Student perceptions on the Internet of Things - a case study from Alliance University, India

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ABSTRACT: It is estimated that in 2035 there will be more than 32 billion devices connected to the Internet that either collect and send raw data or that act upon instructions received from a cloud server or user interface. Many institutions now include the Internet of Things (IoT) in their curriculum as they seek to empower their students to become skilled in this field of expertise. The purpose of this article is to present third-year student perceptions on the IoT to determine their current understanding and willingness to adopt such a system. An exploratory case study is used that focuses on qualitative and quantitative data from one group of students (n = 47) from 2024. The results show that many students have a good understanding of what the terms IoT, open source, protocols and applications mean. Many students were convinced that it would be difficult to design and implement such a system, but that it should be done to benefit their communities, and especially in terms of improving waste management and relieving traffic congestion. Students were divided on the personal adoption of such a system, with many expressing concerns regarding privacy, security and trust. However, many students agreed that the main benefit was convenience. It is recommended to use these perceptions to improve current curricula to focus more on engendering confidence among students in the adoption of such systems.

Keywords: Feedback, perceptions, IoT, concerns, benefits

INTRODUCTION

> *What you see is not what others see. We inhabit parallel worlds of perception, bounded by our interests and experience. What is obvious to some is invisible to others* [1].

This statement from the British writer, George Monbiot, suggests that each person on earth perceives the world in a different way that is primarily influenced by personal interests and experiences in life. This is especially true of students in higher education who enter universities with many preconceived ideas and beliefs that are not always accurate in nature. For example, some students may believe that the equator can only be found on the African continent, which of course is not accurate. It is up to the academics at these institutions to have a positive impact on both the conceptual knowledge and cognitive skills of these students who are the potential leaders of tomorrow, and especially in the field of technology.

Positive impacts of such nature can only really be achieved if academics are aware of some of the preconceived ideas and beliefs of students who enter their classrooms for the first time. This is often achieved through diagnostic assessments. It is a form of pre-assessment that allows a teacher or academic, to determine students' individual strengths, weaknesses, knowledge and skills prior to instruction [2]. This may allow the academic to better tailor the content of a course to meet the specific needs of the students. For example, if an academic learns that many students in a class have never used a learning management system before, then he or she would make time in class to explain the operation of such a system, maybe even logging into one and navigating it with the students. This would be a form of academic student support, which is really the duty and responsibility of each academic in higher education.

Obtaining student perceptions near the end of a course or module is also of benefit. These perceptions can help to determine if the instruction has been effective [3], and in evaluating the nature and quality of educational interventions [4]. Student perceptions are often considered in determining whether student academic satisfaction exists regarding the quality of engineering education being offered [5]. If students are satisfied with the instruction they receive, then they are more likely to be motivated to complete the course or module for which they have registered. One such course involves the Internet of Things (IoT) which has been introduced at several institutions around the world.

It comes as no surprise as more IoT courses are deployed around the world. It has been forecast that IoT devices will triple in the next decade, growing from approximately 11 billion in 2022 to around 32 billion by 2035 [6]. Designing

and developing IoT systems to accommodate this vast number of devices will require attributes and skills that academics will need to equip their students with, so that they may significantly contribute to this every growing field of expertise.

The purpose of this article is to present third-year student perceptions of IoT to determine their current understanding and willingness to personally adopt such a system. The adoption of IoT has not taken place in a generic manner around the world, which includes India [7]. Obtaining these perceptions may help to improve current curricula to focus more on engendering confidence among students in the adoption of such systems. This case study starts with a brief overview of the importance of student perceptions, followed by the context and methodology. Results are given in a series of bar graphs followed by the conclusions.

THE IMPORTANCE OF STUDENT PERCEPTIONS

Student perceptions have been gathered on a diverse range of topics over the past decades. A simple Google Scholar search for the exact term *student perceptions regarding* revealed 5,810 results on 24 February 2024. Limiting the period to the last four years reveals a result of 1,550 publications. Topics have included e-learning during the Covid-19 pandemic, the impact of class size on academic success, teacher-student relationships, intrapersonal skills, the role of spirituality, campus crime and empathy cultivation. Similar terms which may be used to search Google Scholar include *student voices*, *student perspectives*, *student feedback* and *student views*. Student perceptions are important for at least three reasons [8]:

1. Student perceptions of teaching behaviour have a direct effect on learning processes and outcomes;
2. To be able to foster students' knowledge and skill development, teachers should be aware of their students' achievement, motivation and learning preferences;
3. Students' reports of teaching behaviour are an important measurement strategy that teachers, as well as other stakeholders, such as school principals, educators, researchers and policy makers can use to monitor teachers' professional development at the local, regional and national levels [8].

Student perceptions were obtained on the use of audio-feedback in a design-based module [9]. These perceptions of teacher behaviour reinforced the importance of giving individual feedback to students, and especially in modules where individual student projects are required. This in turn helped students to better demonstrate the achievement of the learning outcomes required in the module.

Students were asked to report on their intrapersonal skills required for academic success [10]. This is related to student motivation, which academics need to be aware of, so that they may provide additional academic support to their students. In this study, it was revealed that some students do not consider attitude as contributing to their academic success, which would need to be addressed, as one's attitude plays a major role in life, and especially in obtaining employment after graduation.

Mentee perceptions were obtained on a programme relating to the scholarship of teaching and learning [11]. The main purpose of this programme was to help mentees (students) improve their teaching practice which in turn could help to enhance student learning. This improvement would be noted in a teaching portfolio which these mentees would need to compile in the future for promotion purposes. A key requirement in this portfolio would be student feedback on their teaching practice, which relates strongly to what steps have been taken to ensure continuous professional development.

STUDY CONTEXT

Alliance University, situated in Bangalore, India, is a state private university known for its commitment to academic excellence, innovative teaching methods and holistic development of students. Established in 2010, the University has rapidly emerged as a leading educational institution in India, offering a wide range of undergraduate, postgraduate and doctoral programmes across various disciplines including business studies, law, engineering and liberal arts [12].

The University attracts a diverse student body from across the country and around the world, comprising ambitious individuals who are keen on pursuing quality education and shaping successful careers. Students at Alliance University come from varied backgrounds, bringing with them unique perspectives and experiences, which enrich the learning environment and foster a culture of collaboration and diversity.

Alliance University offers a Bachelor of Technology (BTech) programme in computer science and engineering, which is designed to equip students with a strong foundation in computer science principles, along with specialised knowledge and practical skills in areas such as software development, algorithms, data structures, networking, cloud computing and cybersecurity. The programme follows a comprehensive curriculum that combines theoretical coursework with hands-on projects, industry internships and practical training to ensure students are well-prepared for the demands of the technology industry.

The overall structure of this BTech programme includes foundational courses in mathematics, physics and computer science, followed by core courses covering topics, such as programming languages, computer architecture, operating

systems, databases and software engineering. Students may also choose elective courses or specialisations in areas like artificial intelligence, data science, cybersecurity or cloud computing, depending on their interests and career goals. Upon completion of the programme, graduates are well positioned to pursue rewarding careers in various sectors, including:

- Software development: software engineers, developers or programmers, designing and building software applications, systems and solutions for organisations across industries;
- IT consulting: IT consultants, helping businesses leverage technology to improve efficiency, solve problems and achieve strategic objectives;
- Cybersecurity: security analysts, consultants or engineers, helping organisations protect their networks, systems and data from cyber threats;
- Data science and analytics: data analysts, scientists or engineers, leveraging data to extract insights, drive decision-making and solve complex problems;
- Networking: network engineers, administrators or architects, designing, implementing and managing computer networks for organisations;
- Entrepreneurship: graduates with an entrepreneurial mindset can start their own technology ventures, developing innovative products or services and contributing to the growth and innovation of the technology industry.

Overall, this BTech programme provides students with the knowledge, skills and practical experience needed to succeed in the dynamic and rapidly evolving field of technology, opening diverse career opportunities in the global marketplace.

METHODOLOGY

An exploratory case study was used that focused on qualitative and quantitative data from one group of students (n = 47) from 2024. Explorative case studies were carried out to acquire useful indications in an area not (or partially not) explored and their findings constitute just preliminary interpretations of a phenomenon [13]. In this study, the phenomenon was IoT with interpretations of it being obtained from a single group of students enrolled for the BTech in computer science and engineering at Alliance University.

Qualitative questions were asked to determine if students understood key concepts of IoT. These questions were based on the syllabus and course content, thereby adding to content validity. Content validity refers to the degree to which the instrument includes the content it is supposed to measure [14]. These were obtained by using Google Forms. A QR code was displayed on a screen for students to scan using their mobile devices. This was done at the start of every new session, with the questions posed being related to the content for that session.

Quantitative data was drawn from the final session on Saturday, as most of the syllabus had been covered in the previous four sessions (each session lasting between five and seven hours per day). The main questions for this data were drawn from previous research focusing on personal perceptions of IoT [15]. It focused on two scenarios and four concepts (privacy, security, trust and convenience) relating to IoT.

The first scenario outlined the use of GPS co-ordinates that are automatically transmitted by a smartphone to one's home management system. The home security system recognises the co-ordinates and sends a notification to the smartphone that the home's security system has automatically armed itself and that the heat in the house has been turned off.

The second scenario outlined the use of a smartphone that provides a notification that a smart refrigerator has automatically placed an order for milk and bread. The system determined that these items were almost depleted and would be required for the next day according to the households' dietary choices. The notification also states that these items have been paid for automatically by debiting a banking account and that the items will be available after 4 pm for pick up at the supermarket closest to one's place of work.

RESULTS

Table 1 presents qualitative data relating to student perceptions of key terms used within the IoT context. These terms (IoT, open source, protocols and applications) were drawn from a course syllabus offered at Alliance University within their BTech programme. Thematic analysis of the student responses was used to extract keywords that could be grouped together. The number on the right indicates the number of students who mentioned these keywords in their responses. Many students (26) correctly understand that IoT is an interrelated system (i.e. several devices, controllers, transceivers and a cloud storage platform is used). Fifteen students mentioned the keyword *connect*, which is done at the physical layer of the system. Eighteen students used the keyword *available* to explain the term *open source*. Although this keyword is relevant to IoT, it must be understood in the context of software or coding being freely available to the public. The term *protocol* elicited two main keywords, being *rules* and *procedure*. Forty percent of the students mentioned these keywords, with the remaining students mentioning other keywords that could not be grouped together. A variety of keywords were deduced for the term *applications*, which suggests that these students were not familiar with this aspect of IoT. Seven students used the keyword *appeal* that is irrelevant to IoT systems. These results suggest that

more time and course content should be devoted to the last two terms in Table 1 (protocol and applications), as more than 50% of the students provided an incorrect perception of them.

Figure 1 highlights the responses of students to a question on the difficulty of designing and developing an IoT system. Forty percent (15+4/47) agreed that it would be difficult to implement such a system. This also suggest that more time needs to be devoted to instilling confidence in these students to perform such a design. Additional laboratory time could also be spent programming specific microcontrollers that are connected to a small number of devices, such as a light dependant resistor and infrared diode. Confidence can be instilled by creating incremental successes in the learning process, making success meaningful, and giving the learner control over their progress and assessment [16].

Table 1: Qualitative data presented using thematic analysis.

Questions regarding key terms	Keyword responses	No.
What comes to your mind when you hear the term IoT?	Interrelated	26
	Connect	15
	Communicate	6
What do you think of when you hear the term *open source*?	Free	17
	Available	18
What do you think of when you hear the term *protocol*?	Rules	14
	Procedure	5
What synonyms can you think of for the word *applications*?	Program	5
	Implementation	8
	Request	5
	Appeal	7

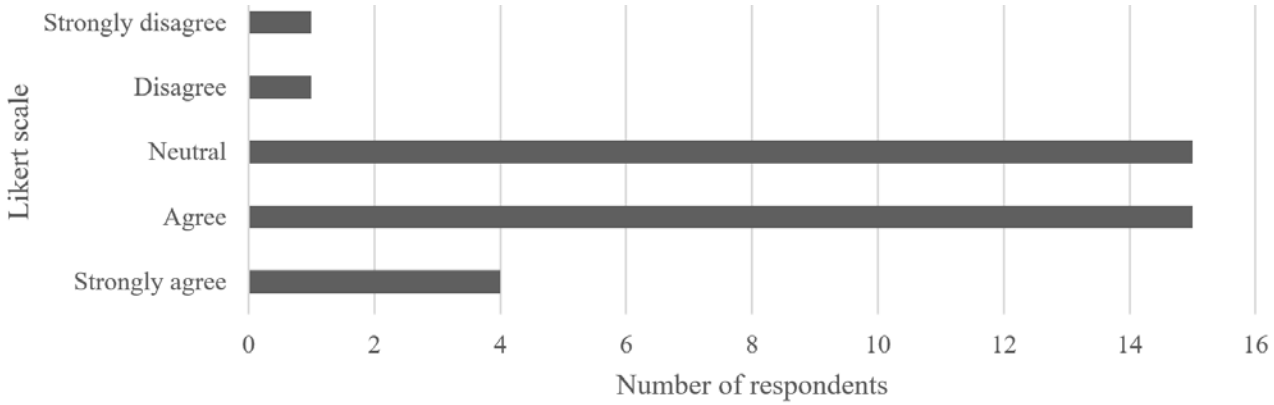

Figure 1: Responses to a question on the difficulty in designing an IoT system.

Figure 2 illustrates Likert scale results of five quantitative questions relating to the first scenario that was shared with the students in a classroom environment.

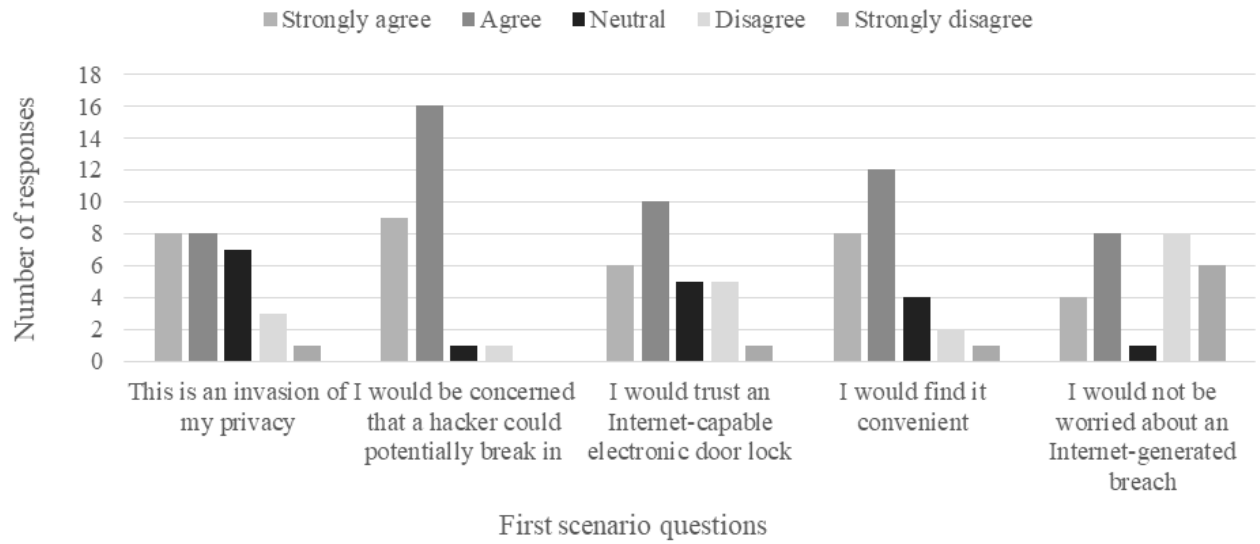

Figure 2: Responses to five questions relating to scenario 1.

Please note that only 27 students completed these questions, as the other 20 students were absent from the class at the time of this session. Many students (8+8/27 = 59%) feel that the use of a home management security system is an invasion of their privacy, while 92% are concerned about a potential hacker. However, 59% did indicate that they would trust an electronic door lock and 74% (8+12/27) felt that such a system would be convenient. The last question elicited a non-uniform response, which may be attributed to being a negatively phrased question. It is like the second question in the figure, but includes the word *not*. Students may not have read this question correctly, which may explain its inconsistency.

Figure 3 shows the Likert scale results of five quantitative questions relating to the second scenario relating to the use of a smart refrigerator. Many students (9+7/27 = 59%) feel that the use of such an IoT system is an invasion of their privacy, while 81% are concerned about a potential hacker. Moreover, only 44% indicated that they would trust such a system. However, 51% (10+4/27) felt that such a system would be convenient. The last question again elicited a non-uniform response. It is like the second question in the Figure but includes the word *not*. Students may not have read this question correctly, which may explain its inconsistency. Interpreting the results of Figure 2 and Figure 3 suggests that more time should again be devoted to instilling confidence in students to both design and use such IoT systems. More students seem to trust an electronic door lock than a smart refrigerator that is linked to their personal bank account. This may be attributed to the fact that electronic door locks are relatively common today, as are fraudulent transactions on banking accounts. Fraudulent bank transactions have the potential to cause significant financial losses, lose client confidence and damage an institution's brand [17].

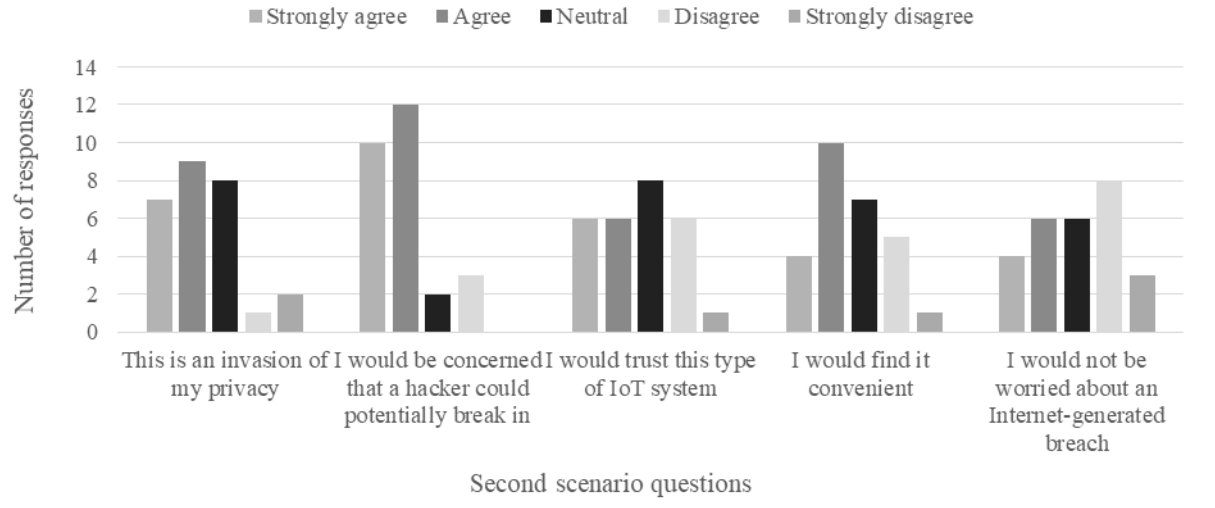

Figure 3: Responses to five questions relating to scenario 2.

CONCLUSIONS

The purpose of this article was to present third-year student perceptions on the Internet of Things to determine their current understanding and willingness to adopt such a system. Obtaining these perceptions may help to improve current curricula to focus more on engendering confidence among students in the adoption of such systems. Key results show that many students have a good understanding of what the terms IoT, open source, protocols and applications mean. Many students were convinced that it would be difficult to design and implement such a system, but that it should be done to benefit their communities, and especially in terms of improving waste management and relieving traffic congestion. Students were divided on the personal adoption of such a system, with many expressing concerns regarding privacy, security and trust. However, many students agreed that the main benefit was convenience.

The study was limited to one group of third-year students at one university in the south of India. Using the questions in this study with students from other universities can help to either collaborate or rupture the results in this current study. However, the perceptions noted here are important in terms of identifying changes that could be made to the curriculum. It is recommended to use them to improve current curricula to focus more on engendering confidence among students in the adoption of such systems.

Each person on earth will continue to perceive the world in a different way that will be primarily influenced by personal interests and experiences in life. It is up to academics in higher education to exert a positive impact on both the conceptual knowledge and cognitive skills of their students, thereby helping to shape their perceptions regarding IoT that can influence them to contribute to the socio-economic development of their communities.

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BIOGRAPHIES

Arthur James Swart completed his Master's degree in education in 2007 and his doctoral in electrical engineering in 2011. He is currently an Associate Professor at the Central University of Technology in South Africa, where he mentors staff members regarding the scholarship of teaching and learning. His educational research focuses on the effective use of educational technology to help students fuse theory and practice. His field discipline research focuses on energy monitoring. James has published close to 200 conference papers and journal articles within the fields of electrical engineering and engineering education. He has a passion for life-long learning and holds the motto that *consistency is often a mark of quality*.

Priestly Shan holds Masters and Doctoral degrees in electronics and communication engineering, earned in 2007 and 2011, respectively, both from Anna University, India. Presently, he serves as the Pro-Vice Chancellor - Academic Affairs at Alliance University, Banglore. He participated in the International Visitor Leadership Programme (IVLP) as a Fellow in 2023. Dr Shan is recognised as a senior member of the Institute of Electrical and Electronics Engineers (IEEE). He is renowned for his dedication to outcome-based education and is a driving force behind various ranking and accreditation endeavours including NBA, ABET, NIRF, NAAC, QS, and others. His research focuses on artificial intelligence, image processing and education technology, and has resulted in 70+ publications in international journals and conferences. Dr Shan is the governing body member of Asian School of Business, Trivandrum and GEMS Polytechnic, Bihar. He is committed to academic excellence and believes that that fostering strong industry-academia-institution collaborations is essential for quality in competency-based curriculum development, teaching methodologies and assessment practices.