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Saudi Learners' Perception of Infographics in Education: A Survey

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Abstract—Learners' learning experiences diverge and undergo rapid shifts due to trends in technology, and the transfer of knowledge in varying formats and styles is ubiquitous. Infographics find its application in instructional design and technology that drives education with state-of-the-art tools and applied methods. Being a format of data, Infographics or visual images presents information or knowledge using visuals. This study aims to present the student perceptions of learning via infographics at Princess Nourah bint Abdurrahman University (PNU) in Saudi Arabia. The study employs a survey questionnaire consisting of 13 close-ended questions posed to assess the learners' responses at PNU. Applied Likert's scale-based questions present a conversion of user data input to quantitative figures, which present the level of understanding and the role of infographics in education. The survey involved 45 undergraduate female students pursuing undergraduate degree courses at PNU. Using survey research design methodology, the study investigated learners' perceptions of infographics to add to their learning experiences and provides a quantitative analysis of observed responses to the survey questionnaire. The study conducts an online survey and classifies participants of different age groups into five categories for assessment. The study findings reveal that PNU learners perceive a positive role of infographics in their learning. However, learners showcase varied perceptions of a) the acceptance of assignments based on infographics and b) the use of static versus animated infographics. The study guides research scholars toward the intuition of infographics in learning environments and reports the two research problems to be addressed in future works.

Keywords— Educational infographics; Saudi learners, instructional design; instructional technology; online media; visual learning.

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I. INTRODUCTION

The world is dynamic, as are the people and communities that engulf it. While dynamically changing with time, people no longer search for queries in the libraries, and most people access web pages and switch to search engines to seek knowledge that guides them toward solutions to the problems of their concern. Rapid diversion towards e-learning technologies and learning online during the COVID-19 pandemic led to many challenges [1], [2]. Nearly all educational institutions during the pandemic adopted online learning as a major platform for delivering education [3]. As such, learning habits changed drastically, and many research studies were conducted to access and improve the quality of learning online using various learning management systems (LMS) [4], [5]. Learners would adapt to learning online as a regular part of their daily life, and eventually, learners developed intuitions that guided them to access, utilize, and perceive information using various mechanisms of information content delivery [6], [7]. State-of-the-art communication technologies allow people to access information and resources ubiquitously. Intuitive methods enabling access to information nowadays, improvise presentation of information by the resources of visual knowledge, which are often supplemented with brief textual details [8].

Instructional technology needs learners to comprehend and recall different types of information. Infographic' is a shortened term or abbreviation for information graphics. Infographics are images and visualization of data using various graphics objects, such as pie charts, bar graphs, line graphs, and histograms etc. Infographics allow transfer and enable translation of knowledge by the audience of interest [9], [10]. Infographic' applied to the domain of instructional technology and design are realized as visually appealing and useful since infographics communicate information, knowledge and findings observed by other stakeholders to media and the public effectively [11]-[14]. While serving as aesthetic presentation aid, infographics also deliver information to non-academic viewers, thereby enabling them to retain information of interest [2]-[4]. Infographics find a place in academic and scientific journals to disseminate knowledge at higher order visibility and to communicate observed results [15], [16].

Learners typically showcase significant written and verbal communication differences, exhibiting varied learning styles [17], [18]. Some learners may prefer to learn via visual methods or processes that incorporate tactile methods for learning [19]. Infographics enable learners to process information easily and in their preferential ways. Images, words, and other interactive elements enabled by Infographics allow learners to stay focused, memorize delivered information, and retrain the delivery process. Infographics may also include supplementary written textual content that enhances learners' visual realization of content, and as such, the wide range of audience is possible to cover with content outsourced.

Preferential and selective use of different learning resource formats directly impacts learning and teaching activities. Learning resources designed and developed by instructors lead to abilities in learners that allow them to: a) select suitable resources for learning; b) prepare and integrate visual learning-based content in their learning materials; c) develop a perception of learning habits based on visual content. As such, virtual literacy involves learning infographic skills and has a major role in promoting the digitalization of instruction design [20]. Infographics as a supportive tool to enhance teaching and learning experiences is envisioned soon.

This study aims to explore the possible opportunities that reveal how infographics offer a solution to the present needs of the educational systems demanding visualization of learning content in a standardized approach. In addition, the study explores the perception levels of learners using infographics as a means of learning.

A. Study Outline

This study is organized according to the following sections: Section of "*Infographics*" and "*Literature Review*" provide the background to the study. Section of "Research *Methodology*" provides the methodology adopted to investigate the role of infographics at PNU. The sub-section details are the instrument, survey design, and data analysis method. Section of "*Results and Discussion*" presents the results of the research and discussion that connects between the results and the literature review. Section of "*Conclusion*" provides the conclusions of the overall study.

B. Research Contribution

The main contributions of this study are listed here as under:

- The study highlights the concept and the role of infographics in educational settings.
- The study presents the survey results conducted at Princess Nourah bint Abdulrahman University (PNU) to characterize female students' perceptions about learning with infographics.
- The study provides a survey data set of 45 participants.
- The study examines survey results using quantitative analysis of data collected on a 5-point Likert's scale to investigate the perceptions of infographics.
- The study presents findings guiding a new research questions for future research works.

Research and development processes, including innovation and evolution of technology, are found in almost every sphere of life. Intensive access to knowledge and sharing of data online at ease prerequisites advanced methods and techniques for selecting correct and meaningful information. Innovative technologies are essential to enable the evolution and empowerment of societies demanding digitalization of various resources [21]–[23].

Sylvester [24] coined the term "graph" which demonstrated logical associations between mathematical properties and chemical bonding chemistry with a set of graphs published in the Nature Scientific magazine. However, Christopher Scheine in 1626 introduced the concept of infographic in the Rosa Ursina sive Sol [25]. The next person to introduce was Peter Sullivan, who coined the term "Infographic" in 1980s, 1980s, 1990s [26]. The term was meant for The Sunday Times; the newspaper that asked for and preferred Infographic. In 2000, Adobe Flash animation was used to deliver Infographic for creating games and other types of products [27]. Albers [28] defines infographics as information, knowledge, or even data words. Infographics include graphical objects, such as charts, maps, graphics, and even images. Instructional design also seeks intervention and incorporation of digitalization to embed and amalgamate state-of-the-art methods and tools to increase instruction delivery and performance levels of learners in academia. As such, infographics may be advantageous and effective means to meet the growing demands for enhanced and interactive presentations at academic levels. Infographics aim to illustrate complex information with clear explanations. According to Albers [28], a designer visualizes an infographic for a specific purpose and with an objective in mind. For both accomplishments to be achieved require infographics to communicate complex information. Therefore, standard infographics ensure complexity of information remains unaltered whilst barriers to its comprehension are lowered. Alternatively, infographics visualize data, allows presentable information design, or guides to steps how information could be structured in a particular context.

Infographic or information graphics is a systemic organization of a set of graphic objects (images) and textual data. Collection and communication of information, as well as visual literacy as assignments, help facilitate learning processes [2], [29], [30]. Defining a systematic and structured way to organize and reveal qualitative data can be advantageous since infographics mainly architect a graphical representation of knowledge and information. Alternatively, an infographic refers to an image that conveys information using text and graphical patterns framed on data under context. Infographics preserves the textual informational message and enables communication of complex representations or ideas of a given topic [31]. The development of infographics relies on data visualization and architecting the structure of information. Infographics find applications in newspapers and in educational materials, and as an approach to visual learning, infographics enable support to the processes of instruction delivery. For a viewer who seeks more insights into the content, infographics can: a) help improve the visual perception of data or information in viewers or stakeholders; (b) present conceptual models or information in a refined and structured design to viewers; (c) reduce the level of cognitive

C. Infographics

load required to perceive complex information; and (d) improve the cognition level of viewers to recall and retain information for longer times [20], [32].

The key objectives to be accomplished by incorporating infographic for effective delivery of data and information fall under the following three categories: hold audience attention, present information and entertain the audience; and enable persuasive public communication. Infographic applications showcase diverse application range [33], and the applications of infographics must visualize stories, processes, conceptual ideas. As infographics present processes or information of high complexity clearly and concisely to reveal underlying information structures [31], [34]. Nonetheless, applications of infographics are not specific to any domain, rather find their applications for visual presentations in different disciplines [35].

D. Literature Review

Infographics help to clarify complicated material, boost engagement, improve memory recall, promote critical thinking, and give context to data as they play a significant part in data visualization for educational reasons. Teachers can improve students' learning results by using infographics in their lessons to help students comprehend and recall difficult information. By deconstructing complex information, boosting engagement, improving memory retention, encouraging critical thinking, promoting data literacy, supporting differentiated instruction, emphasizing key takeaways, improving communication, and encouraging creativity, infographics play a crucial role in data visualization for educational purposes.

1) Infographics and Information visualization

In data visualization for educational purposes, infographics are crucial. They are employed to convey complex information in an appealing, memorable, and understandable visual fashion. In data visualization for education, infographics can play a number of distinct roles. Simplifying complex information: By presenting it in a visually appealing and understandable style, infographics can aid instructors in deconstructing complex material and data [36]–[38]. Infographics may simplify complex facts into more digestible bits that are simpler for students to understand by utilizing visual components like charts, graphs, and icons.

- Increasing engagement: Infographics can assist students in becoming more engaged with the material because they are visually engaging. Infographics can attract students' attention and maintain their concentration by presenting data in an intriguing and aesthetically appealing way [3], [27].
- Enhancing memory retention: Students may learn information more effectively with infographics. Infographics are a powerful tool for presenting information in a way that is visually appealing and easy to recall. Research has shown that using visuals can aid in increasing memory retention [19], [39], [40].
- Encouraging critical thinking: By presenting facts in a way that necessitates analysis and interpretation on the part of the audience, infographics can help promote critical thinking abilities [3], [7], [18], [41]. Infographics can help students think critically about the

data being presented and come to their own conclusions by interestingly visualizing the material.

- Providing context: Infographics that provide context for the information being given can aid pupils in understanding data. Infographics can aid students in comprehending the relevance of the information being presented by employing visual components to provide context, such as maps or timelines, to show them how the data fits into a larger framework [19], [29], [40], [42], [43].
- Promoting data literacy: By presenting data in a way that is simple to understand and interpret, infographics can aid in the promotion of data literacy [9], [13], [33], [44]. Infographics can assist students in developing fundamental data literacy skills and a better understanding how to read and analyze data by employing visual components to communicate data, such as charts and graphs.
- Supporting differentiated instruction: By offering numerous ways to communicate information, infographics can also promote differentiated education [45]–[50]. Infographics can supplement typical textual formats for pupils who may learn the material more effectively through visual or graphical representations.
- Highlighting key takeaways: Aside from simplifying complicated information or data, infographics may also be utilized to emphasize the main points [37], [51], [52]. Infographics can aid students in recognizing the most crucial data and comprehending the presented material's overall message by employing visual clues to direct attention to vital information [53]–[57].
- Improving communication: By displaying information clearly and succinctly, infographics can also enhance communication between instructors and students. Infographics can increase communication between teachers and students by presenting data in a way that makes it easier for students to grasp and ask informed questions [38], [47], [58]–[60].
- Promoting creativity: By challenging pupils to think outside the box and convey information in a way that is aesthetically appealing, infographics can help foster creativity [45], [56], [59], [61], [62]. By allowing students the opportunity to create their own infographics, educators can inspire kids to be imaginative and think critically about the best methods to present information.

2) Infographics and Education

Since infographics can present highly complex information and ideas in simpler and organized forms, instructional designers can develop learning activities, such as introductory sessions that include warm-up sessions, short stories, or even revision of prior learned topics. In addition, brief introductory session to new topics may be brought up for preliminary interaction with learners [63], [64]. In fact, the study of Yuruk et al. [39] reveals that the training process employing infographics for information delivery has a significant effect on academic achievement and metacognitive skills, and in particular, the use of infographics facilitates the management of the learning process [65], [66].

Non-digital transient approaches for displaying information in public space have also found place in the research. Methods, such as chalk infographics, provide several benefits compared to digital displays. These offer adhoc deployment, barrier-free interaction, and are more sustainable. Hoggenmueller et al. [42] develop a slow-moving "Woodie "robot that draws on the ground using conventional chalk sticks. Realizing it as a living being Woodie stimulated emotional responses among observers. The study finds that Woodie successfully caught people's attention and emerged to act as a facilitator for collaborative and creative placemaking. Likewise, Locoro et al. [43] present the strand of Cairo's wheel made for an infographic. It is a unified view via multidimensional wheels, devised to identify, analyze, and evaluate design patterns for multiple views.



Fig. 1 Five participants age groups

While infographics strongly impact cognition, viewers generally experience lower stress in understanding and interpreting the information [30]. Cheng et al. [41] explore the effective growth mindset intervention applicable to higher education. The first phase is conducted as a two-phase study; the first phase systematically reviews and analyzes literature published between 2010 and 2021. A total of thirteen articles analyzed showcase how the intervention is designed, conducted, and evaluated. The few studies analyzed show that visual images being realized as mindset intervention in the existing literature are still in the infancy stage of progression. To cultivate a growth mindset, the the author developed a set of infographic resource materials for delivery to thirty participants recruited at a university during the second phase. Cheng et al. [41] reveal significant differences between the two groups. The study analyzes weekly reflections to observe the impacts of designed study materials. Different formulated groups are observed after a 6-week intervention, with the experimental group perceiving more malleable intelligence significantly.

Cognitive abilities and the abilities that led to creativity and self-reliance support lifelong learning, thereby allowing learners deep-rooted to retain and comprehend delivered knowledge and information. According to the author [29] the assignments to design infographics assigned to students improvise the delivery of information while transfers of visuals occur. Apparently, motivation for learning increases with a visual transfer of information [67]. Applications of infographics and associated information delivery models setup platforms that drive cognizance of information at high level. Application as such, also direct to opportunities that optimize the cognitive abilities of learners' subject to visual literacy settings. Learners' skill level and prior knowledge level guide them to the next level: thinking, learning, and expression. To enhance learners' visual communication skills, infographics could be designed and developed based on their visual perception strengths. As an alternative tool that enable support to learners, the use of infographics have resulted in highest achievements by students in education [44].

E. Motivation

Literature reviews show that infographics play a vital role in delivering information to a wide audience range. However, the perception of infographics among learners at educational institutions needs further research. The proposed research results would guide the scholars to discover newer challenges for further research. To realize the perception of infographics among learners, this study experiments at Princess Nourah bint Abdulrahman University (PNU), Riyadh, Saudi Arabia, to explore the possible opportunities and applications of infographics in teaching and learning practices at the University.

	TABLE I		
AGE GROUPS			
Age Group	Group Name		
16-18	G1		
18-20	G2		
20-22	G3		
22-24	G4		
24-above	G5		

F. Research Questions

The following research objective aims to investigate the learner perceptions of infographics. The study aims to address the following proposed research questions:

- What is the understanding of visual literacy and infographics in education among female learners?
- Do female learners find education based on infographics effective?

II. MATERIAL AND METHOD

The study applies quantitative research methodology to uncover the findings presented. The author developed the survey questionnaire to collect data. Likert's scale-based questions present a conversion of data input by users to quantitative figures, which present the level of understanding and the role of infographics in education. As such, the study implements a questionnaire with (13) survey questions seeking responses from learners on a five-point Likert scale.

A. Participants

The survey involved 45 undergraduate female students pursuing undergraduate degree courses at PNU. The participants involved in the survey were informed and briefed about the survey to be conducted before conducting the



Fig. 1 illustrates the count of participants according to their age groups. The authors conducted an online survey, and the study classifies different age groups into five age groups defined in TABLE . As illustrated in



Fig. 1, the student age group G3 included maximum number of participants equal to 14, whereas the age group G1 has the lowest count of 1 in the survey. Between the two groups, 6, 9, and 15 students from the age group G1, G3, and G5, respectively.

B. Survey Questionnaire

To introduce the concept of infographics, an introductory session on infographics with some samples of educational infographics is before conducting a survey. Next, the study asks 13 questions (see TABLE) to the students to seek findings on their perceptions about infographics. A closedended strategy is used to develop the questionnaire for the questions. Additionally, learners are explained the applications of infographics to other learning courses.

C. Reliability Test – Cronbach's Alpha

The reliability of the survey research is the degree of result being constant over time and reproducible into another similar technology, implying a reliable instrument of the study [68].

 TABLE II

 ASSESSMENT INSTRUMENT - 13 SURVEY QUESTIONS (SQS).

Qno.	Survey Question
1.	Infographics can present information with high quality visual effects يمكن أن تقدم الانفوجر افيك معلومات ذات تأثيرات بصرية عالية الجودة
2.	Infographics reflect contributions to your learning practices as learner تساهم الانفوجر افيك في ممارسات التعلم الخاصة بك كمتعلم
3.	Infographics help you read the content more clearly تساعدك الانفوجر افيك على قراءة المحتوى بشكل أكثر وضوحًا
4.	Infographics help you understand complex information and data تساعدك الانفوجر افيك على فهم المعلومات والبيانات المعقدة
5	

 Infographics help you compare and analyze information تساعدك الانفوجر افيك على مقارنة المعلومات وتحليلها

- 6. Learners should be assigned home works based on infographics
 - يجب أن يكلف المتعلمين بالواجبات المنزلية التي تعتمد على الانفوجر افيك
- 7. Visuals based learning is way better than traditional lecture mode
- التعلم القائم على المرئيات أفضل بكثير من وضع المحاضرة التقليدي 8. Static Infographics resources are better than animated
- infographic resource الانفوجر افيك الثابتة أفضل من الانفوجر افيك المتحركة
- Infographics help you retain concepts for longer times
 تساعدك الانفوجر افيك على الاحتفاظ بالمفاهيم لفترات أطو□
- 10. Infographics help you remember information easily تساعدك الانفوجر افيك على تذكر المعلومات بسهولة
- Infographics make learning interesting and comprehensive الانفوجر افيك تجعل التعلم ممتعًا و□ الملأ
- 12. Infographics helps increases your creative thinking تساعد اللانفوجر افيك على زيادة قدرتك بالتفكير الإبداعي
- Infographics visualizes complex concepts into simple visuals
 الانفوجرافيك تصور المفاهيم المعقدة في صور بسيطة

Cronbach's alpha is a metric used to evaluate the internal consistency or reliability of a group of scale or test items. Cronbach's alpha (α) is one approach to gauge the strength of such consistency. In other words, the reliability of any measurement relates to the degree to which it is a consistent measure of a notion. The score for each scale item is correlated with the overall score for each observation (often individual survey respondents or test takers), and the variation, including all specific survey items, is then compared using the expression eq **Error! Reference source not found.**:

$$\alpha = \left\{\frac{n}{n-1}\right\} \left\{1 - \frac{\sum_{i=1}^{n} \sigma_{y_i}^2}{\sigma_x^2}\right\}$$
(1)

Where α represents the estimated probability value – Cronbach's Aplha; *n* represents the number of questions; $\sigma_{y_i}^2$ represents the variance associated with questions *i*; and σ_x^2 represents the variance associated with the observed total scores.

MS Excel provides data analysis tool is used to analyze the collected data. The study applies the Analysis of Variance (ANOVA) [69]: Two-Factor Without Replication to measure the internal consistency of the developed survey questionnaire. **Error! Reference source not found.** in the appendix section illustrates the results of the test. Two-Factor ANOVA is a development of one-way analysis of variance, commonly referred to as factorial analysis.

TABLE III ANOVA STATISTICAL RESULTS

ANOVA STATISTICAL RESULTS						
Source of Variation	SS	df	MS	F	P-value	Fcritical
Participants	117.1009	44	2.66	7.21	4.64E-32	1.398468
RQ s	65.84957	12	5.49	14.88	4.99E-27	1.770519
Error	194.7658	528	0.37			
Total	377.7162	584				
RESULTS OF ANOVA - TWO-FACTOR WITHOUT REPLICATION TEST IN MS EXCEL.						
Summary	Count	Sun	n	Avera	ige va	ariance
Participant 1	13	64		4.92	0.0	08
Participant 2	13	56		4.31	0.9	90
Participant 3	13	65		5.00	0.0	00
Participant 4	13	65		5.00	0.0	00

Summary	Count	Sum	Average	Variance
Participant 5	13	64	4.92	0.08
Participant 6	13	60	4.62	0.92
Participant 7	13	54	4.15	0.47
Participant 8	13	62	4.77	0.36
Participant 9	13	65	5.00	0.00
Participant 10	13	65	5.00	0.00
Participant 11	13	59	4.54	1.44
Participant 12	13	65	5.00	0.00
Participant 13	13	65	5.00	0.00
Participant 14	13	63	4.85	0.14
Participant 15	13	63	4.85	0.31
Participant 16	13	63	4.85	0.31
Participant 17	13	60	4.62	0.76
Participant 18	13	65	5.00	0.00
Participant 19	13	62	4.77	0.36
Participant 20	13	59	4.54	0.44
Participant 21	13	64	4 92	0.08
Participant 22	13	60	4.62	0.59
Participant 23	13	64	4.92	0.08
Participant 24	13	63	4.85	0.31
Participant 25	13	63	4.85	0.31
Participant 26	13	58	4.05	1 27
Participant 27	13	65	5.00	0.00
Participant 28	13	57	4.38	0.00
Participant 20	13	61	4.50	0.39
Participant 20	13	54	4.05	1 47
Participant 31	13	65	4.13 5.00	0.00
Participant 32	13	63	1.85	0.00
Participant 33	13	51	3.02	1.24
Participant 34	13	53	3.92	0.58
Participant 35	13	58	4.08	0.38
Participant 35	13	56	4.40	0.44
Participant 37	13	57	4.31	0.90
Participant 37	13	61	4.38	0.70
Participant 30	13	46	4.09	0.40
Participant 39	13	40	3.34	0.42
Participant 40	13	50	4.02	0.42
Participant 41	13	J0 42	4.40	0.94
Participant 42	13	43	2.54	0.90
Participant 45	13	40	3.34	0.00
Participant 44	15	30 45	4.51	0.44
Participant 45	15	45	3.40	0.44
RQI	45	214	4.76	0.23
RQ 2	45	206	4.58	0.52
RQ 3	45	218	4.84	0.13
RQ 4	45	217	4.82	0.24
RQ 5	45	214	4.76	0.23
RQ 6	45	181	4.02	1.52
RQ 7	45	203	4.51	0.71
RQ 8	45	164	3.64	1.64
RQ 9	45	206	4.58	0.43
RQ 10	45	212	4.71	0.30
RQ 11	45	212	4.71	0.35
RQ 12	45	208	4.62	0.56
RQ 13	45	216	4.80	0.21

As opposed to a single variable in a single-factor analysis, there are two variables in a two-factor analysis. Both variables or causes impact the dependent variable. Each component has two or more classes, and each variable has one lower degree of freedom than levels. ANOVA tests examine more than two groups at once to see if they are correlated. The *F* statistic, or F - ratio, as the outcome of the ANOVA formula, enables examination of several groups of data to ascertain the variability within and across samples. The ANOVA is

described by the eq Error! Reference source not found.Error! Reference source not found.:

$$F = \frac{MST}{MSE}$$
(2)

Where F is the ANOVA coefficient, MST means the sum of squares due to treatment, and MSE means the sum of squares due to error. TABLE shows the different statistics computed after applying the ANOVA test to a survey questionnaire. The two-factor ANOVA test applied to the survey data tests the validity of the following two hypotheses: a) The sample means of the participants are equal, and b) The sample means of the research questions (RQs) are equal.

D. Hypothesis

Null Hypothesis $[H_{P0}]$: No significant difference in the group means of the Participants. Alternate Hypothesis $[H_{P1}]$: A significant difference in the group means of the Participants. Null Hypothesis $[H_{SQ0}]$: No significant difference in the group means of the Participants. Alternate Hypothesis $[H_{SQ1}]$: A significant difference in the group means of the Participants.

Results of TABLE present row-wise and column-wise computation to enable acceptance and rejection of a null hypothesis H_0 . Analysis of RQs shows that the mean value (*MS*) for RQs equals 5.49. Since the probability factor p = 4.99E - 27 < 0.05, and $F = 14.88 > F_{critical} = 1.77$, the study rejects null hypothesis and accepts the alternate hypothesis that there is a significant statistical difference in the group means of the survey questionnaire at 95% level of confidence.

Also, results of TABLE present row-wise and columnwise computation to enable acceptance and rejection of null hypothesis H_0 . Analysis of participants shows that the mean value (*MS*) for rows equals 2.66. Since the probability factor p = 4.64E - 32 < 0.05, and $F = 7.21 > F_{critical} = 1.398$, the study rejects null hypothesis and accepts the alternate hypothesis that there is a significant statistical difference in the group means of the participants at 95% level of confidence.



Fig. 2 $\,$ SQ1 - Infographics can present information with high quality visual effects

Cronbach's Alpha

Using the statistics of TABLE, the Cronbach's alpha [70] is computed. The following eq **Error! Reference source not found.** enabled estimating the Cronbach's alpha for the study questionnaire:

$$\alpha = \left\{1 - \frac{MS \text{ of Error}}{MS \text{ of Participants}}\right\} = \left\{1 - \frac{0.37}{2.66}\right\}$$
(3)

Where *MS* represents the mean score.

The survey conducted was subject to a reliability test. The outcome of the reliability test for the study employing 45 participants and the survey questions (n = 13) resulted in a Cronbach's alpha value of **0.861**. The computed Cronbach's value shows a high level of internal consistency in the survey instrument, thereby showing the reliability of the questionnaire used in the study.

III. RESULTS AND DISCUSSION

In this section, quantitative survey data are examined and analyzed in order to research students' perceptions about using infographics in their learning environment and perceptions concerning visual literacy based on infographics. The questionnaire formulated by researchers enabled researchers to determine the trends in perceptions of learners employing infographics in learning practices. The sections next describe the students' response level in response to the survey questions.

Improvements to effectiveness, efficacy, and motivation towards e-learning technology adaptation and gamification, offers a pleasurable educational environment that substitutes the time-consuming instructional strategies [71]. The use of effective graphics greatly influences students' reasoning [72]. Recent technologies enable content delivery with high-quality graphics and are observed to showcase high cognitive effects in learners. An experiment by Kitahara et al. [72], reveals that students' judgment changed on seeing an activating figure, and an alteration in the EEG signal's trend was noted at that time. This demonstrates the cognitive effects are linked to graphics content. Effective instructional materials aided by visuals can significantly impact students' ability to reason.

The first survey question SQ1 asked participants seeks a response describing the realization of visual cognition effects imposed by graphics-rich content experienced by the participants during usual classroom sessions conducted at PNU.



Fig. 2 Participants' response to research question RQ1. The legends 3, 4, and 5 represent points on Likert's scale



Fig. 4 SQ2 - Infographics reflect contributions to your learning practices as learner.

Error! Reference source not found. depicts that 78% (35 participants) agree to the statement that infographics present information with high quality visual effects. The high percentage of agreeing participants implies that infographic driven education is more commonly realized compared to traditional information presentation approaches. As shown in



Fig. 2, the age groups G3, G4, and G5 fully realize the potential use of infographics. The groups showcase the highest number of participants, who perceive infographics as vital in representing information during learning sessions. However, G1 and G2 appear to be less motivated towards the fact, perhaps may not realize the role of infographics. Although considering it imperative to investigate, the research questions - why age groups G1 and G2 unrealized the potential of infographics? is left to further investigation in future research studies. In addition, which factors help learners to realize infographics as an ineffective approach towards learning practices using visuals either online or offline.

eLearning is experiencing a remarkable surge and popularity due to the advancement of online learning technologies, video conferencing platforms, online training and practice sessions, and the internet. Contrary to other platforms managing teaching formats that limit in-person engagement of instructors and students [73]. An effective learning component, or intrinsic learning motivation, is also associated with creating a usability assessment method for interactive learning applications that blends web and instructional design factors. Recent instructional design techniques consider learning experiences with a high emphasis on learners to co-construct knowledge and cognitive structure in more efficient ways [13].



Fig. 5 Participants' response to research question RQ2. The legends 3, 4, and 5 represent points on Likert's scale.



Fig. 3 SQ3 - Infographics help you read the content more clearly

The second survey question SQ2 asked to the participants reveals the level of motivation of participants exposed to infographics-based learning (see **Error! Reference source not found.**). The responses to the second question suggest that infographics influence participants' learning practices, and as such participants may expect more contribution in terms of learning behaviors. As shown in **Error! Reference source not found.**, again, the age groups G3, G4, and G5 show more inclination towards the premise that infographics enable them to showcase more contributions in learning practices.

As shown in **Error! Reference source not found.**, 28 out of 45 students from G3, G4, and G5 agree to the statement that infographics reflect learning practices, whereas only 4 participants of G2 showcase a below average response. Moreover, only a few other participants in all five groups chose a low Likert scale rating. This implies that most age groups realize the potential role of infographics in their contribution to learning practices. This indicates the level of motivation towards learning via infographics rather than text only containing instructional materials.

An effective technique to express difficult ideas in an understandable and enjoyable way is through data visualization, which combines text with pictures [74]. An infographic visual represents information that integrates graphic elements to clearly and succinctly convey data or concepts to a targeted audience [75]. Infographics can present study findings in a clear and eye-catching way. By doing this, infographics enable support to practitioners to get an insight into and spread the word about their research findings [76], [77].



Numer of Participants

Fig. 4 SQ4 - Infographics help you understand complex information and data



Fig. 5 Participants' response to research question RQ3. The legend 4 and 5 represent points on Likert's scale



Fig. 9 Participants' response to research question RQ4. The legends 3, 4, and 5 represent points on Likert's scale

The survey questions SQ3 and SQ4 almost show similar Likert scale response scores. Fig. 3 shows that out of 45 participants 37 agree that presentation of content by infographics is more clear. However only 8 participants agree a level below the highest scale. Likewise, Fig. 4 depicts that 39 out 45 participants agree that infographics comprehensively present complex information to the learners while only 6 participants rate below at 3 and 4 points for SQ4 on Likert's scale. Looking at both the figures, on average 84% (38 of 45) of learners find visually presented information with infographics more appealing and easy to understand.



Fig. 6 RQ5 - Infographics help you compare and analyse information



Fig. 11 RQ6 - Learners should be assigned home works based on infographics.

Error! Reference source not found. and **Error! Reference source not found.** illustrate the distribution of rating by five groups against the RQ3 and RQ4. 37 participants from G2, G3, G4 and G5 agree that infographics simply complex concepts whereas 39 agree that infographics help explain and understand complex concepts. Again, the most rated scale of 5 by participants for SQ4 presents strong evidence that learners of G2, G3, G4, and G5 can easily interpret complex representations and information. This really reveals how participants realize the influence of infographics over their cognition and retention of complex knowledge structure.

Fig. 6 and **Error! Reference source not found.** illustrate the distribution of rating by five groups against the SQ5 and SQ6, respectively. For RQ5 77.7% (35 out of 45) participants rate high on Likert's scale, implying infographics enable them to compare and analyze information. On the other hand, SQ6 has varied responses from participants. Only 24 participants out of 45, meaning approximately 53.3% (24 out 45) agree to assignment of tasks based on infographics as homework. 7 participants have contrasting opinions as 7 agree at a 4-point scale, whereas other 7 disagree. However, 6 participants rate 3 points on the Likert's scale to represent an intermediate selection against the SQ6. Although unanswered in this study, further exploration is required to research the level of agreement and disagreement by participants over the SQ6.

Error! Reference source not found. and Fig. 7 illustrate the distribution of rating by five groups against the SQ7 and SQ8, respectively. For RQ7 68.8% (31 out of 45) participants rate high on Likert's scale, implying infographics enabled visuals based learning is way better than traditional lecture delivery mode with no visuals.



Fig. 12 SQ7: Visuals based learning is way better than traditional lecture mode.



Fig. 7 SQ8: Static Infographics resources are better than animated infographic resource.

Half of the 50% of the participant's (14 out of 45) submit a low rating against SQ7, meaning some participants still perceive traditional lectures better. On the other hand, SQ6 has varied responses from participants. Only 24 participants out of 45, meaning approximately 53.3% (24 out 45) agree to assignment of tasks based on infographics as homework. 7 participants have contrasting opinions as 7 agree at a 4-point scale, whereas other 7 disagree. However, 6 participants rate 3 points on the Likert's scale to represent an intermediate selection against the SQ6. Although unanswered in this study, further investigation is needed to research the level of agreement and disagreement by participants over the SQ6.

Fig. 7 represents participants' responses for SQ8, interestingly worth to notice since participants varied responses. The figure shows 17 participants rated high on Likert's scale. However, there is huge contrast in participant rating since 11 participants rate average against the SQ8 compared to high rating (5 point) by 17 participants. Likewise, 15 students almost rate similar, however comparatively a bit lower than 11 participants rating on average 3-point scale. Nevertheless, only 2 participants rate very low to the SQ8. On average, only 9 participants out of 45 agree with SQ8, that static infographics serve as better learning resources than animated infographic resources. As the average count of participants is 9, this implies static infographics are realized more effectively than animated infographic resources.



Fig. 8 SQ9: Infographics help you retain concepts for longer times



Fig. 15 SQ10: Infographics help you remember information easily

Fig. 8 and **Error! Reference source not found.** illustrate the distribution of rating by five groups against the SQ9 and SQ10. For SQ9 64.4% (29 out of 45) participants rate high on Likert's scale, whereas one percent less than 50% of highest rating is observed. This implies infographics enable participants retain concepts for longer times.

In contrast, only two participants do not agree with statement and rated low. For the SQ10 34 out of 45 participants rated high on the scale. This evolves to the premise that infographics increases cognition and enables participants to remember or recall information at ease, though with lower count of just 11 participants are not satisfied. The 9 participants rated 4 points on Likert's scale, demonstrating infographics may not suffice for easily recalling information. Only 2 participants rated low at an average level of 3 on the Likert scale, basically neither agreeing or disagreeing to the premise. For both SQ9 and SQ10, high participant count is observed to accept that infographics help in learning cognition and information retention for longer periods.

Fig. 9 and Error! Reference source not found. illustrate the distribution of rating by five groups against the SQ11 and SQ12. For SQ7 77.7% (35 out of 45) participants rate high on Likert's scale, implying infographics makes learning interesting and more comprehensive. However, only 22.2% of the participants (10 out of 45) submit a low rating against SQ11, meaning participants' motivations are low towards adopting infographics in learning processes. SQ12 shows similar variations as SQ11 with 33 participants rating 5 points on the scale. Participant count of 9 rated 4 points on the scale, while only 6% that is 1 participant rated average with other two participants rated 2 points on the Likert's scale. Apparently, responses to SQ11 and SQ12 are above average, implying that creating thinking abilities, motivation, and comprehension are key traits enabled by using infographics in teaching and learning.



Fig. 9 SQ11: Infographics make learning interesting and comprehensive



Fig. 17 SQ12: Infographics helps increase your creative thinking

Finally, Fig. 10 illustrates the distribution of rating by five groups against the SQ13. For SQ7 80% (36 out of 45) participants rate high on Likert's scale, implying infographics enabled visualization using infographics turns complex concepts to be represented by simple visuals. Half of the 50% of the participant's (14 out of 45) submit a low rating against SQ7, meaning some participants still perceive traditional lectures better. On the other hand, SQ6 has varied responses from participants. Nonetheless, only 8 participants rated 4 points whereas only 1 participant rated on average (3) points on the scale. Thus, the role of infographics in the visualization of concepts has high realization among learners, though might contrast with fact the that assigning homework based on infographics may be an nonfeasible option.



Fig. 10 SQ13: Infographics visualizes complex concepts into simple visuals

IV. CONCLUSION

Although many studies attempt to leverage the role of infographics in education, still there is room to enhance the vision of infographics among learners. This study aims to uncover different perceptions of female learners at PNU in Saudi Arabia concerning infographics.

The study is designed using a survey method that enables quantitative analysis of the various perceptions. A total of 45 participants submitted their rating on a Likert's scale that enabled researchers of this study to conclude their results. The findings suggest that infographics enable learners to differentiate between traditional learning and visual-based learning whilst supplementing them with cognitive abilities to retain, express, and sensitize information.

The key findings suggest that students exhibit mixed perceptions of accepting assignments or homework involving practices employing the application of infographics. In addition to this concern, students also reflect varied perceptions on using static versus animated infographics. However, these two research questions remain unanswered and are left for further investigation in future works. Overall, the responses to the other survey questions reflect high motivation towards using infographics in learning, and learners find learning complex ideas at ease with the simple application of infographics in education.

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