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Scientific Knowledge and Fourth-Generation Learning Skills among University Students in Saudi Arabia

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ABSTRACT

The study assessed scientific knowledge and fourth-generation learning skills (4GLSs), including cognitive, information technology, creative thinking, and problem-solving skills, among University of Jeddah students in Saudi Arabia. We aimed to identify 4GLSs based on recent scientific research, construct scales to measure them, define the mechanism of their application and automation, and assess participants' scientific knowledge and 4GLSs. After two pilot studies confirmed the validity and reliability of the measurement scales, a questionnaire survey was sent to all undergraduate students via official emails. Each skill was assessed via separate questionnaires distributed one week apart. The results revealed that 4GLSs increased with the student's academic year. Differences were observed in creative thinking and problem-solving skills, with men scoring higher than women. Additionally, problem-solving skill levels were higher among students in the Faculty of Science than those in the Faculty of Arts. These findings suggest that universities should implement programs to increase students' 4GLSs.

Keywords: cognitive skills, creative thinking skills, fourth-generation learning skills (4GLSs), information technology skills, problem-solving skills

INTRODUCTION

In the twenty-first century, the world experienced the Fourth Industrial Revolution, which led to a radical transformation of the academic and work industries. This revolution primarily involves qualitative knowledge and skills,

integrating physical, technical, and biological systems, along with qualitative changes in educational systems. The fourth generation of learning is part of these systems and encompasses skills that are consistent with those emerging in the Fourth Industrial Revolution. As a result, universities have been prompted to compete by adopting the benchmarks of this learning generation to ensure that their graduates meet labor market demands. The University of Jeddah was among the first universities in the Kingdom of Saudi Arabia (KSA) to implement fourth-generation learning skills (4GLSs) in all its courses. The university selected the four most essential skills: cognitive, information technology (IT), creative thinking, and problem-solving skills. 4GLSs are essential for twenty-first-century employment and economic growth. In the modern globalized world, a competitive, dynamic, and knowledge-based economy supports a prosperous and sustainable society. Within this global economy, 4GLSs enhance the effectiveness of occupational training and education.

Saudi Arabia's Vision 2030 (the Vision) aims to transform the country's economy from a historical reliance on oil revenue toward a diversified economy and society integrated with the global landscape. This transformation seeks to establish an "ambitious nation" (KSA, 2023) as a global logistics hub. The Vision outlines national objectives across various sectors: science, technology, culture, the environment, tourism, research, and education. It is structured around three key themes: a vibrant society, a thriving economy, and an ambitious nation. Education is central to achieving these goals.

A vibrant society is the foundation for economic prosperity by ensuring a high quality of life and a desirable living environment. Strengthening this foundation through better education facilitates the development of a strong and productive society while also reinforcing robust healthcare and social systems.

The thriving economic theme focuses on aligning the education system with market needs to create better career opportunities for citizens. Supporting individuals in acquiring the necessary skills and competencies to achieve their goals will enable diverse economic advancements. Refining the national curriculum and training Saudi instructors and educational leaders will ensure that educational outcomes align with global market demands, thereby fostering an education sector that contributes to economic growth.

The ambitious national theme aims to create an environment where citizens can navigate challenges and seize opportunities. Instilling a sense of responsibility and engagement encourages individuals to contribute to national development. National excellence relies on individuals taking responsibility for themselves and their families. Therefore, education can help citizens build professional careers and attain financial independence.

The economy and education are intertwined in the Vision's three main themes. Although the relationship between them is logical, the order of their effects is uncertain. The Vision cannot be achieved without high-quality education, which provides students with wide-ranging career opportunities. The incorporation of 4GLSs presents a strong platform for high-quality education. Therefore, 4GLSs can bridge the gap between education and employment, helping to engage Saudi individuals in the global market and achieve the economic

transformation from an oil-reliant to a knowledge-based economy outlined in the Vision. Consequently, Saudi education must emphasize 4GLSs to prepare students for new commercial activities and organizational positions. Saudi educational policymakers must consider 4GLSs, and long-term measures for strengthening them are needed to meet the Vision's objectives.

Considering the Fourth Industrial Revolution and the accompanying Fourth Generation of Learning, it has become important for students to develop skills aligned with the demands of this transformation. A review of the theoretical literature and previous studies revealed a lack of research on the extent to which Saudi university students, particularly those at the University of Jeddah, possess fourth-generation learning skills. The most critical of these skills—cognitive skills, information technology skills, creative thinking skills, and problem-solving skills—are the focus of this study. Therefore, the researchers found it necessary to conduct this investigation.

THEORETICAL FRAMEWORK AND LITERATURE REVIEW

Cognitive Skills

Cognitive skills are defined by Diaz-Bilello et al. (2021) as "interdisciplinary skills that require higher-order thinking and application, such as making connections and inferences and evaluating arguments" (p. 44). These core skills are vital for mental processes such as memory, attention, executive functions, language, and perception. They significantly impact individuals' ability to think, read, learn, remember, reason, and focus. Moreover, cognitive skills are fundamental to independent functioning in both social (Aboud & AlAli, 2023) and professional settings (Annunziata et al., 2012).

General cognitive abilities provide the foundation for processing and acquiring work-related knowledge (Kuncel et al., 2001). For example, higher-order cognitive processing skills, such as analytical reasoning and problem solving, are essential for success in teaching and learning professions (Haataja et al., 2023). Hence, the development of cognitive skills facilitates and reinforces the acquisition of planning and organizational skills, which play crucial roles in successful social interactions (Aboud & AlAli, 2023). Additionally, discussions on quality of life frequently include cognitive functioning. Despite their significance, many people struggle to fully recognize and articulate their cognitive skills (Annunziata et al., 2012).

IT Skills

IT skills are defined as "managerial, intrapersonal, and interpersonal skills used to solve information technology-related work issues" (Adam et al., 2020, p. 3). These skills include computer competency, including proficiency in programming languages, databases, and networking (Russell et al., 2000). Furthermore, IT skills encompass the ability to perform various tasks in technology-related roles. Jobs

in public organizations and universities increasingly require expertise in managing and utilizing computers (Ahmad Marzuki et al., 2015). Therefore, students with strong technical skills gain distinct advantages beyond academic achievements (Bannister et al., 2024; Saaty, 2015, 2019). IT skills are an essential prerequisite for professional development (Russell et al., 2000).

When combined with knowledge bases, they play a crucial role in the development, utilization, and management of various technologies. The specific IT skills required vary by position (Ahmed, 2003; Jones & Abraham, 2007). Cultivating these skills in education remains a growing concern for professionals, educational institutions, and educators worldwide (Alsarayreh, 2023; Chang & Hwang, 2003; Lin et al., 2005; Saaty, 2019).

Creative Thinking Skills

Creative thinking skills play a crucial role in teaching and learning processes, contributing to societal development. These skills reflect the ability to generate original ideas, suggestions, and solutions (Duff et al., 2013), as well as to recognize unexpected connections between seemingly unrelated elements (Piawa, 2010). Creativity involves discovering new approaches to unique correlations or solutions (Cropley, 2001). Creative thinking skills emphasize developing new insights, novel perspectives, and innovative methods of understanding and conceptualizing information (Eragamreddy, 2013; Mo & Ko, 2024).

Previous studies have identified various creative thinking traits (Aizikovitsh-Udi & Amit, 2011; Mo & Ko, 2024; Piawa, 2010; Ülger, 2016), including the ability to generate ideas, provide alternative perspectives, embrace flexibility, and accept new ideas. Additionally, these skills help individuals implement changes. Creative thinking fosters multiple perspectives and enables people to extend and redefine problem boundaries (Piawa, 2010).

Problem-Solving Skills

Problem-solving skills are complex mental activities involving various intellectual capabilities and actions to solve problems (Rahman, 2019). Higher-order mental abilities, such as imagination, association, abstraction, comprehension, manipulation, reasoning, analysis, synthesis, and generalization, are part of problem-solving skills (Garofalo & Lester, 1985). Kantowski (1983) and Krulik and Rudnick (1989) described problem solving as a process comprising behaviors, actions, and activities that guide an individual to a solution.

In education, problem solving is described as a mental process focused on accomplishing an objective for which students do not know a solution technique (Mayer & Wittrock, 2006; Rahman, 2019). It is also viewed as a perplexing phenomenon that raises doubts and uncertainty in educated individuals (Malkawi et al., 2019). Thus, problem-solving competence, which has been the subject of educational research, is associated with academic accomplishment (Alsarayreh, 2023; Joshi & Sheela, 2020; Pathak, 2015; Sutha & Vanitha, 2017).

RESEARCH QUESTIONS

This study examined scientific knowledge and 4GLSs among undergraduate students at the University of Jeddah. It aims to identify 4GLSs based on recent scientific research, construct scales to measure them, devise a mechanism for applying and automating these scales, and assess participants' scientific knowledge and 4GLSs.

This study posed the following research questions:

RQ1: What levels of 4GLSs do University of Jeddah students possess?

RQ2: Do University of Jeddah students' 4GLSs differ significantly on the basis of academic level?

RQ3: Do University of Jeddah students' 4GLSs differ significantly on the basis of gender?

RQ4: Do University of Jeddah students' 4GLSs differ significantly across colleges?

This study has both theoretical and practical significance. With respect to theory, the research variables examined are especially important following the University of Jeddah's adoption of fourth-generation learning in its courses. From a practical perspective, the findings are expected to benefit university policymakers and decision-makers, helping them develop programs to increase students' knowledge of the sciences and 4GLSs.

MATERIALS AND METHODS

This study used an analytical descriptive approach to collect data. This method involves studying a phenomenon, analyzing it, and examining its various dimensions to explain it and draw conclusions contributing to improvement and development.

Research Population

The University of Jeddah has two main campuses in Jeddah: the men's main campus in Asfan, and the women's main campus in Al-Faisaliyah. Besides, there are two additional campuses for men and women are located in Khulais and Alkamil, respectively. The university offers undergraduate and graduate programs in disciplines such as engineering, business, law, medicine, education, and the social sciences.

The participants included all undergraduate students at the University of Jeddah in the 2022–2023 (1444 AH) academic year. The study included 25,937 participants, comprising 8,264 men and 17,673 women. Table 1 presents the participant distribution by gender and college.

Table 1: Participant Distribution by Gender and College

College	Men	Women	Total
Languages and Translation	0	1194	1194
Communication and Media	138	226	364
Art and Design	0	1816	1816
Computer Science and Engineering	1308	1563	2871
Business	727	939	1666
Computers and Information Technology – Khulais Campus	268	289	557
Science and Arts – Khulais Campus	177	259	436
Business – Alkamel Campus	246	439	685
Computers and Information Technology – Alkamel Campus	29	46	75
Science and Arts – Alkamel Campus	37	57	94
Law and Judicial Studies	620	725	1345
Business	1625	2604	4229
Engineering	980	0	980
Medicine	281	285	566
Preparatory Year	776	1231	2007
The Holy Qur'an and Islamic Studies	237	508	745
Science	241	2330	2571
Social Sciences	192	1949	2141
Sports Sciences	374	1212	1586
Total	8264	17673	25937

Study Scales and Instruments

Cognitive Skills Scale

After reviewing the theoretical literature and multiple previous studies, we constructed a cognitive skills scale on the basis of prior research (e.g., Chaturvedi et al., 2022; Fé et al., 2022; Fin & West, 2014; Kim et al., 2015; Ng et al., 2022). The scale, comprising 15 items, was designed to align with the study's objectives and target population. The responses were rated on a five-point Likert scale (1 = never; 5 = always), with reverse scoring for negatively oriented items. The total scores ranged from 15 to 75, with higher scores indicating greater cognitive skills.

IT Skills Scale

Similarly, an information technology (IT) skill scale was constructed on the basis of previous studies (e.g., Hazar et al., 2021; Janicki et al., 2014; Maceli & Burke, 2016; Rodrigues et al., 2021; Uziak et al., 2018). This scale, consisting of 20 items, was tailored to the study's purpose and population. The responses were rated on a five-point Likert scale (1 = never; 5 = always), with reverse scoring for

negatively oriented items. The total scores ranged from 20 to 100, with higher scores indicating higher IT skills.

Creative Thinking Skills Scale

Creative thinking skills were measured using the Creative Thinking Skills Scale developed by Al-Enezi (2020). Since Al-Enezi's study examined similar demographics and had a comparable objective, we adopted this scale. This scale comprises 46 items in one dimension. The responses were rated on a five-point Likert scale (1 = never; 5 = always), with reverse scoring for negatively oriented items. The total scores ranged from 46 to 230, with higher scores indicating higher creative thinking skills.

Problem-Solving Skills Scale

Problem-solving skills were assessed using the scale developed by Abdul-Azim (2013), which has demonstrated a high degree of validity and reliability. We selected this scale because it was specifically designed to investigate a similar population and research objective. Moreover, it was deemed well suited to the Saudi context and the study sample. The scale comprises 35 items in five dimensions: general orientation, problem definition, generation of alternatives, decision making, and evaluation. Responses were rated on a four-point Likert scale (1 = not at all applicable; 4 = highly applicable), with reverse scoring for negatively oriented items. The total scores ranged from 35--140, with higher scores indicating higher problem-solving skills.

Study Procedures

The study followed these steps:

- Choosing the research subject and title in relation to the problem.
- Reviewing the theoretical literature and previous studies related to the variables and study subject.
- Selecting the study scales and applying them to the first pilot-study sample.
- Assessing the psychometric properties of the study scales.
- Applying the study scales to the second pilot- study sample.
- Reassessing the psychometric characteristics of the study scales.
- Automating the study scales.
- Applying them to the total study sample.

As faculty members at the University of Jeddah, we conducted this study as part of our participation in the university's Economic Impact and Added Value Program. This initiative is a critical pillar of the university's vision, linking all its activities to the local economy. One of the most significant economic outcomes of this program is the university's contribution to the Saudi economy through job creation, human capital development, and increased economic turnover. The

program enables the university to generate economic activity in the Kingdom and supports the objectives of Saudi Vision 2030 by facilitating direct employment and indirect job creation through institutional spending on goods, services, and capital projects. Furthermore, the program highlights the university's role in fostering knowledge-based thinking and skills among graduates, as reflected in their impact on the economy through their employers. The greater this impact is, the stronger the university's capacity to develop human capital. Consequently, the findings of this study will provide policymakers and decision-makers with valuable insights into students' proficiency in the four key skills, helping the university align its educational strategies with the goals of Saudi Vision 2030.

We first conducted a pilot study to assess the psychometric properties of the study scales. Then subsequently measured validity through expert review (virtual validity) by presenting the scales to a group of specialists in psychology, measurement, and evaluation, who provided feedback on item formulation and scale appropriateness for the study population. Consequently, all four scales were amended. The chi-square test measured agreement, with an 80 % coefficient adopted as the criterion for item validity. Internal consistency validity was assessed by calculating the correlation coefficient between each item and the total scale score.

Discriminant validity was measured by ranking the respondents' total scores in descending order and dividing them into upper and lower groups. The arithmetic mean and standard deviation for both groups were calculated, and the highest and lowest 27 % were compared using an independent-sample t test. Split-half reliability was assessed by calculating the Pearson correlation coefficient between the two halves of the scale and then applying the Spearman–Brown formula.

A second pilot study was conducted to verify these psychometric properties. We measured virtual validity using the same method as in the first pilot study. The agreement coefficient was high ($X^2 = .93$), and none of the participants commented on any scale items. Furthermore, we measured internal consistency validity, discriminant validity, and split-half reliability. The study scales were then automated.

Finally, a questionnaire survey was administered via official emails to all university students. Separate questionnaires were distributed for each skill, with a total of four official emails sent over one month—one per week. All faculty members were informed and encouraged to motivate their students to participate in the study. To facilitate participation, 10 minutes of class time were allocated each week for the students to complete the survey. Additionally, faculty members emphasized the significance of this study in supporting Saudi Vision 2030, further motivating students to contribute. For cognitive skills, the assumption of normality was tested using the Shapiro–Wilk test, which yielded a nonsignificant result ($p = .964$, $\alpha \leq .05$). As the assumption of normality was violated, a one-sample Wilcoxon signed-rank test was conducted. For IT skills, the Shapiro–Wilk test yielded a nonsignificant result ($p = .931$, $\alpha \leq .05$). As the assumption of normality was violated, a one-sample Wilcoxon signed-rank test was performed. For creative thinking skills, the Shapiro–Wilk test yielded a nonsignificant result

($p = .061$, $\alpha \leq .05$). As the assumption of normality was violated, a one-sample Wilcoxon signed-rank test was conducted. For problem-solving skills, the Shapiro–Wilk test yielded a nonsignificant result ($p = .072$, $\alpha \leq .05$). As the assumption of normality was violated, a one-sample Wilcoxon signed-rank test was performed. Considering the violation of normality for all 4GLSs, the nonparametric Kruskal–Wallis test was conducted to assess whether the distribution of these skills was uniform across academic levels.

Statistical Analysis

The participants' responses in both pilot studies were coded and processed via the Statistical Package for Social Sciences (SPSS, version 29). To verify the psychometric properties of the study scales, the following statistical analyses were conducted:

- Frequencies, percentages, arithmetic means, and standard deviations.
- Pearson correlation, Cronbach's alpha reliability, and split-half reliability coefficients.
- Independent-sample t test.

Ethical approval was obtained from the appropriate local ethics committee and Institutional Review Board. Informed consent was obtained where relevant. The collected data were managed according to Institutional Review Board principles.

RESULTS

First Pilot Study

To ensure the validity of applying the study scales in the Saudi environment, we applied each scale to the first pilot study sample in the first semester of the academic year (2022–2023). Table 2 presents the sample size. The internal consistency of all four scales was high, with a significant correlation coefficient ($p < .05$). The t test results were statistically significant ($p < .05$) for all scales, confirming discriminant validity (Table 3).

Table 2: Sample Size for the First Pilot Study

Scale	n
Cognitive skills	32
Information-technology skills	34
Creative thinking skills	30
Problem-solving skills	35

Table 3: Discriminant validity of the study scales (first pilot)

Scale	n	First group > 27 %			Second group > 27 %			t- value
		n	Mean	SD	n	Mean	SD	
Cognitive skills	32	9	58.89	9.05	9	30.67	8.83	6.696**
Information-technology skills	34	9	80.33	11.94	9	40.00	15.44	6.201**
Creative thinking skills	30	8	168.75	25.31	8	99.38	28.19	5.971**
Problem-solving skills	35	9	132.44	15.91	9	61.89	18.92	8.560**

** $p < .01$.

All split-half reliability coefficient values were statistically significant ($\alpha = .01$; Table 4). The Cronbach's alpha values for the scales were high, confirming their good degree of reliability (Table 4).

Table 4: Split-Half and Cronbach's alpha reliability coefficients for the study scales (first pilot)

Scale	n	Split-half reliability coefficient	Cronbach's alpha reliability coefficient
Cognitive skills	32	.87**	.89
Information-technology skills	34	.89**	.92
Creative thinking skills	30	.91**	.92
Problem-solving skills	35	.87**	.88

Second Pilot Study

The sample sizes are presented in Table 5. The internal consistency was good ($p < .05$). The t test results were statistically significant ($p < .05$) for all scales, confirming discriminant validity (Table 6). All values for split-half reliability were statistically significant ($\alpha = .01$; Table 7). The Cronbach's alpha values were high, confirming good reliability (Table 7).

Table 5: Sample size for the second pilot study

Scale	n
Cognitive skills	35
Information-technology skills	33
Creative thinking skills	35
Problem-solving skills	34

Table 6: Discriminant validity of the study scales (second pilot)

Scale	n	First group > 27 %			Second group > 27 %			t- value
		Mean	Median	SD	Mean	Median	SD	
Cognitive skills	35	9	58.78	9.24	9	30.56	9.07	6.538**
Information-technology skills	33	9	71.33	14.52	9	34.22	11.02	6.108**
Creative thinking skills	35	9	186.33	28.79	9	87.00	18.47	8.712**
Problem-solving skills	34	9	129.22	21.87	9	68.44	19.18	6.268**

** $p < .01$.

Table 7: Split-Half and Cronbach's alpha reliability coefficients of the study scales (second pilot)

Scale	n	Split-half reliability coefficient	Cronbach's alpha reliability coefficient
Cognitive skills	35	.87**	.90
Information-technology skills	33	.88**	.92
Creative thinking skills	35	.92**	.93
Problem-solving skills	34	.89**	.90

** $p < .01$.

Main Study Results

The levels of cognitive (Tables 8 and 9), IT (Tables 10 and 11), creative thinking (Tables 12 and 13), and problem-solving (Tables 14 and 15) skills were higher than their respective hypothetical medians. Table 16 presents the results of the Kruskal–Wallis test, which were statistically significant ($\alpha \leq .05$) for cognitive skills. A pairwise comparison revealed that students with an academic level of 8 or higher scored higher on cognitive skills.

Similarly, the test produced statistically significant results ($\alpha \leq .05$) for IT skills, with students at academic level 8 or higher demonstrating higher proficiency. Statistically significant results ($\alpha \leq .05$) were also found for creative thinking skills, with students at academic level 7 or higher scoring higher. Similarly, statistically significant results ($\alpha \leq .05$) were observed for problem-solving skills, with students at academic level 8 or higher showing greater proficiency.

Table 8: Cognitive Skills by Gender and College

College	Women	Men	Total
Preparatory Year	47	78	125
Business – Khulais Campus	101	85	186
Communication and Media	18	16	34
Business	297	94	391
Business – Alkamel Campus	22	15	37
Art and Design	166	0	166
Computers and Information Technology – Alkamel Campus	13	3	16
Computers and Information Technology – Khulais Campus	185	101	286
Medicine	94	60	154
Science	288	25	313
Social Sciences	127	28	155
Science and Arts – Khulais Campus	46	10	56
Science and Arts – Alkamel Campus	16	11	27
Law and Judicial Studies	43	13	56
The Holy Qur'an and Islamic Studies	22	35	57
Languages and Translation	146	0	146
Engineering	0	34	34
Sports Sciences	64	60	124
Computer Science and Engineering	115	72	187
Total	1810	740	2550

Table 9: Wilcoxon Signed-Rank Test Results for Cognitive Skills

n	Wilcoxon signed-rank test	p	Hypothetical median	Observed median
2550	2210717	.000	45	49

Table 10:IT Skills by Gender and College

College	Women	Men	Total
Preparatory Year	60	60	120
Business – Khulais Campus	71	56	127
Communication and Media	28	27	55
Business	192	86	278
Business – Alkamel Campus	13	18	31
Art and Design	93	0	93
Computers and Information Technology – Alkamel Campus	9	8	17
Computers and Information Technology – Khulais Campus	137	117	254

Medicine	54	50	104
Science	173	41	214
Social Sciences	91	53	144
Science and Arts – Khulais Campus	41	20	61
Science and Arts – Alkamel Campus	15	19	34
Law and Judicial Studies	68	15	83
The Holy Qur'an and Islamic Studies	14	38	52
Languages and Translation	89	0	89
Engineering	0	42	42
Sports Sciences	34	87	121
Computer Science and Engineering	81	61	142
Total	1263	798	2061

Table 11: Wilcoxon Signed-Rank Test Results for IT Skills

n	Wilcoxon signed rank test	p	Hypothetical median	Observed median
2061	1952860	.000	60	86

Table 12: Creative Thinking Skills by Gender and College

College	Women	Men	Total
Preparatory Year	95	50	145
Business – Khulais Campus	95	62	157
Communication and Media	25	25	50
Business	369	80	449
Business – Alkamel Campus	9	6	15
Art and Design	139	0	139
Computers and Information Technology– Alkamel Campus	4	2	6
Computers and Information Technology– Khulais Campus	146	113	259
Medicine	27	67	94
Science	309	30	339
Social Sciences	134	64	198
Science and Arts – Khulais Campus	48	23	71
Science and Arts – Alkamel Campus	13	11	24
Law and Judicial Studies	69	78	147
The Holy Qur'an and Islamic Studies	51	13	64
Languages and Translation	109	0	109
Engineering	0	101	101
Sports Sciences	57	55	112
Computer Science and Engineering	90	93	183
Total	1789	873	2662

Table 13: Wilcoxon Signed-Rank Test Results for Creative Thinking Skills

n	Wilcoxon signed-rank test	p	Hypothetical median	Observed median
2662	3220015	.000	138	160

Table 14: Problem-Solving Skills by Gender and College

College	Women	Men	Total
Preparatory Year	109	42	151
Business – Khulais Campus	85	60	145
Communication and Media	26	38	64
Business	197	88	285
Business – Alkamel Campus	6	45	51
Art and Design	155	0	155
Computers and Information Technology – Alkamel Campus	6	5	11
Computers and Information Technology – Khulais Campus	110	125	235
Medicine	37	39	76
Science	205	29	234
Social sciences	92	66	158
Science and Arts – Khulais Campus	70	9	79
Science and Arts – Alkamel Campus	14	16	30
Law and Judicial Studies	64	20	84
The Holy Qur'an and Islamic Studies	75	28	103
Languages and Translation	69	0	69
Engineering	0	30	30
Sports Sciences	37	77	114
Computer Science and Engineering	62	47	109
Total	1419	764	2183

Table 15: Wilcoxon Signed-Rank Test Results for Problem-Solving Skills

n	Wilcoxon signed-rank test	p	Hypothetical median	Observed median
2183	2189052	.000	87	101

The results indicate that 4GLSs increase with students' academic level. Given the violation of the assumption of normality for all 4GLSs, the nonparametric Mann–Whitney U test was conducted to assess skill distribution by gender (Table 17). The test yielded nonsignificant results ($\alpha \leq .05$) for cognitive skills, indicating equal proficiency among men and women. However, it produced statistically significant results ($\alpha \leq .05$) for IT skills, with women scoring higher. Additionally,

statistically significant results ($\alpha \leq .05$) were observed for creative thinking and problem-solving skills, with men scoring higher in both.

Table 16: Kruskal-Wallis Test Results

Fourth-generation learning skills	n	Kruskal–Wallis statistic	DF	p
Cognitive skills	2550	30.840	7	.000
Information technology skills	2061	19.453	7	.007
Creative thinking skills	2662	18.374	7	.010
Problem-solving skills	2183	17.902	7	.012

Table 17: Mann-Whitney U Test Results by Gender

Fourth-generation learning skills	Men		Women		Mann–Whitney U test	p
	n	Mean rank	n	Mean rank		
Cognitive skills	740	1292	1810	1269	657775	.479
Information-technology skills	798	956	1263	1078	443961	.000
Creative thinking skills	873	1377	1789	1309	740914	.032
Problem-solving skills	764	1140	1419	1066	505713	.010

Table 18: Mann-Whitney U Test Results by Faculty

Fourth-generation learning skills	Faculty				Mann–Whitney U test	p
	Science		Arts			
	n	Mean rank	n	Mean rank		
Cognitive skills	990	1308	1560	1255	739559	.071
Information-technology skills	773	1021	1288	1037	489776	.539
Creative thinking skills	982	1298	1680	1351	791718	.083
Problem-solving skills	695	1132	1488	1073	489154	.042

Furthermore, faculties were divided into science and arts. Considering the violation of the assumption of normality for all 4GLSs, the nonparametric Mann–Whitney U test was used to assess the skill distribution across colleges (Table 18). The test yielded nonsignificant results ($\alpha \leq .05$) for cognitive, IT, and creative thinking skills by college. However, it produced statistically significant results (α

≤ .05) for problem-solving skills, with students in the Faculty of Science scoring higher.

DISCUSSION AND CONCLUSION

Findings and Future Research

The results demonstrate that men and women at the University of Jeddah possessed above-average levels of 4GLSs. These skills were higher among students at advanced academic levels, confirming the university's success in adopting fourth-generation learning. The results also confirm the university's role in and support for achieving the Saudi 2030 Vision. The observed variations between men and women and between science and arts faculties may be linked to course content differences. However, further research is needed in this area.

4GLSs must be prioritized to help in fulfilling the Vision, ensuring that Saudi residents can compete in the global labor market. The University of Jeddah has addressed this need by integrating 4GLSs into most majors. Nonetheless, to reduce the need for remediation in higher education, 4GLSs must be emphasized as early as primary education. All Saudi students should have access to 4GLSs and actively engage with them while pursuing both professional and scientific qualifications. This study established a foundation for future research pursuing a similar purpose and investigating similar populations. Other Saudi universities should build on this study to support the achievement of the Vision.

The findings provide valuable insights for university decision-makers and assist in developing programs to enhance students' proficiency in science and 4GLSs. Thus, we recommend that university leaders and decision-makers develop programs to enhance creative thinking and problem-solving skills, particularly for women; boost IT skills, particularly for men; and improve problem-solving skills, particularly for students in the Faculty of Arts.

With the development of the Vision, increased knowledge of 4GLSs can increase Saudi Arabia's economic potential. Teaching these skills is central to the Vision's success, as both the Saudi and global economies depend on them. Thus, incorporating fourth-generation skills in education is essential to achieving Vision's three main themes: a vibrant society, a thriving economy, and an ambitious nation.

To further our understanding of key issues in this domain, future studies should recruit larger student samples and conduct interviews to generate richer data for analysis. To extend this research, we plan to conduct separate in-depth studies of undergraduate and graduate students. Our approach should be used to study each major at a university. Additionally, future research should discuss the implementation barriers in more depth, thereby offering more practical insights for educators.

STUDY LIMITATIONS

With respect to objective limitations, the study focused on only four variables: cognitive, IT, creative thinking, and problem-solving skills. Moreover, the study was conducted on a limited sample of male and female students from the University of Jeddah, which constitutes a spatial limitation. Finally, the study was time-limited because it focused on only one academic year (1444 AH/2023 AD). Future research should address these limitations by incorporating a wider range of variables, larger and more diverse samples, and longitudinal analyses.

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