Volume: 10 Issues: 75 Special Issue [August, 2025] pp. 1 - 8
Journal of Islamic, Social, Economics and Development (JISED)
eISSN: 0128-1755
Journal website: www.academicinspired.com/jised
DOI: 10.55573/JISED.107501

A CASE STUDY ON OVERVIEW OF CRYPTOGRAPHY UNDERSTANDING AMONG GIFTED SCHOOL STUDENTS

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Article history

Received date	:	5-7-2025
Revised date	:	6-7-2025
Accepted date	:	20-8-2025
Published date	:	29-8-2025

To cite this document:
Zulkifli, R., Mohd, S. M., Khairul Rizal, H. A., Noraizuddin, N. Z., Mohamad Jan, N., & Kamarudin, S. (2025). A case study on overview of cryptography understanding among gifted school students. *Journal of Islamic, Social, Economics and Development (JISED),* 10 (75), 1 - 8.

Abstract: *Cryptography is essential for securing digital communication, but many school students have a limited understanding of it, especially in modern and quantum cryptography. This case study examines the understanding of cryptography concepts among gifted students in the school context, focusing on awareness and perceptions. The study involved 45 secondary school students aged between 13 and 17 years. The quantitative questionnaire item was developed based on the KAP model. The survey was conducted online and was distributed via a messaging platform. Data have been analysed using descriptive statistics, including frequencies, percentages, and mean scores. The results showed that approximately half of the students were aware of general cryptographic concepts, fewer reported having learned about modern cryptography, and only a minimal number were familiar with quantum cryptography. The mean score for each item indicated the highest satisfaction. Despite these gaps, most students agreed that cryptography is important for protecting data and involves encoding messages using mathematical and key-based methods. This case study concludes that there is a considerable lack of awareness and conceptual clarity among students regarding advanced cryptographic topics. The findings underscore the importance of incorporating cryptography into the national school curriculum, particularly in light of the increasing digital threats and the future relevance of quantum technologies. Early exposure to and engagement with educational modules can help bridge the gap and foster a new generation of cybersecurity-aware learners equipped for the digital age.*

Keywords: *cybersecurity education; secondary school; cryptograhy; quantum cryptography; Kolej PERMATA Insan*

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Introduction

Gifted schools and programs have undergone significant changes over the last two decades, evolving from a focus on extracurricular activities to a more systemic, inclusive process that encompasses kindergartens, schools, colleges, universities, families, the economy, and the broader community (Resch, C., 2014). Nevertheless, challenges persist in allocating resources in an equitable manner that does not compromise other educational needs, dispelling elitist images by creating a positive and inclusive school climate, and increasing equity in identifying America's gifted students, especially those from diverse and underprivileged backgrounds. Solutions to these challenges include open and honest communication, raising awareness of the value of gifted education for all students, and widening identification practices and access to services for all potentially gifted and talented students (Kuykendall, T., 2023; Matthews, D., & Kitchen, J. 2007)

Bringing cryptography into gifted education curriculum can help students develop the skills to comprehend, use, and protect 21st-century digital communications. This will encompass a broad range of learning objectives across several major fields of study. In turn, linking theory with practical use makes school mathematics more meaningful and realistic for students. Another important advantage of this approach is the significant increase in student involvement and motivation that results from incorporating cryptography-related tasks, such as creating and decoding codes, engaging in secret-sharing tasks, or experimenting with zero-knowledge protocols. The most compelling reason for keeping cryptography in public education is probably its relevance to real life applications, as digital technologies assume more and more importance in everyday life, ranging from smartphones and the internet of things to cloud computing, an understanding of secure communication, digital signatures, authentication, and blockchain grows vital for the digital citizen. In teaching the basic elements of cryptography, students are introduced to concepts related to privacy, data security, and ethical responsibility in today’s digital society. They are also trained for future possible careers in areas such as computer security and cybersecurity, algorithms and software engineering, as well as data science fields where experience with cryptography is increasingly required. In addition to technical skill, introducing cryptography into education promotes higher-order thinking, a sense of ethics and responsible digital citizenship. It encourages students to consider matters such as trust, security, and privacy in their dealings with technology, thus preparing them for a generation of informed and discerning digital users (Caballero-Gil, P., & Bruno-Castañeda, C., 2007; Erdoğan, F., & GÜL, N., 2023; Hossain, G., & Yarra, D., 2024).

Literature Review

Gifted School in Malaysia

Gifted education in Malaysia has made significant progress, primarily through the establishment of schools specialising in developing high-ability individuals. Kolej PERMATA@Pintar, a boarding school modelled after the Australian system, is a government-run, academically selective institution where students follow an accelerated, enrichment-driven curriculum to excel in STEM and the arts. One major initiative is PERMATApintar™, a nationwide talent identification program that searches for talents throughout Malaysia by offering stages of talent search, holiday camps, and pre-university programs (Ismail, M. J., at al., 2021). In addition, Kolej PERMATA Insan has been developed in conjunction with PERMATA@Pintar, a hybrid gifted education programme that combines Islamic science and STEM at Universiti Sains Islam Malaysia (USIM). An alternative and unique "INAQ" (integration of Naqli and Aqli knowledge) curriculum is offered for Muslim gifted students.

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This institute's focus is on holistic learning, with the integration of Al-Qur'an modules and 21st-century pedagogy. It also conducts international work through consultative committees, overseas camps, student exchange programs, and partnerships involving STEM programs. The lecturer's competencies, such as awareness of the needs of gifted learners, strategies for implementing and forming differentiation in education and integration of technology skills for success in these programs, remain essential to these programs (Universiti Sains Islam Malaysia. (n.d.).

Cryptography Education

Teaching the concept of cryptography is essential for high school students who enrol in computer science and related fields due to its importance in knowing how to secure information in the digital world. The teaching can be focused on two main aspects, which are foundation knowledge (Temkin, A., 2007) and an interdisciplinary nature (Al-Amri, R. M., et al., 2023). By teaching the foundation, students are able to understand the importance of pursuing careers in computer science, specifically in data security. Meanwhile, the interdisciplinary nature must be related to mathematics, engineering and computer science to enable the student to view a large domain in future. The concept of cryptography can be taught through two main approaches: first, by incorporating the topic as an elementary subtopic within the mathematical subject, as the central concept primarily deals with mathematical notations (Caballero-Gil, P., & Bruno-Castañeda, C., 2007). Secondly, through experiential learning with interactive simulations, students can see the process of cryptography itself (Wang, B. & Li, S., 2021). Instructing high school students in cryptography brings significant advantages, as it immerses them in practical situations and links academic mathematics to real-world research and industry uses. By introducing concepts such as blockchain (Hossain, G., & Yarra, D., 2024) and cryptography, students acquire valuable skills for secure computing and enhance their understanding of career opportunities in cybersecurity. Nevertheless, challenges arise due to the intricate nature of cryptographic algorithms and the limited mathematical skills of students, which can lead to anxiety or a fear of difficulty. To address this challenge, it is essential to employ flexible, diverse, and engaging instructional methods to boost students' self-confidence, sustain their engagement, and effectively develop their skills in this area (Gaio, A, 2023; Hossain, G., & Yarra, D., 2024).

Methodology

Figure 1 demonstrates the methodology in this study which employ the quantittave survey design to evaluate students' knowledge, attitudes, and understanding related to modern cryptography and quantum cryptography.

Instrument Development

The questionnaire is divided into two main sections. Section 1 consists of five (5) closed-ended questions with three response options: Yes, No and Not Sure. The question is based on the KAP model (Liu, P. et al., 2025; Qiquan, Z., 2021) that focuses on awareness and perception. In Section 2, seven (7) questions have been developed using a five-point Likert Scale to capture the understanding and agreement in the KAP model.

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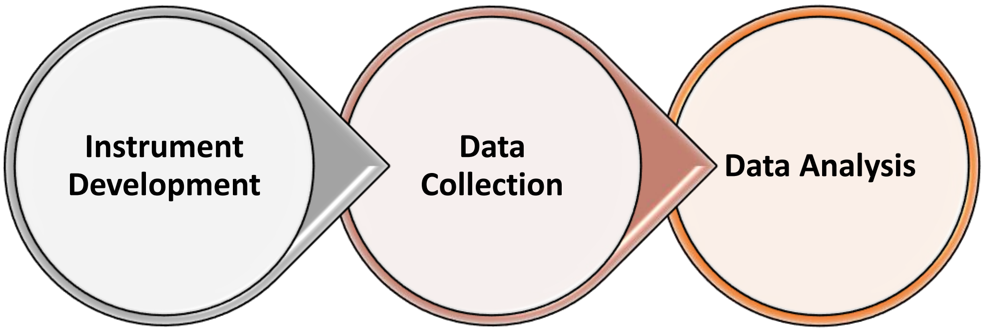

Figure 1: Methodology

Data Collection

The data were collected through an online questionnaire distributed on messaging platforms. The survey employs purposive sampling and utilises volunteers to answer the questions. Respondents were anonymised to ensure confidentiality and privacy.

Data Analysis

The data collected has been analysed using descriptive statistical methods. For Section 1, the Yes/No /Not Sure responses were coded numerically (Yes =1, No = 0, Not Sure = 2) for internal calculation. Frequency counts and percentages were calculated for each response option to identify the distribution of awareness and perceptions among participants. Special attention was given to the proportion of Not Sure responses, as they indicate areas of uncertainty or limited knowledge. For Section 2, the frequency and mean have been calculated for each item for factor practices. The mean score attained from the survey were interpreted based on the satisfaction scale shown in Table 1, which was adapted from (Mohamad Faiz Zainuddin, et al., 2020)

Table 1: Satisfaction Scale Used for Interpretation

Mean Score, M	Level
$1.00 \leq M \leq 1.50$	Extremely Dissatisfied
$1.51 \leq M \leq 2.50$	Dissatisfied
$2.51 \leq M \leq 3.50$	Slightly Satisfied
$3.51 \leq M \leq 4.50$	Satisfied
$4.51 \leq M \leq 5.00$	Extremely Satisfied

Results and Discussion

Student Respondent Demographic

Figure 2 illustrates the distribution of data from 45 students from a gifted school who participated in a survey. The participants were from three different types of residential areas: rural, urban, and suburban. According to the data, 25 students were from suburban areas, 14 from urban areas, and six from rural areas. This indicates that the largest group of participants came from suburban backgrounds, followed by urban, while the rural group was the smallest.

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Volume: 10 Issues: 75 Special Issue [August, 2025] pp. 1 - 8
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This distribution is significant for interpreting the survey findings. Students living in suburban and urban environments may have greater exposure to digital technologies, better internet access, and more formal or informal learning opportunities related to cybersecurity and cryptography compared to those in rural areas. Although the survey did not specifically aim to compare cryptography understanding among these residential categories, the distribution of areas suggests a potential avenue for future research, whether factors related to location (such as internet infrastructure, educational resources, and exposure to technology) influence students' knowledge and views of complex digital concepts like cryptography**.**

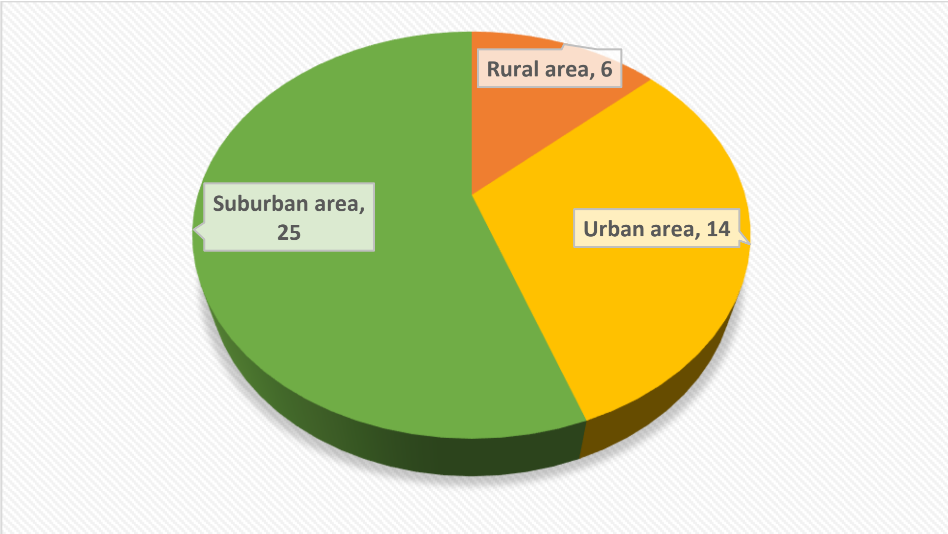

Figure 2: Distribution of Student by Area of Residence

Awareness and Perception of Cryptography

Table 2 summarises the student responses to questions 1 through 5 (Q1-Q5) about cryptography. For the knowledge factor, question 1 (Q1) was relatively balanced, with 46.67% answering 'Yes', 37.78% answering 'No', and 15.55% answering 'Not Sure', suggesting moderate awareness among students. However, from Q2 to Q4, the percentage decreased to 28.89%, 20%, and 4%.44% respectively. The majority of students are unsure about what modern cryptography and quantum cryptography are. It indicates that the students have limitations on both modern cryptography and quantum cryptography concepts. Meanwhile, regarding factor attitudes, only Q5 requires clarification from students, whether modern cryptography is equivalent to quantum cryptography. The high percentage of 'Not Sure' (57.59%) and 40% of 'No' responses suggest that the student lacks confidence and is unsure about the two fields. In summary, the student generally has a basic knowledge of cryptography, but a limited understanding of more advanced topics. It signals an opportunity for curriculum development that bridges foundational knowledge with more advanced, real-world applications, thereby strengthening both knowledge and attitudes toward cryptography.

Table 2: Frequency and Percentage (%) of Student Renponses

Factor	Q	No		Yes		Not Sure	
		Frequency	%	Frequency	%	Frequency	%
Knowledge	Q1	17	37.78	21	46.67	7	15.55
	Q2	26	57.78	13	28.89	6	13.33
	Q3	26	57.78	9	20.00	10	22.22
	Q4	38	84.45	2	4.44	5	11.11
Attitudes	Q5	18	40.00	1	2.22	26	57.78

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Understanding of Cryptographic Concepts

In this subsection, the interpretation of the practice factor reflects the student's understanding and confidence in applying cryptographic concepts. Table 3 shows the frequencies of responses on a 5-point Likert scale, while the mean score and satisfaction level are stated in Table 4.

Table 3: The frequency of Score

Score	Question						
	S1	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**
1	0	0	2	1	0	0	0
2	0	4	5	0	2	0	1
3	19	22	16	19	19	22	18
4	15	7	14	11	17	18	14
5	11	12	8	14	7	5	12

Most questions in both tables indicate a 'Satisfied' level, except for S3, which is rated as 'Slightly Satisfied'. It noted that students from S1, S2, S4, S5, S6, and S7 were confident in cryptography concepts, including encryption, the role of keys, and general security. This gives a positive self-perception of their ability to understand and apply fundamental cryptographic ideas.

Table 4: The Mean Score (M) for Each Question

Question	Mean Score (M)	Satisfaction Level
S1	3.82	Satisfied
S2	3.60	Satisfied
S3	3.47	Slightly Satisfied
S4	3.82	Satisfied
S5	3.64	Satisfied
S6	3.62	Satisfied
S7	3.82	Satisfied

In S3, it has become apparent that students experience difficulties in comprehending the intricate aspects of cryptography, particularly those related to mathematical foundations and algorithms. This subject matter necessitates a profound understanding and mastery that the student has yet to achieve.

Discussion

The result above shows the gap between surface understanding and deep conceptual knowledge. Additionally, there is the possibility of response bias, where students may tend to give neutral or slightly positive ratings on Likert scales due to social desirability or a misunderstanding of the technical content. This could lead students to overestimate their understanding or interpret statements at a superficial level. These findings highlight a significant educational gap, as students have a moderate awareness of cryptography as a security tool, but possess a limited grasp of its mathematical, technical, and quantum foundations. This distinction is crucial, as cryptography involves not only recognising terms but also understanding how these systems function

Conclusions

This study can conclude that most students who participated in this survey were aware of basic cryptography; notable gaps existed in their knowledge of modern and quantum cryptography, as well as a high level of uncertainty when comparing these advanced topics. Even though, in general, most students study to understand the basic concept, when dealing with deep knowledge, they are unable to understand exactly what it is. Therefore, in future work, an educational design approach is needed to deliver cryptography to high school students, incorporating both theoretical and hands-on components to facilitate a better understanding.

Acknowledgements
The authors would like to acknowledge and extended special gratitude to Kolej PERMATA Insan, Universiti Sains Islam Malaysia for funding.

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