Instructors' Perceptions of Intelligent Tutoring Systems and Their Implications for Studying Computer Programming in Omani Higher Education Institutions

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Abstracts: It is a serious problem that universities worldwide, especially in the middle east, have a high rate of failure in programming courses. To overcome this issue which could probably be due to students' lack of engagement, motivation and problem-solving skills, the Intelligent Tutoring System (ITS) can be an effective tool for enhancing student learning. Despite its effectiveness, no prior research has been conducted on the impact of using ITS in higher education institutions in Oman. This study therefore investigates the perceptions of Omani University instructors to determine the levels of awareness, readiness and challenges among Omani higher institutions concerning their integration of ITS. Also, to investigate the reasons for the poor achievement of students in programming courses. We adopted two approaches in this study. First, quantitative research was conducted via a 5-point Likert scale questionnaire distributed to 59 programming instructors from different higher education institutions. Second, quantitative research interviewed 10 instructors. Our questionnaire data reveals that most of the participants are aware of ITS' effectiveness in the learning process. They believe that Oman's higher education institutions are ready to adopt ITS if sufficient training and support is provided. Via text mining, our interview data illustrates the reasons behind poor performance in programming courses which includes English language barriers, deficient critical thinking, lack problem-solving skills and inadequate modes of teaching. This study clarifies the situation of higher educational institutions in terms of their awareness, redness and the challenges that they may face in adopting ITS.

Keywords: Programming fundamentals, Intelligent tutoring system, Computer assisted learning, E-learning, Artificial intelligence.

1. INTRODUCTION

The concepts of learning and pedagogy are crucial due to their essential role in the proliferation of education as a factor for growth and advancement. However, with the rise of information and technological systems, there is a need to search for the best possible approach for fostering the equalization of learners that adapts to their needs. The adaptation of learning is based on the reality that students have different needs in education and therefore entails various alignment methods. In recent years, the adoption of artificial intelligence (AI) in all fields has experienced an outstanding increase. For example, AI has contributed immensely to enhancing the capabilities of e-learning systems. In fact, the use of AI techniques, such as machine learning and deep learning, has engendered the intelligent tutoring system (ITS). ITS is an adaptive learning system that allows learners to have a smoother experience by providing personalized content that fits the needs and capabilities of learners. ITS architecture comprises four components: the domain model, learner model, tutoring model and user interface [1]. The domain model is a source of knowledge that evaluates students' performance and diagnoses their level of knowledge. The learner model is constructed through a student's interaction with the system, where all inferences and system beliefs about the student are stored in the learner model. It may compromise information about the student, such as his or her level of knowledge and possible misconceptions, emotions or competencies [2]. Based on the traits stored in the learner model and the content in the domain model, the tutor model acts as an intermediary between the two; it is the driving engine in the system serving pedagogical purposes. Not only does the model suggest the learning sequence regarding what to teach, but it is also responsible for dynamically modifying the learning path; meanwhile, both the system and learner are in a shared control environment, exchanging questions and answers. The user interface is the communicating component of the system, as it is the form in which the ITS presents itself; thus, it is crucial for it to be accepted by learners due to its ease of use and attractiveness [1]. Figure 1 illustrates the ITS architecture.

ITS plays an important role in education, enabling students to be life-long learners. Different ITSs use different metacognitive skills, such as reflection [3], help seeking [4] or self-assessment [5]. ITS shows its effectiveness when helping learners learn a particular subject, such as programming [6], math [7] or grammar [8], where it enhances students' learning outcomes. Moreover, ITS has the potential to allow students to reach a high level of learning, in contrast to the poor performance of students under conventional instruction methods [9].

Programming language courses often challenge most students due to their technicalities. This is especially true for students learning a second language who do not have a natural inclination toward computing and technology. Omani students completing a programming course, as an introductory course, therefore face difficulties, resulting in a high rate of student failure or dropout among introductory programing courses [10]. This problem is not limited to Omani students; a similar situation also occurs among Saudi-Arabian students [11] and even worldwide [12].

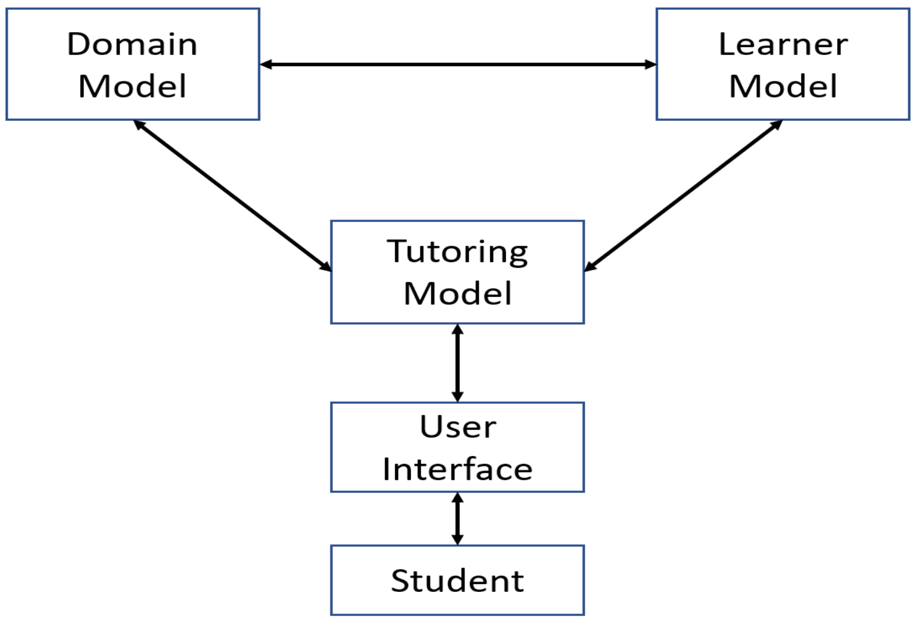

Figure 1. Hierarchical visualization of the typical ITS components. Adapted from [1].

1.1. Research Problem

The problem of poor performance among students in programming courses is common across universities in the Sultanate of Oman. The reasons for this may include the methods of presenting the content to learners. A number of research papers have revealed a consensus regarding the importance and effectiveness of employing ITS in teaching and learning [13], [14], and [15]. However, to the best of the authors' knowledge, no research has been conducted on ITS in Omani higher education institutions and the implications of ITS deployment in programming course instruction. Therefore, there is a need to fill this research gap.

1.2. Research Objectives

This study addresses the use of ITS in computer programming courses in Omani higher education institutions by utilizing an analytical approach. Focusing on the perceptions of faculty members, this study explores the reasons for the poor achievement of learners in programming courses, the need for using ITS in programming courses, and the levels of readiness concerning ITS integration. Specifically, this study addresses the following questions:

1- To what extent are instructors in Omani higher education institutions aware of ITS?
2- To what extent are higher education institutions prepared to apply ITS?
3- What challenges may confront higher education institutions when applying ITS?
4- Do the levels of awareness, readiness and challenges differ due to demographics (gender, qualifications, years of experience or type of institution)?
5- What are the reasons for the poor achievement of learners in terms of programming fundamentals?

1.3. Significance of the Study

Obviously, research on integrating modern technologies into teaching and learning processes is essential. With regard to the Omani context, no previous analytical research has investigated ITS and its importance and implications for learner achievement in higher educational institutions. Thus, the contributions of this study should be of interest to instructors of programming courses in Omani higher educational institutions. Hence, this study is expected to

1- Extend the literature on ITS in the Omani context;
2- Offer potential recommendations for fieldwork, derived from the focal literary evidence;
3- Reveal the effect of ITS on learner performance in programming courses; and
4- Help IT curriculum developers determine the effectiveness of using ITS in programming courses.

This paper is organized as follows: Section 2 summarizes the related research on the reasons for student failure in programming courses and how teaching methods could play a vital role in enhancing student understanding of programming concepts. Section 3 is the methods section, which describes the mixed approach used in this study to answer the research questions. Next, Section 4 describes the results of our study. Section 5, the discussion section, elaborates on these results and the issues raised by them. Finally, the conclusion and future work discussed in Section 6.

2. RELATED WORK

According to some recent research, the rate of failure among students studying programming as a first course is approximately 25% [16] and [17]. Researchers argue that this high failure rate may be due to different reasons, such as motivation and teaching method [18]. According to Shi et al. [19], the teacher of a programming course plays a crucial role in a computer course, but this is a very challenging task, as students face difficulties assimilating the main concepts of programming. These authors introduce a blended learning approach that consists face-to-face classes to teach the theoretical concepts of a programming language while providing practical operation experiments through online tools such as instructional videos, programming online judges, online open source code analyses, simulations, forums and visual conferences. This study shows that the blended learning approach, adopted to teach a programming course, fully mobilizes students' learning enthusiasm and enhances their practical ability. Preliminary research on the opinions of students regarding the use of advanced technologies to study programming has shown that students are motivated to use ICT in these practical courses [20]. They believe that the delivery of programming courses through ICT will enhance their understanding and their performance in these courses. As a result, the authors found that this system contributes effectively to teaching programming in the above mentioned university, as student performance was enhanced.

An investigation was conducted in three different regions in Saudi Arabia to examine the difficulties when learning computer programming [21]. This study pointed out some major drawbacks of conventional classroom courses. The first drawback is the inadequacy of time allocation for experiments and tutorial sessions. Another is the absence of quality assurance and monitoring methods for governing the teaching process. The study also highlighted the lack of responsiveness of instructors, which leads to students' low motivation; however, Alhazbi [18] has emphasized students' motivation as central to their success in introductory programming courses that blend online coursework with face-to-face interaction, which engages students actively in their learning process.

Given the challenge of optimizing learning for Omani students, a case study on students at Nizwa University showed that students studying "Introduction to Algorithms and Programming" as their first course in programming face some difficulties understanding the course. Researchers have listed some of the main reasons for this problem and how to tackle it [22]. First, instructors' teaching methods may be overly traditional, keeping programming concepts ambiguous to their students. Second, instructors tend to focus more on teaching the programming syntax than allowing students to learn how to trace programs to gain a full understanding of how these computer programs work. The third reason is that learning is not sufficiently personalized in an educational environment where each student has different capabilities. Hence, traditional teaching cannot provide each student with exercises that fit his or her level of knowledge and need to understand the algorithms and techniques of a programming language.

In Oman, students at Buraimi University face similar difficulties while studying introductory courses in programming, and thus researchers have applied the approach, deployment, result and improvement (ADRI) method to find a solution enhance the performance of students. Instead of writing code directly to solve a problem, teachers give students the opportunity to analyze the problem using flow charts and pseudocode before they write code in a chosen programming language [10]. Further research has been conducted by Buraimi University to study the ability of a hybrid e-Learning model to enhance communication between instructors and students and to construct a robust performance tracker [23] to improve the relevant learning outcome with tangible evidence. This solution aligns well with the concerns over instructors' challenges and the student-teacher gap highlighted by [18]. Al-Shanfari et al. investigated the effectiveness of adaptation ITS for Omani higher education students in domains other than programming suggests that providing students with instant feedback not only has a positive impact on their engagement and performance but also builds their confidence. The sample involved 110 students from Sultan Qaboos University to examine the alignment between students' level of knowledge and their confidence in the correctness of their answers while completing system assessments [24].

The main goal of this study is thus to analyze the need to deploy ITS in higher education institutions in Oman in programming courses and whether deploying ITS in this practical course in an educational setting can efficiently overcome the various extant challenges. Our analysis of the need for such a system involves instructors teaching level 1 programming courses at different higher education institutions in Oman.

3. METHODS

This study used a two-stage concurrent mixed approach involving, simultaneously, a quantitative approach and a qualitative approach. The quantitative approach involved collecting quantifiable information for statistical analysis, and the qualitative approach involved collecting and analyzing nonnumeric data. The mixed approach is clearly the most appropriate approach to answering research questions, as it allows researchers to integrate the strengths of both quantitative and qualitative approaches and thus develop a stronger understanding of their research problem or questions [25]. In both stages, data collection was conducted with a large sample of programming instructors in public and private universities to explore their perceptions of ITS and their implications for teaching computer programming at Omani HEIs, reflecting the primary goal of this study. The two-stage mixed approach in this study followed the design strategy proposed by Venkatesh et al. [26]. The stages of this mixed approach are elaborated on in the following sections.

3.1. Population and Sample

Omani HEIs are the context of this study. The higher education system in the Sultanate of Oman includes educational institutions, i.e., universities and colleges, distributed geographically across the various regions and governorates in the Sultanate. The number of public institutions affiliated with the Ministry of Higher Education, Research and Innovation is 15. Public institutions accept approximately 15 thousand students each year. There are also 28 private higher educational institutions. The study population comprises the number of instructors who teach programming courses in public and private educational institutions. This population was personally accessed through the heads of the relevant departments in every educational institution. To extrapolate our results to the entire population, all members of the focal population were given an equal opportunity to respond to the questionnaire. Second, a random subgroup from prespecified categories within the sample was selected for qualitative data collection. The sample of this study consisted of 59 instructors. Table 1 lists the numbers and characteristics of the instructors who responded to the questionnaire, and Table 2 provides the numbers and characteristics of the instructors who were interviewed in the qualitative data collection phase. Although private institutions account for up to 65% of higher education institutes in Oman, it is worth mentioning that government institutions accommodate more computer science students; therefore, the number of programming instructors from government institutes is far higher.

Table 1. Numbers and Characteristics of the Respondents to the Questionnaire.

Variables	N	Percentages
Gender		
Male	39	66.1%
Female	20	33.9%
Qualification		
MA Degree	40	67.8%
PhD	19	32.2%
Teaching Experience		
Less than 10 years	25	42.4%
More than 10 years	34	57.6%
Programming Languages Taught		
Python	30	51.7%
Java	40	69%
C++	36	62.1%
C#	9	15.5%
Institution Type		
Governmental	43	72.9%
Private	16	27.1%
Total Responses of Instructors	59	-

Table 2. Numbers and characteristics of the respondents interviewed.

Variables	N	Percentages
Gender		
Male	7	70%
Female	3	30%
Qualification		
MA Degree	8	80%
PhD	2	20%
Teaching Experience		
Less than 10 years	5	50%
More than 10 years	5	50%
Programming Languages Taught		
Python	7	31.9%
Java	6	27.2%
C++	7	31.9%
C#	2	9%
Type of Institution		
Governmental	7	70%
Private	3	30%
Total Responses of Instructors	10	-

3.2. Research Instruments

Two instruments were used to collect the requisite data in this study: a questionnaire and open questions in semi-structured interviews. The questionnaire comprised two parts. The first part was collected participants' demographic data: gender, qualification, teaching experience, programming languages taught, and type of institute. The second part of the questionnaire was divided into three dimensions. The first dimension was "Awareness of ITS", which included 7 items concerning ITS awareness among the instructors of programming courses. The second dimension, "Readiness to apply ITS", referred to an educational institution's readiness to apply ITS within its programming courses and included 14 items. Last, the third dimension was "Challenges of applying ITS" and included 10 items referring to the challenges entailed by ITS adoption in programming courses. To allow the participants some freedom in expressing their opinions on ITS readiness and challenges, we added open question fields to the second and third dimensions. A five-point Likert scale (Strongly Agree = 5, Agree = 4, Neutral = 3, Disagree = 2, Strongly Disagree = 1) was used in the questionnaire. The range of intervals was determined according to Allen & Seaman [27]. Table 3 shows the evaluation criteria we used to measure perception levels.

Table 3. Evaluation Criteria used to Measure Perception Levels.

Likert Scale	Means	Decision
Strongly disagree	1.00–1.79	Very low
Disagree	1.8–2.59	Low
Neutral	2.6–3.39	Medium
Agree	3.4–4.19	High
Strongly Agree	4.2–5.00	Very high

For the semi-structured interview open questions, 11 open questions were included as a checklist for the topics to be covered. The main intention was to make the participants freely express their opinions and thoughts concerning the difficulties that confront instructors in teaching programming fundamentals courses and the reasons for them, as well as the effectiveness of employing ITS in programming courses for learners' achievement. The duration of the interviews was between 20–30 minutes, and all interviews were recorded and converted to text manually. Table 4 shows the 11 open-ended questions that were given to the instructors during their semi-structured interviews. The questions were later grouped into four categories for further analysis.

Table 4. Interview Question Groups with Corresponding Questions.

Reasons for failures in programming courses	What are the problems you face while teaching programming fundamentals, in terms of the instructional environment?
	What are the difficulties you encounter while teaching programming fundamentals when you consider your students?
Engagement & motivation	Do you use tools to increase the engagement and motivation of each student with the course content?
	Do you provide your students with visual representations or animations to clarify difficult programming concepts?
Customization in teaching and learning	Do you customize course content according to differences in students' skill sets?
	Do you provide personalized tasks that fit the different needs and levels of knowledge of the students?
	Do you use innovative methods (simulation-based and analysis-based) to teach programming fundamentals?
	During a practical session, do you look at the work of each student individually and give instant feedback and hints in this regard?
Effectiveness of ITS	Do you think ITS could create an effective teaching and learning process that can identify gaps in students' knowledge and improve these with customized instruction and feedback?
	To what extent does ITS mimic face-to-face human tutoring?
	To what extent do you perceive ITS to be an effective or ineffective tool?

3.3. Validity and Reliability of the Questionnaire

Three subject matter experts in the fields of IT with sufficient knowledge of ITS and experts in designing research tools reviewed the questionnaire's dimensions and items to ensure its validity and the extent to which it met the objectives of the study. Based on the experts' notes, some items were edited or rewritten, and others were removed from the questionnaire. For example, the item "*I will use ITS in the future*" in the first dimension was moved to the second dimension and modified to "*I am ready to use ITS in the future*". For reliability, the questionnaire was pilot-tested with a convenience sample, and then Cronbach's alpha was used to examine its consistency, as this is the most popular test for consistency reliability [28]. Table 5 shows the Cronbach's alpha values for each dimension and for the questionnaire as a whole. The Cronbach's alpha values reached a good level of consistency ($\alpha = 0.88$). The process of examining the validity and reliability of the questionnaire was completed within a period of four weeks. Moreover, the Cronbach's alpha values of the "Awareness of ITS", "Readiness to apply ITS", and "Challenges of applying ITS" dimensions reached an acceptable level of consistency—$\alpha = 0.92$, $\alpha = 0.80$, and $\alpha = 0.69$, respectively.

Table 5. Cronbach's Alpha Values.

No.	Dimension	Items	Cronbach's Alpha
1	Awareness of ITS	7	0.92
2	Readiness to apply ITS	14	0.80
3	Challenges of applying ITS	10	0.69
Overall questionnaire		31	0.88

3.4. Data Collection

The data collection process in this study was as follows:

1. The required quantitative and qualitative data were collected from the study sample and determined by the research questions.
2. The instruments used in the data collection were designed and validated.
3. A timeframe for the data collection was established by creating a plan to specify the period of data collection.
4. Data were collected, and these collected data were then analyzed using the appropriate data analysis tool.
5. The research findings were organized, and the recommendations were written.

3.5. Data Analysis

The first part of the questionnaire represented the demographic variables based on the responses to the first part, and each demographic variable item was classified into two categories. Instructors' qualifications were classified as Master's or PhD holders, and gender was classified as male or female. Types of institutions have been classified as private or government higher education institutions. Furthermore, instructor experience in teaching was classified as more than ten years or less than ten years. For the quantitative data analysis, a software tool (R) was the main analysis tool for analyzing the data collected from the first instrument. Moreover, descriptive statistics, specifically the means, standard deviations, and frequency percentages, were extracted to answer the first, second, third, and fourth research questions. A Likert scale of five points (strongly disagree, disagree, neutral, agree and strongly agree) was used for the questionnaire items. Nonparametric tests have been proposed to be the most appropriate method for ordinal data types [29]. In addition, several types of statistical analyses were used to answer the fourth research question, such as the Wilcoxon Mann–Whitney test. Ordered logistic regression was also used to delineate the relationship between an ordinal response variable and one or more explanatory variables. Effect sizes for logistic regression were reported as odds ratios.

For the qualitative data analysis, a coding process with text mining techniques was performed on the semi-structured interview answers in the grouped interview questions shown in Table 4.

All interviews were recorded. The recorded interviews were first transcribed manually and then presented in a table of columns, with the questions and rows representing the corresponding answers of each interviewee. The following steps were followed to analyze the collected qualitative data:

1. The recorded interviews were converted into transcripts
2. The interview transcripts were placed in MS Word documents in a two-column format.
3. The line-by-line technique was used to define and categorize the codes of the transcripts.
4. The frequency list of words was created using the software tool. The word frequency list identified the most frequently occurring words in the transcripts.
5. These words were grouped into categories based on the fourth research question.

Our analysis in this phase applied natural language processing (NLP) to the interview transcripts with the objective of aggregating all abstractive answers to the interview questions. Practical NLP dates to 1999, when a roadmap of computing patterns in text was realized [30]. The approach used in this research has also been successfully applied in previous studies in different fields, such as medicine and business development [31] and

[32]. The analysis phase entailed using the programming language Python—the free version of Google Collaboratory, a cloud-based Python executable notebook service. In addition, many open source Python libraries including TextBlob and NLTK libraries or core NLP, were used for various tasks, while the RE library was used to preprocess and prepare the text data; Pandas was used to store, transform, and visualize the tabulated data. Table 6 shows the results of these preprocesses concerning the same samples of sentences. The preprocessing steps were as follows:

1. Removed special characters, such as punctuation.
2. Removed stop words using the NLTK stop word list.
3. Lemmatized text to process words via their basic and simple form.
4. Broke down text by tokenizing each individual answer.

The goal was to obtain an abstract answer that aggregates the majority of the most common answers. To achieve this, we resorted to distilling top frequency by part of speech and n-grams. To represent text in a statistically manner, we used a method called N-grams—a sequence of windows of words with a prefixed length, a common practice in the NLP space that is often used in speech recognition machine translation and spelling correction [33]. N-grams are obtained by iterating text with a predetermined window of words (2, 3, 4,…*n*), appended to a buffer list to be counted for frequency after the whole process is performed for each answer. The NLP approach in this study employed the N-gram sequence. To illustrate the different types of N-grams, Table 7 shows how an input is transformed from tokens to statistically counted objects.

Table 6. Sample Sentence, Through Each Preprocessing Step.

Sample	"So, the main thing is that each student has different capabilities"
Remove special characters	"So the main thing is that each student has different capabilities"
Remove stop words	"Main thing student different capabilities"
Lemmatizing	"Main thing student different capability"
Tokenizing	{"Main", "thing", "student", "different", "capability"}

Table 7. A Tokenized Sample, Converted to 3-, 4-, and 5-Grams.

NLP Method	**Output**
Tokenized	{"Main", "thing", "student", "different", "capability"}
2-Grams	{Main thing},{thing student}{student different}, {different capability}
3-Grams	{Main thing student},{thing student different}{, student different capability}
4-Grams	{Main thing student different},{thing student different capability}

The final step was to count any repeating N-gram for each unique tag, ranked from the most frequent, to formulate an abstractive answer and visualize a cloud of words/phrases.

4. RESULTS

This study measured the awareness, readiness, and challenges of deploying ITS in higher education institutions in Oman- i.e., programming courses - and whether it could efficiently overcome various challenges. The study sample included 59 teachers who either currently teach or have taught programming courses. A questionnaire was designed and validated by some experts and then modified accordingly. Next, the questionnaire was distributed to the entire population using electronic means. The questionnaire was designed in two parts. The first part was devoted to collecting participants' demographic data, and the second part was divided into three dimensions: Awareness of ITS, Readiness to apply ITS, and Challenges of applying ITS. The R programming language for statistical computing and graphics was the primary tool used to analyze the data constructed from the instrument. Descriptive statistics, specifically means and standard deviations, were computed to answer the first, second, and third research questions. To answer the fourth research question, several types of statistical analyses were used - e.g., the Wilcoxon Mann-Whitney test to investigate the significant difference between each category based on the specific demographic variable regarding the three dimensions (awareness, readiness and challenges). Finally, for the fifth research question, a coding process with text mining techniques was performed on the semi-structured interview answers to reveal instructors' perceptions concerning the reasons for failure in computer programming courses and the effectiveness of the ITS in programming courses.

Research question 1: To what extent are instructors in Omani higher education institutions aware of ITS?

Table 8 shows the means and standard deviations of the data for the second part, the first dimension of the questionnaire, which relates to ITS awareness. In the results, the statement "*I am familiar with the term Intelligent Teaching Systems (ITS)*" (Mean = 3.85) was the highest average and scored "High", while the lowest mean (Mean = 3.29) with level of "Medium" was for the statement "*I am constantly following the new trends and developments of ITS*". The overall score of the awareness dimension showed a high level of awareness (Mean = 3.60), which means that the instructors are well aware of ITS and that they have sufficient knowledge of its role in teaching and learning, teaching and learning models, its advantages, and its usage. Moreover, they also believe that ITS will support learners studying computer programming.

Table 8. Means and Standard Deviations of the "Awareness of ITS" Dimension.

#	Question	M	SD	Level	Order
1	I am aware of the term Intelligent Tutoring Systems (ITS)	3.85	0.81	High	1
2	I am aware of the role of ITS in teaching and learning	3.69	0.84	High	4
3	I am aware of ITS learning and teaching models	3.41	1.00	High	5
4	I have an idea of how to use ITS	3.37	0.93	Medium	6
5	I believe that using ITS will help achieve learning objectives	3.76	0.80	High	3
6	I believe that ITS will support learners studying computer programming	3.85	0.74	High	2
7	I am constantly following the new trends and developments of ITS	3.29	0.87	Medium	7
	Overall	3.60	0.85	High	

Research question 2: To what extent are higher education institutions prepared to apply ITS?

Table 9 illustrates the means and standard deviations for the data of the second part, the second dimension, which relates to the readiness for applying ITS. According to the table, the statements "*My university/college has adopted learning management systems (LMS)*" (Mean = 4.08) scored the highest mean and "High" level. In contrast, the statement "*ITS has been adopted for teaching computer programing or other subjects at my university/college*" (Mean = 2.71) scored the lowest mean and "Medium" level. The overall score of the readiness dimension showed a high level of readiness (Mean = 3.54). This dimension is related to the availability of capable infrastructures, internet speeds, devices, e-learning modules, security levels, etc. From the instructors' perspectives, Omani higher education institutions thus have a high level of readiness to apply ITS. Some important points worth mentioning are as follows:

1. The statement "*I am ready to use ITS in the future*" (Mean = 3.98) shows that the instructors are highly prepared to use ITS for teaching a computer programming course.
2. Statements 13, 10, 11, 12, 9, 8, 2, and 7, which are related to the learning systems, learning environment security levels, and network infrastructures, show that Omani higher education institutions have a high level of readiness for applying ITS.

Table 9. Means and Standard Deviations of the "Readiness for Applying ITS" Dimension.

#	Question	M	SD	Level	Order
1	ITS has been adopted for teaching computer programing or other subjects at my university/college	2.71	0.95	Medium	14
2	My university/college has a network infrastructure that provides sufficient bandwidth for ITS deployment	3.51	0.92	High	9
3	My university/college classrooms/labs are equipped with high specification PCs	3.36	0.96	Medium	11
4	My university/college has adopted learning management systems (LMS)	4.08	0.93	High	1
5	My university/college has adopted AI-based tools for teaching	2.93	1.05	Medium	13
6	My university/college provides learning systems that introduce personalized content that fits	3.31	1.10	Medium	12

	the needs and capabilities of learners				
7	My university/college applies learning systems that provide mechanisms to ensure all learners are supported when solving their learning difficulties	3.41	0.89	High	10
8	My university/college applies learning systems that help learners build proficiency	3.54	0.92	High	8
9	My university/college applies learning systems that help learners become more engaged and highly motivated	3.60	0.84	High	7
10	My university/college applies learning systems that provide mechanisms to check students' progress	3.81	0.86	High	4
11	My university/college applies learning systems that provide mechanisms that monitor learners' overall progress	3.77	0.85	High	5
12	My university/college provides a secure environment to defend against cyber-attacks and data loss	3.75	0.92	High	6
13	My university/college provides a secure environment that guarantees learners' privacy	3.83	0.93	High	3
14	I am ready to use ITS in the future	3.98	0.80	High	2
	Overall	3.54	0.92	High	

Research question 3: What challenges may confront higher education institutions when applying ITS?

Table 10 presents the means and standard deviations for the data of the second part, the third dimension, which relates to the challenges when applying ITS. Most of the statement responses are at a high medium, except statements 1, 3, and 5. The statement "*Lack of skilled specialists and trainers when developing and using ITS*" had the largest mean, 3.68 with the "High" level. This value shows that the greatest challenge when applying ITS in Omani education institutions, according to the instructors of computer programming courses, is the lack of ITS specialists who can provide training courses on how to use and employ ITS. In the same context, the results reveal that the absence of required technical support is also considered a major challenge by the instructors. The challenge with the least impact on the application of ITS, from the instructors' perspectives, is "*Teaching approaches at my university are not supporting the use of ITS*" (Mean = 3.05). These results show that most Omani higher education institutions provide teaching approaches that support the application of ITS.

Table 10. Means and Standard Deviations of the "Challenges for Applying ITS" Dimension.

#	Question	M	SD	Level	Order
1	Lack of skilled specialists and trainers when developing and using ITS	3.68	0.73	High	1
2	The network infrastructure is insufficient for using ITS	3.12	0.83	Medium	8
3	Absence of required technical support for instructors and students to use ITS	3.56	0.79	High	3
4	Security and privacy are not guaranteed while using ITS	3.08	0.86	Medium	9
5	Lack of sufficient proper training and guidance on ITS for instructors	3.61	0.72	High	2
6	Developing and deploying ITS are not affordable	3.25	0.80	Medium	5
7	The requirements for adopting ITS are highly complex	3.17	0.72	Medium	7
8	The whole setup of an ITS-based learning system is expensive	3.34	0.69	Medium	4
9	Teaching approaches at my university are not supporting the use of ITS	3.05	0.73	Medium	10
10	The IT system lacks the appropriate resources to adopt ITS efficiently	3.22	0.79	Medium	6
	Overall	3.31	0.77	Medium	

Table 11 summarizes the means and standard deviations of the three focal dimensions, from the instructors' points of view. It shows that the dimension of awareness of ITS is the highest (Mean = 3.60; "High" level), followed by the dimension of readiness for applying ITS (M = 3.54; "High" level). Therefore, overall, our results on the perceptions of computer programming instructors suggest the following:

1. The instructors of computer programming courses in Omani higher education institutions have a high level of ITS awareness.
2. Omani higher education institutions are prepared to apply ITS at a high level.
3. The level of challenges entailed by the application of ITS in Omani higher education institutions is medium.

Table 11. Descriptive Statistics for the Dimensions.

#	Dimension	M	SD	Level	Order
1	Awareness	3.60	0.85	High	1
2	Readiness	3.54	0.92	High	2
3	Challenges	3.31	0.77	Medium	3

Research question 4: Do the levels of awareness, readiness and challenges differ due to demographics (gender, qualifications, and years of experience or type of institution)?

ITS Awareness

Table 12 shows the p values of the awareness questionnaire items, based on each demographic variable. A Wilcoxon Mann–Whitney test was used to determine whether the level of awareness differed based on each demographic category. These findings show no differences denoted by a p value > 0.05. This demonstrates that the level of awareness is not influenced by any demographic variable (qualification, gender, type of institution or years of experience).

Table 12. P values for the awareness questionnaire's items, based on each demographic variable.

Awareness	Independent Variables			
	Qualification	Gender	Type of Institution	Years of Experience
I am aware of the term Intelligent Tutoring Systems (ITS)	0.676	0.237	0.660	0.327
I am aware of the role of ITS in teaching and learning	0.949	0.851	0.654	0.744
I am aware of ITS learning and teaching models	0.589	0.773	0.353	0.884
I have an idea of how to use ITS	0.883	0.301	0.467	0.768
I believe that using ITS will help achieve learning objectives	0.972	0.152	0.096	0.408
I believe that ITS will support learner in studying computer programming	0.380	0.596	0.099	0.872
I am constantly following the new trends and developments of ITS	0.685	0.639	0.176	0.080

4.1. HEI Readiness to adopt ITS

Table 13 shows the p values for the readiness questionnaire items, based on the demographic variables. The Wilcoxon-Mann–Whitney test was used to test whether the level of readiness differed based on the demographic variables.

Table 13. P Values for the Readiness Questionnaire's Items, Based on Each Demographic Variable.

Readiness	Independent Variables			
	Qualification	Gender	Type of Institution	Years of Experience
ITS has been adopted for teaching computer programming or other subjects at my university/college	0.247	0.687	0.009*	0.389
My university/college has a network infrastructure that provides sufficient bandwidth for ITS deployment	0.478	0.091	0.170	0.307
My university/college classrooms/labs are equipped with high specification PCs	0.952	0.866	0.383	0.968
My university/college has adopted learning management systems (LMS)	0.357	0.507	0.664	0.903
My university/college has adopted AI-based tools for teaching	0.352	0.154	0.274	0.598
My university/college provides learning systems that introduce personalized content that fits the needs and capabilities of learners	0.281	0.538	0.436	0.065
My university/college applies learning systems that provide mechanisms to ensure all learners are supported when solving their learning difficulties	0.850	0.400	0.201	0.156
My university/college applies learning systems that help learners build proficiency	0.637	0.939	0.352	0.691
My university/college applies learning systems that help learners become more engaged and highly motivated	0.840	0.582	0.609	0.334
My university/college applies learning systems that provide	0.261	0.467	0.698	0.292

mechanisms to check students' progress				
my university/college applies learning systems that provide mechanisms to monitor the overall progress of the learners	0.554	0.350	0.940	0.261
My university/college provides a secure environment to defend against cyber-attacks and data loss	0.721	0.602	0.442	0.385
My university/college provides a secure environment that guarantees learners' privacy	0.572	0.488	0.174	0.432
I am ready to use ITS in the future	0.937	0.564	0.317	0.591

Note: * p-value is less than 0.05.

All the questionnaire items revealed no difference in the level of readiness to adapt ITS in higher education institutions, except one item where the type of institution showed a significant difference regarding ITS adoption in computer programming or courses in other subjects, as shown in Figure 2 ($Z = -2.6131$, $p = 0.009$, $r = 0.34$). That is, instructors in private institutions revealed that they are adopting ITS in their teaching more than instructors at government institutions. To further investigate the effect of every demographic variable (qualification, gender, type of institution and years of experience) on how "ITS is adopted when teaching computer programing or other subjects at my university/college", ordinal logistic regression was used to obtain the probability odds ratio for each independent variable. This showed that instructors in private institutions are more willing to adapt ITS in their teaching (odds ratio, 4.66; 95% CI, 1.541 to 15.1687) than instructors in government institutions.

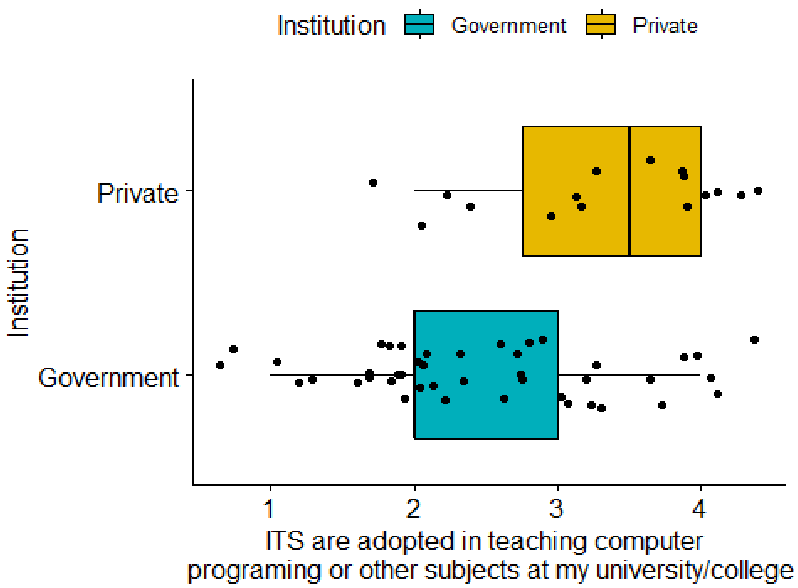

Figure 2. Box plot Pf Questionnaire Items (ITS Has Been Adopted in Computer Programming or Courses in Other Subjects at my University/College), Based on Institution Type.

4.2. Challenges

Table 14 shows the p values for the challenges questionnaire items, based on demographic variables. The Wilcoxon-Mann–Whitney test was used to test whether each challenge item differed based on the demographic variables.

Table 14. The P Values for the Challenges Questionnaire Items.

Challenges	Independent Variables			
	Qualification	Gender	Type of Institution	Years of Experience
Lack of skilled specialists and trainers when developing and using ITS	0.466	0.581	0.382	0.421
The network infrastructure is insufficient for using ITS	0.385	0.502	0.752	0.238
Absence of required technical support for instructors and students to use ITS	0.497	0.408	0.415	0.334
Security and privacy are not guaranteed while using ITS	0.461	0.436	0.893	0.827
Lack of sufficient proper training and guidance on ITS for instructors	0.498	0.039*	0.711	0.614
Developing and deploying ITS are not affordable	0.889	0.594	0.059	0.928
The requirements for adopting ITS are highly complex	0.986	0.467	0.026*	0.460
The whole setup of an ITS-based learning system is expensive	0.739	0.439	0.155	0.752
Teaching approaches at my university are not supporting the use of ITS	0.776	0.937	0.164	0.464
The IT system lacks the appropriate resources to adopt ITS efficiently	0.792	0.405	0.083	0.528

Note: * p-value is less than 0.05.

A questionnaire item differed based on the gender variable: *"Lack of sufficient proper training and guidance on ITS for instructors*", as shown in Figure 3, and this entailed different perceptions. That is, female instructors more often agreed that a lack of sufficient proper training is one of the challenges for adopting ITS in higher education institutions, which we found using the Wilcoxon-Mann–Whitney Test ($Z = 2.0771$, $p = 0.0378$, $r = 0.27$). Further analysis, using ordinal logistic regression, calculated the effect size, which shows that male instructors agree less that a lack of sufficient proper training and guidance on ITS is one of the challenges for adopting ITS (reported by the odds ratio, 0.30; 95% CI 0.089 to 0.91).

Figure 3. Box plot of the questionnaire item "lack of sufficient proper training and guidance of ITS for instructors", based on the gender variable.

Figure 4 shows that the questionnaire item "the requirements for adopting ITS are highly complex" showed a significant difference, based on the type of institution, using the Wilcoxon-Mann–Whitney Test (Z = -2.2383, p = 0.0252, r = 0.29); instructors at private institutions believe that ITS requirements are highly complex and that this is one of the challenges for adopting ITS in HEIs. Further analysis, using ordinal logistic regression, was used to calculate the effect size, reported by the odds ratio (odds ratio, 4.28; 95% CI 1.355 to 14.584), which shows that instructors at private institutions are believe that the requirements for adopting ITS are highly complex more than often than those at governmental institutions.

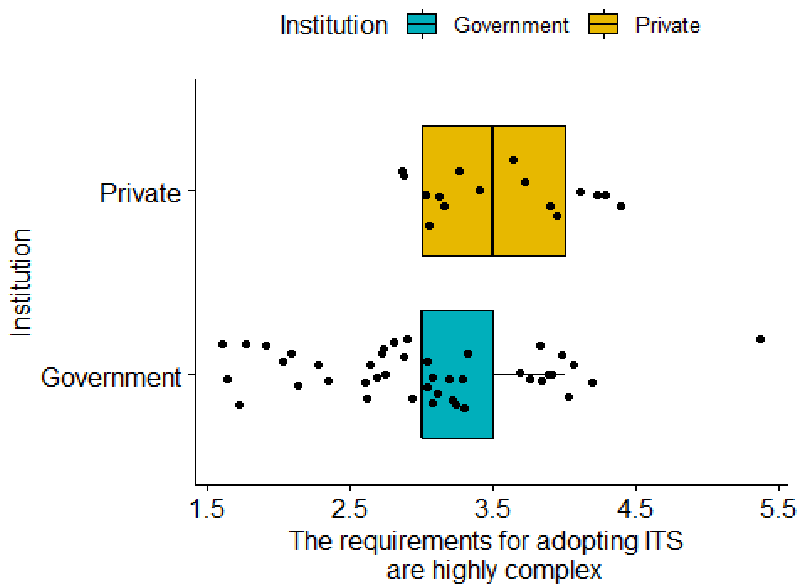

Figure 4. Plot of the item "the requirements for adopting ITS are highly complex", based on institution type.

Research question 5: What are the reasons for the poor achievements of learners in terms of programming fundamentals?

Semi-structured interviews were conducted with instructors from different HEIs to investigate their perceptions of the difficulties that instructors face while teaching computer programming and the effectiveness of ITS in programming courses. Tables 15–18 show the results of the N-gram (bigram, tri-gram and N-4 gram) that we constructed with the transcripts of the semi-structured interviews, divided into three parts: reasons for failures in programming fundamentals, customization in teaching and learning, and motivation and engagement.

4.3. Reasons for Failures in Programming Fundamentals

Based on the N-Gram, shown in Table 15, the main reasons that explain the failures in programming fundamentals are English language barriers, deficient critical thinking and problem solving skills, and inadequate modes of teaching.

Figure 5 visualizes the bigrams of the reasons for failures in programming fundamentals. The color shading variance and scale of a phrase represents its frequency.

Table 15. N-grams frequency for reasons for failures in programming.

N-grams	Reasons for failures in programming	Frequency
2 -Grams	make understand	7
	critical thinking	5
	teaching programming	5
	problem solving	4
	programming fundamental	4
3 -Grams	student difficulty understanding	3
	toward problem solving	3
	didn't face much	2
	face much difficulty	2
	one support	2
4 -Grams	didn't face much difficulty	2
	attitude toward problem solving	2
	difficult student follow instruction	1
	student follow instruction sometimes	1
	follow instruction sometimes manage	1

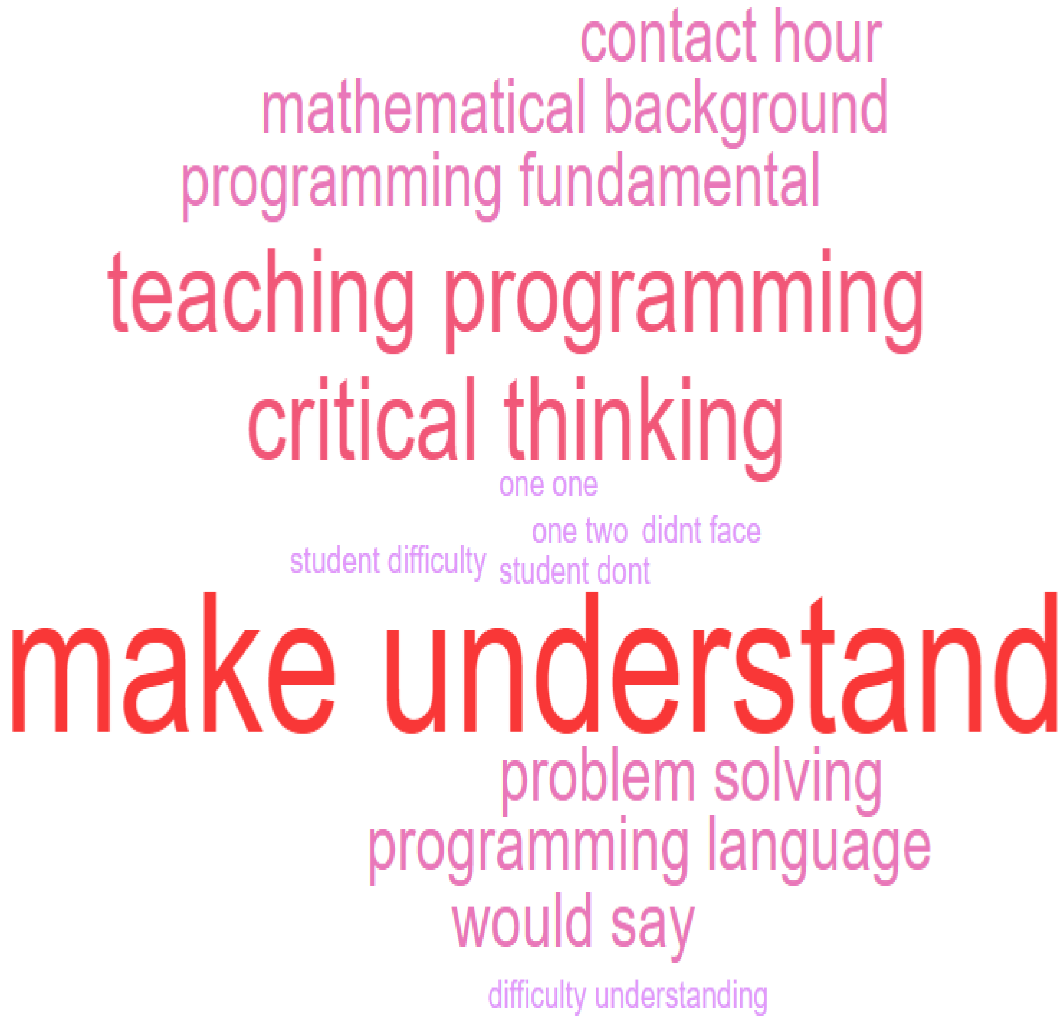

Figure 5. Phrase cloud of bigrams for reasons for failures in programming fundamentals.

4.4. Customization in Teaching and Learning

Most of the instructors believe that customization in programming instruction, i.e., one-to-one support, extra exercises, and intensive practical sessions, as well as tailored extra assignments, helps both excellent and struggling students. Table 16 and Figure 6 show the N-gram frequency and bigram phrase cloud, respectively.

Table 16. N-gram frequency for customization in teaching and learning

N-grams	Customization in teaching and learning.	Frequency
2 -Grams	one	6
	give extra	5
	course content	5
	don't use	4
	practical session	4
3 -Grams	customize course content	3
	don't use innovative	2
	use innovative method	2
	innovative method teach	2
	method teach programming	2
4 -Grams	don't use innovative method	2
	use innovative method teach	2
	innovative method teach programming	2
	method teach programming fundamentals	2
	able keep track student	2

4.5. Engagement and Motivation

Instructors use flow charts and certain tools, such as PowerPoints to show animations that illustrate difficult concepts such as loops and data structures; however, some do not seem to use any tools to specifically increase engagement and motivation, as some of the N-grams shown in Table 17 indicate. Figure 7 illustrates the engagement and motivation phrase cloud bigrams.

Figure 6. Phrase Cloud of Bigrams for Current Customizing in Teaching and Learning.

Table 17. N-Gram Frequency for Engagement and Motivation.

N-grams	Engagement and Motivation	Frequency
2 -Grams	flow chart	6
	data structure	5
	don't use	4
	use tool	3
	loop statement	3
3 -Grams	don't use tool	2
	animation slide help	2
	student submit answer	2
	beginning course give	1
	course give two	1
4 -Grams	beginning course give two	1
	course give two game	1
	give two game reward	1
	two game reward love	1
	game reward love programming	1

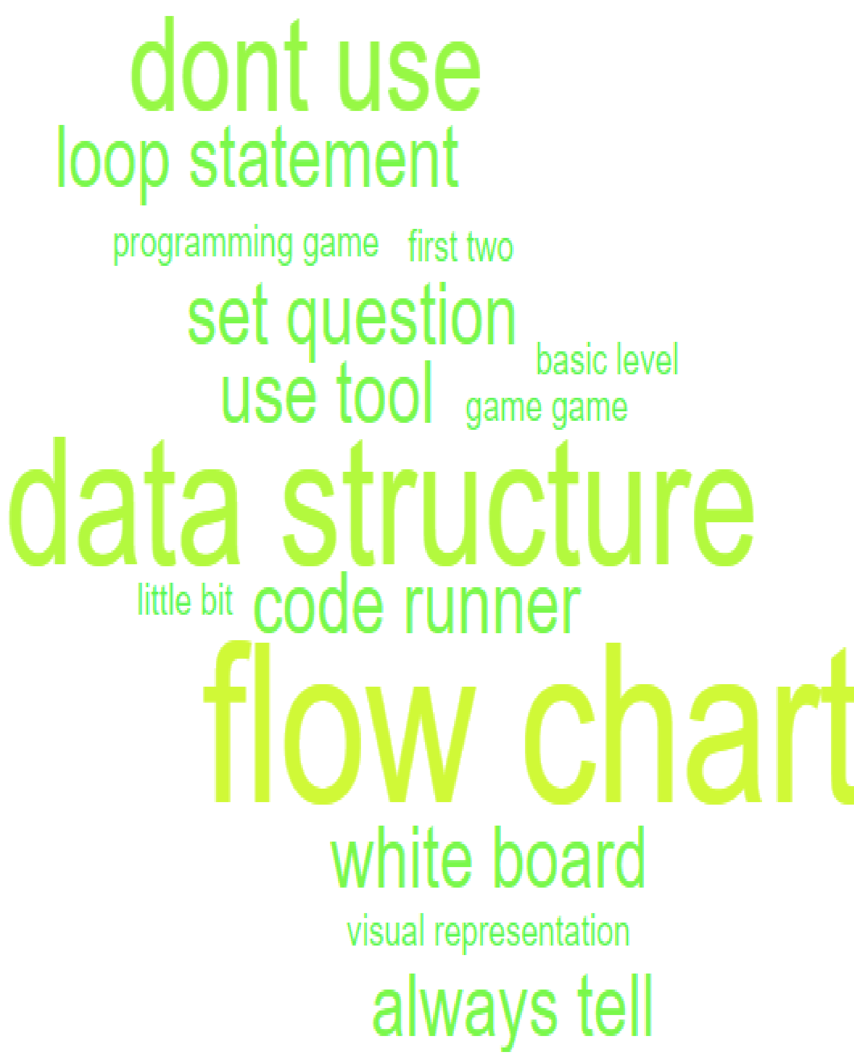

Figure 7. Phrase cloud of bigrams for tools used to enhance engagement and motivation.

4.6. ITS Effectiveness

Instructors' have the perception that applying ITS when teaching programming fundamentals will be an effective tool to enhance student understanding and performance and that this will extend their learning hours, since practical session time is normally insufficient. Table 18 and Figure 8 show the relevant N-grams and phrase cloud bigrams, respectively.

Table 18. N-Gram Frequency for ITS Effectiveness.

N-grams	ITS Effectiveness	Frequency
2 -grams	Face-face	14
	help student	4
	thinking process	4
	face tutoring	4
	one element	4
3 -grams	face face tutoring	4
	taken face face	4
	mimic face face	3
	element face face	3
	would help lot	2
4 -grams	struggle lot know practical	2
	lot know practical session	2
	know practical session provide	2
	practical session provide assistance	2
	session provide assistance teach	2

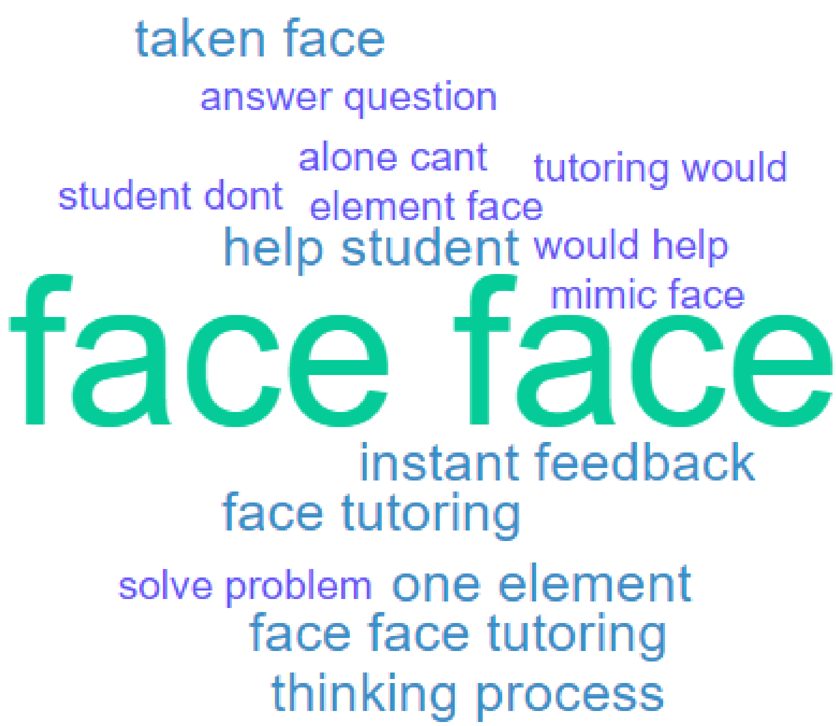

Figure 8. Phrase Cloud of Bigrams on How Instructors Regard the Effectiveness of ITS.

5. DISCUSSION

This paper shows that instructors at higher education institutions in Oman are well aware of ITS and its effectiveness in supporting the learning process and achieving learning objectives. It also shows that HEI infrastructures are prepared to apply ITS, based on their learning environment security and network infrastructure, which contrasts with the medium level of agreement on classroom specifications' readiness to apply ITS for providing personalized systems or adopting AI tools for teaching.

The most concerning challenge for applying ITS, from instructors' viewpoint, is the lack of skilled specialists and trainers when developing and using ITS to provide sufficient training and support. Regarding the readiness of higher education institutions to adopt ITS, there were no differences in respondents' opinions in terms of their demographic variables, except for the type of institution—instructors in private institutions showed more willingness to adopt ITS in their courses. Prior research has shown that the English language can be one of the main reasons for a higher rate or failures in programming fundamentals among nonnative speakers [22] and [10].

Our research has confirmed this result with the text-mining technique, which we applied to the semi-structured interviews. Additionally, this research is aligned with prior research that has shown deficient critical thinking and problem solving skills, and inadequate modes of teaching could be the reasons for high failure rates in programming courses [10]. One of the challenges for students learning programming fundamentals is the lack of personalized learning that is based on their needs. Instructors try to give extra exercises to poor students to enhance their learning or to good students to increase their level of critical thinking and problem solving. However, personalized instruction in a class with a high number of students can be a challenge. Thus, using ITS can solve this problem and allow students to learn on their own time and based on their own learning needs. Instructors try to allow students to engage in the classroom using PowerPoint presentations, animated flow charts to explain some programming concepts and whiteboards.

Engagement and motivation is one of the main ways to allow students to practice more exercises. ITS has been shown to increase students' engagement and confidence when completing assessments [24]. Instructors in higher education institutions believe that ITS is an effective tool if it is deployed in educational institutions, as it supports one-on-one teaching, which can be time-consuming for instructors teaching programming fundamentals.

6. CONCLUSION AND FUTURE WORK

High rates of failure in programming courses have been reported often by universities worldwide, particularly in the Sultanate of Oman. This could be due to a lack of student engagement, motivation, problem-solving skills or because of deficient teaching methods. Despite its importance and effectiveness, no prior research has been conducted on the impact of using ITS in Omani higher education institutions to teach programming courses. This study has investigated the ITS perceptions of programming instructors and their implications for computer programming instruction in Omani higher education institutions. This study has identified the reasons for the poor achievement of students in programming courses and has determined the levels of awareness, readiness and challenges at Omani higher institutions regarding their deployment of ITS. Two approaches were adopted to achieve the research objectives: a qualitative approach and a quantitative approach. The study population covered all instructors who teach programming courses in public and private educational institutions in the Sultanate of Oman.

The population was personally accessed through the heads of the departments in their respective educational institution. The sample of the study consisted of 59 instructors. The quantitative data analysis revealed that most of the participants are aware of ITS' effectiveness for supporting the learning process and agreed that their higher education institutions are ready to adopt ITS on the condition of them receiving sufficient training and support. The quantitative data analysis was performed through text mining; these results indicated that the causes of poor performance in programming courses include English language barriers, deficient critical thinking and problem solving skills, and inadequate modes of teaching. These results could therefore help IT curriculum developers determine the effectiveness of using ITS in programming courses.

Future research could investigate the reasons for failures in programming courses from the student perspective. Thus, combining both instructors' and students' viewpoints would allow us to implement an ITS that could support students in programming courses and address the causes of students' failure in or departure from the computing field.

7. ACKNOWLEDGMENT

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