeable F (%)	Mean	Interpretation
1. Install new software on a computer.	81 (78.8)	22 (21.2)	0.21	Not Knowledgeable
2. Use software such as JAWS or NVDA on a computer.	50 (48.5)	53 (51.5)	0.52	Knowledgeable
3. Update software to current version.	84 (81.8)	19 (18.2)	0.18	Not Knowledgeable
4. Playing music and video with a computer.	50 (48.5)	53 (51.5)	0.52	Knowledgeable
5. Create backup copies of a document.	66 (63.6)	37 (36.4)	0.36	Not Knowledgeable
6. Open and switch between more than one application at a time.	62 (60.6)	41 (39.4)	0.39	Not Knowledgeable
7. Use a computer software to record audio files.	69 (66.7)	34 (33.3)	0.33	Not Knowledgeable
8. Play audio files after recording.	41 (39.4)	62 (60.6)	0.61	Knowledgeable

Table 3 shows the result of the analysis on knowledge in the use of software and applications. It emerged from the results that majority of the participants were only knowledgeable in three out of the eight activities. These include the use of software such as JAWS or NVDA, where 51.5% of the participants were knowledgeable, compared to 48.5% were not knowledgeable; playing music and video with a computer, also with 51.5% of the participants being knowledgeable, compared to 48.5% who were not knowledgeable; and playing audio files after recording, which had 60.6% of the participants indicating that they were knowledgeable, while the remaining 39.4% indicated that they were not knowledgeable in using software and applications.

On the other hand, the results on the remaining five activities showed that majority of the participants were not knowledgeable in these activities. The results showed that 78.8% of the participants were not knowledgeable about installing new computer software. Also, 81.8% of the participants were not knowledgeable in updating computer software to its current version, while 63.6% of the participants were found not to be knowledgeable in creating backup copies of documents. Again, with respect to opening and switching between more than one application at a time and using computer software to record audio files, the results indicated that the majority of the participants (60.6% and 66.7%, respectively) were not knowledgeable.

Discussion

Knowledge in Basic Computer Operations

The results on Basic Computer Operations point to the fact that most participants are knowledgeable in tasks such as booting, restarting, and shutting down computers, using the keyboard for scrolling, and inserting and ejecting USB drives from ports. Also, most of the participants were knowledgeable in accessing files from different storage locations and deleting files from a computer.

The results agree with the viewpoint of Simsek, Altun and Ates (2010) who noted that students with visual impairments had no difficulty booting and shutting down computers and opening a specified folder. It also affirms De Wit, Heerwegh, and Verhoeven's (2012) position that in order for students with visual impairments to survive in higher education, they must seriously acquire the basic competencies of being able to operate computers, including ability to boot and shut down computers, and master the keyboard. It is therefore necessary for teachers of students with visual impairments to concentrate on the basic skills that are needed to boost computer use among students with visual impairments. This targeted concentration on required skills is critical for the envisaged growth in computer adoption and use by students with visual impairments. Also, an ICT curriculum must be developed for students with visual impairments, with specific arrangements made for ICT teacher training programs that will equip them to effectively teach these skills.

Overall, the findings corroborate the results of Hozmi's (2008) study which found that students with various disabilities, including deaf-blindness, visual impairments and hearing impairments had some knowledge in some specific areas of ICT, whiles they lack knowledge in other areas of ICT competence.

Knowledge in the Use of Software and Applications

The responses from participants in relation to their knowledge in the use of software and applications revealed that majority of the participants were knowledgeable in the use of software such as JAWS or NVDA. Also, majority of the participants were knowledgeable in playing music and video with a computer, as well as playing audio files after recording. This agrees with the findings of Eligi and Mwantimwa (2017) which indicated that most students with visual impairments were knowledgeable in accessing audio recordings using software such as JAWS and NVDA installed on computers.

Conversely, the results showed that majority of the participants were not knowledgeable in installing new software on a computer or updating software to current versions. This validates the views of Simsek, Altun and Ates (2010) who reported that students with visual impairments had difficulties in installing computer programs. Also, it was found that majority of the participants were not knowledgeable in creating backup copies of documents. This may suggest that most of the participants do not back up their files, confirming the observation by Romaniuk (2015) that students are not accustomed to backing up their data or protecting them more efficiently. Overall, it emerged that most students with visual impairments lacked knowledge in computer software and applications.

It is important that the training offered to students with disabilities in the use of computers are designed to encompass a comprehensive software and application skills set that is relevant and tailor-made to meet the needs of students with disabilities. This will ensure that data loss, including the loss of audio recordings and other educational resources, is significantly minimized. In sum, deliberate attention must be paid to training students with visual impairments in creating multiple copies of their educational resources for easy retrieval and use in times of need.

Conclusion

Particularly for students with visual impairments, knowledge in basic computing is essential for educational achievement. Whereas the findings of this study suggest that students with visual impairments have basic knowledge in computer operations, it also reveals their lack of basic skills in the use of software and applications. These basic skills are essential for the daily use of computers and mobile technologies, and therefore purposeful measures must be put in place for these students to build their knowledge in computing through appropriate regular training schemes.

Recommendations

Based on the results of the study, the researchers made some recommendations for implementation. Firstly, it is recommended that students with visual impairments be taught some basic ICT skills to enable them to gain and improve upon their ICT knowledge and competencies. This would go a long way to reduce their dependence on colleagues for all ICT-related activities such as accessing learning materials online, printing documents, and sending emails. Secondly, it is recommended that competent ICT professionals with proficiency in Assistive

Technology should be employed to teach ICT and take charge of the technology needs of students with visual impairments. This would create an opportunity for the students with visual impairments to have access to personnel who have the understanding and ability to assist them with their ICT-related needs to help them acquire the requisite ICT competencies.

References

Abubakar, B. M., & Hassan, B. B. (2010). Incorporating Information Technology in Library and Information Science curriculum in Nigeria: A strategy for survival in the 21st century. *Library Philosophy and Practice*, (ISSN 1522-0222).

Ademodi, D. T., & Adepoju, E. O. (2009). Computer skill among librarians in academic libraries in Ondo and Ekiti states, Nigeria. *Library Philosophy and Practice*, (ISSN 1522-0222).

Albion, P. R. (2007). *Student teachers' confidence and competence for finding information on the Internet.* Retrieved on June 1, 2017, from http://eprints.usq.edu.au/2099/1/infolit.pdf.

Ampratwum, J., Offei, Y.N., & Ntoaduro, A. (2016). Barriers to the use of computer assistive technology among students with visual impairment in Ghana: The case of Akropong school for the blind. *Journal of Education and Practice*, *7*(29), 58-61.

Apeanti, W. O., & Essel, D. D. (2015). *Introduction to ICT (4th Ed)*. Kumasi: Fresh Publications

Arslantas, T. K., & Gul, A. (2022). Digital literacy skills of university students with visual impairment: A mixed-methods analysis. *Education and Information Technologies*, 27, 5605–5625.

Askar, P., & Umay, A. (2001). Perceived computer self-efficacy of the students in the elementary mathematics teaching program. *Hacettepe University Journal of Education*, *33*(21), 1- 8.

Association of College & Research Libraries, (2005). *Information literacy competency standards for higher education*. Chicago: American Library Association.

Avoke, M. (2005). *Special educational needs in Ghana: Policy, practice and research.* Winneba: Special Educational Books.

Balavivekanandhan, A. & Arulchelvan, S. (2015). A study on students' acquisition of IT knowledge and its implication on m-learning. Retrieved from https://doi.org/10.1155/2015/248760

Bayer, N. L. & Pappas. L. (2006) Case history of blind testers of enterprise software. *In Technical Communication*, *53*(1), 32-35.

Bhattacharya, I. & Sharma, K. (2007). India in the knowledge economy – an electronic paradigm. *International Journal of Educational Management*, *21*(6), 543-568.

Bordbar, F. (2010). English teachers' attitudes toward computer-assisted language learning. *International Journal of Language Studies*, *4*(3), 27-54.

Bransford, J. D., Brown, A. L., & Cocking, R. R. (2000). *How people learn: Brain, mind, experience, and school.* Washington, D.C.: National Research Council.

Buabeng-Andoh, C. (2012). Factors influencing teachers' adoption and integration of information and communication technology into teaching: A review of the literature. *International Journal of Education and Development using Information and Communication Technology*, *8*(1), 136-155.

Callinan, J. E. (2005). Information-seeking behaviour of undergraduate biology students: A comparative analysis

of first year and final year students in University College, Dublin. *Library Review*, *54*(2), 86–99.

Chandra, S. & Patkar, V. (2007). ICTS: A catalyst for enriching the learning process and library services in India. *The International Information & Library Review*, *39*(1), 1-11.

Chiang, M., Cole, R., Gupta, S., Kaiser, G., & Starren, J. (2005). Computer and World Wide Web accessibility by visually disabled patients: problems and solutions. *Survey of Ophthalmology*, *50*(4), 394-405.

Cross, M. & Adam, F. (2007). ICT policies and strategies in Higher Education in South Africa: National and Institutional Pathways. *Higher Education Policy*, *20*(1), 73-95.

Dampson, G. D. & Danso Mensah, D. K. (2012). *A practical guide to action and case study research.* Amokom-Kumasi. Payless Publication Ltd.

Danner, R. B., & Pessu, C. O. A. (2013). A Survey of ICT Competencies among Students in Teacher Preparation Programmes at the University of Benin, Benin City, Nigeria. *Journal of Information Technology Education: Research, 12*, 33–49.

Davis, P. (1999). How undergraduates learn computer skills: Results of a survey and focus group. *THE Journal, 26*(9). Retrieved on June 15, 2017, from http://www.thejournal.com/articles/14120_3.

De Wit, K., Heerwegh, D., & Verhoeven, J. C (2012). Do ICT competences support educational attainment at university? *Journal of Information Technology Education: Research*, *11*, 1–25.

Diso, L. I., & Njoku, I. F. (2007). Library and Information Science Education in Nigeria: Curriculum Contents versus Cultural Realities. *International Information and Library Review*, *39*(2), 121-133.

Douglas, G. & Long, R. (2003). An observation of adults with visual impairments carrying out copy-typing tasks. *Behaviour & IT 22*(3), 141-153.

Edwards, V. E., Portman, T. A. A., & Bethea, J. (2012). Counseling students' computer competency skills: effect of technology course in training. *Journal of Technology in Counseling*, *2*(2). Retrieved on November 20, 2022 from http://jtc.columbusstate.edu/vol2_2/edwards.htm.

Elder, B., L., & Koehn, M. L. (2009). Assessment tool for nursing student computer competencies, *Nursing Education Perspectives*, *30*(3), 148-152.

Eligi, I., & Mwantimwa, K. (2017). ICT accessibility and usability to support learning of visually-impaired students in Tanzania. *International Journal of Education and Development using Information and Communication Technology, 13*(2), 87-102.

Ely, D. P. (1999). Conditions that facilitate the implementation of education technology innovations. Educational Technology, 39(6), 23-27.

Frempong, G. (2011). Developing information society in Ghana: How far? *The Electronic Journal of Information systems in Developing Countries, 47*(8), 1–20.

Hackett, S., & Parmanto, B. (2006). Usability of Access for Web Site Accessibility. *Journal of Visual Impairment and Blindness*, *100*(3), 173-181.

Hafiar, H., Subekti, P., & Nugraha, A. R. (2019). Internet utilization by the students with visual impairment disabilities. *International Journal of Emerging Technologies in Learning, 14*(10), 200-207.

Hakkarainena, K., Ilomaki, L., Lipponena, L., Muukkonena, H., Rahikainenb, M., Tuominena, T., et al. (2006). The disability divide in internet access and use. *Information, Communication & Society*, *9*(3), 313-334.

Hasselbring, T. S., & Glaser, C. H. W. (2000). Use of Computer Technology to Help Students with Special Needs. *Children and Computer Technology*, *10*(2), 102-122

Indongo, N., & Mufune, P. (2011). ICT barriers for people with disabilities in Namibia: Evidence from the 2011 Namibia population and housing census. *Review of Disability Studies: An International Journal,* 11(1), 51-67.

Itsekor, V. O. & Ugwunna, I. S. (2014). ICT competencies in the 21st century library profession: a departure from the past. *International Journal of Academic Library and Information Science*, *2*(5), 51-57.

Jaffer, S., Ng'ambi, D., & Czerniewicz, L. (2007). The role of ICTs in higher education in South Africa: One strategy for addressing teaching and learning challenges. *International Journal of Education and Development using ICT* [Online], *3*(4), 131-142.

Jones, R. (2004). Teaching Internet skills to pupils with a severe visual impairment. *British Journal of Visual Impairment*, *22*(3), 84-88.

Kaminski, K., Seel, P., & Cullen, K. (2003). Technology literate students? Results from a survey. *Educause Quarterly*, *26*(3), 34-40.

Khalid, F., Nawawi, M. H., & Roslan, S. (2009). Integration of ICT in Malaysian secondary schools: What conditions will facilitate its use? *The International Journal of Learning*, *15*(12), 85-93.

Lancioni, G. E., N. N. Singh, et al. (2007). Microswitch technology to promote adaptive responses and reduce mouthing in two children with multiple disabilities. *Journal of Visual Impairment and Blindness 101*(10), 628–636.

Majid, S., & Abazova, A. F. (1999). Computer literacy and use of electronic information sources by academics: A case study of International Islamic University, Malaysia. *Asian libraries*, *8*(4), 100–111.

Manir, A. K. (2011). ICT competency framework for library and information science in schools in Nigeria: The need for model curriculum. *International Journal of Library and Information Science*, *3*(4), 68-80.

Masood, S., Khan R. A., & Waheed, G. (2010). Computer literacy among the medical staff at Avicenna Medical College and Hospital. Retrieved on November 22, 2022, from http://pjmhsonline.com/computer_literacy_among_the_medi.htm.

Mat-jizat, J. E. (2013). Developing an ICT-literacy task-based assessment instrument: The findings on the final testing phase. Retrieved from https://files.eric.ed.gov/fulltext/ED562271.pdf

Megnigbeto, E. (2007). LIS curriculum in French-speaking West Africa in the age of ICTs: The case of Benin and Senegal. *International Information and Library Review*, *39*(2), 158–165.

Mioduser, D., Tur-Kaspa, H., & Leitner, I. (2000). The learning value of computer-based instruction of early skills. *Journal of Computer Assisted Learning, 16*, 54–63.

Mishra, M. P., Sharma, V. K., & Tripathi, R. (2010). ICT as a Tool for Teaching and Learning in Respect of Learner with Disability. *Indira Gandhi National Open University, New Delhi, India.*

Mooij, T. (2007). Design of educational and ICT conditions to integrate differences in learning: Contextual learning theory and a first transformation step in early education. *Computers in Human Behaviour*, *23*(3), 1499-1530.

Nwachuku, V. N. (2004). Computer skill competencies among academic librarians: An imperative for the computerization of Nigerian university libraries. *The Nigerian Library Link. 3*(1&2), 97–106.

Ochogwu, M. G. (2009). *Educating library and information science professionals to bring library service to all*, Paper presented at the NALISE conference held at the University of Nigeria, Nsukka. June 2-5, 2009.

Oliver, R. (2000). Information and communications technology literacy: Getting serious about IT. *Proceedings of*

ED-MEDIA 2000. AACE, Montréal, Canada, June 26 - July 1, 2000.

Oyeronke, A., & Fagbohun, M. (2013). An assessment of computer and ICT skills among secondary school teachers in Ota Ogun State. *Library Philosophy and Practice (e-journal).* Paper 846. Retrieved on June 23, 2017, from http://digitalcommons.unl.edu/cgi/viewcontent.cgi?article=2193&context=libphilprac.

Ozcelik, H., & Kurt, A. A. (2007). Primary school teachers' computer self-efficacies: Sample of Balikesir, *Elementary Education Online, 6*(3), 441-451.

Ozoemelem, O. A. (2010). Web affinity: A study of undergraduate students in Nigerian universities. *Library Philosophy and Practice [e-journal]*. Retrieved on November 23, 2022 from http://www.webpages.uidaho.edu/~mbolin/obuh2.htm

Peralta, H., & Costa, F. A. (2007). Teachers' competence and confidence regarding the use of ICT. *Educational Sciences Journal, 3*, 75-84.

Peterson, S. L., & Palmer, L. B. (2011). Technology confidence, competence and problem-solving strategies: Differences within online and face-to-face formats. *Computers & Education, 57*(1), 1138-1148. doi:10.1016/j.compedu.2011.02.002

Preston, C., Cox, M., & Cox, K. (2000). Teachers as innovators: an evaluation of the motivation of teachers to use Information and Communications Technology. London: Teacher Training Agency/MirandaNet Publishers Ltd.

Rather, S. A. & Kuraishy, S. (2015). Assimilation of information and communication technology (ICT) in education for improving teaching-learning processes: A critical review of literature. *Reviews of Literature, 2*(6), 1-11.

Ren, W. H. (1999). Self-efficacy and the search for government information: A study of small-business executives. *Reference and User Services Quarterly, 38*(32), 283–291.

Romaniuk, M. W. (2015). Digital competences of Maria Grzegorzewska Academy of Special Education students – Method and results of a survey. *International Journal of Electronics and Telecommunications, 61*(3), 267-272.

Sales, A. S., Evans, S., Musgrove, N., & Homfray, R. (2006). Full-screen magnification on a budget: Using a hardware-based multi-display graphics card as a screen-magnifier. *The British Journal of Visual Impairment*, 7(2), 432.

Samuel, R. J. & Zaitun, A. B. (2005). *English language content management system*: International Arab Conference on Information Technology (ACIT'2005) - Al-Isra Private University Jordan, 6th- 8th, December 2005.

Sanyal, B. C. (2001). New functions of higher education and ICT to achieve education for all. Paris: *UNESCO International Institute for Educational Planning*. Retrieved on October 27, 2022, from http://bern.library.nenu.edu.cn/upload/soft/0-article/030/30020.pdf.

Shelstad, K. R., & Clevenger, F. W. (1996). Information retrieval patterns and needs among practicing general surgeons: A statewide experience. *Bulletin the Medical Library Association, 84*(4), 490–497.

Simsek, O., Altun, E., & Ates, A. (2010). Developing ICT skills of visually impaired learners. *Procedia Social and Behavioral Sciences, 2*, 4655–4661.

Singh, R. (2012). Blind Handicapped Vs. Technology: How do Blind People use Computers? *International Journal of Scientific & Engineering Research, 3(4),* 1-7.

Tasir, Z., Abour, K., Halim, N., & Harun, J. (2012). Relationship between teachers' ICT competency, confidence level, and satisfaction toward ICT training programmes: A case study among postgraduate students. *The Turkish Online Journal of Educational Technology, 11*(1), 138-144.

Taylor, S. J., Bogdan, R., & De Vault, M. (2016). *Introduction to qualitative research methods: A guidebook and resource*. New Jersey, USA: John Wiley & Sons.

Tella, A., & Mutula, S. M. (2008). Gender differences in computer literacy among undergraduate students at the University of Botswana: Implications for library use. *Malaysian Journal of Library & Information Science, 13*(3), 59-76.

Teye, E. Q. (2014). Computer competencies of students with disabilities in the University of Education, Winneba. *Unpublished Master's Thesis.* University of Education, Winneba, Ghana.

Uimueka, O., Altuna, E., & Ateu, A. (2010). Developing ICT skills of visually impaired learners. *Procedia Social and Behavioral Sciences, 2*, 4655–4661.

UNESCO (2002). Information and Communication Technology in Education–*A Curriculum for Schools and Programme for Teacher Development*. Paris: UNESCO.

Vidhya, P. & Meena-Kumari, J. (2015). ICT based learning tools and its impact on students with visual Impairment. *International Journal of Computer Science and Information Technology & Security, 5*(6), 396.

Wu, M. D., & Yeh, S. T. (2012). Effects of undergraduate student computer competence on usage of library electronic collections. *Journal of Library and Information Studies, 10*(1), 1-17.

Yong, T. L. (2011). Integrating the Technological Dimension into Teaching and Learning: A sociocultural perspective. *Technology in higher education*, retrieved on October 22, 2022, from http://www.cdtl.nus.edu.sg/tech-in-he/pdf/Section2-Article6.pdf.

Yu, B., Kim, K., & Roh, S. (2001). *A user analysis for web-based distance education*. Proceedings of the Annual Topics on Distance Learning Conference, Purdue University

Yusuf, M. O. (2005). Information and communication technology and education: Analyzing the Nigerian national policy for information technology. *International Education Journal, 6*(3), 316-321.