The Nominal Group Technique is Used to Develop Numflex Applications for System Numbers

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ABSTRACT

This research examines the necessity of creating interactive applications for number system conversion, explicitly focusing on binary, octal, decimal, and hexadecimal systems in Malaysia's Basic Computer Science curriculum. By utilizing the Nominal Group Technique (NGT) to collect expert opinions, the study identifies significant challenges students face when learning and applying these fundamental concepts through traditional methods. The results unanimously support the need for additional interactive learning materials to enhance understanding and engagement. A high consensus score across all items strongly advocates for the proposed application, emphasizing its potential to address educational deficiencies. The modified NGT technique proved to be an effective alternative to the Delphi method, confirming the practicality and acceptance of the application among the target population. This study concludes that developing an interactive application for number system conversion is crucial for advancing students' comprehension and aligning with global educational standards, thereby significantly contributing to the quality of computer science education in Malaysia.

Keywords: Nominal Group Technique, Number system

INTRODUCTION

Digital literacy and knowledge of computer science are crucial and indispensable parts of education in our rapidly developing digital age. Increasing access to computer science education is essential for achieving Sustainable Development Goal 4, which calls for universal access to high-quality, inclusive education and opportunities for continuous learning. A fundamental familiarity with the number system, including the ability to convert between the decimal, binary, octal, and hexadecimal formats, is a must in this digital era.

There has been some discussion on the need to include digital literacy in higher education, with research highlighting the need for student empowerment via digital literacy [1]. Education has a crucial role in fostering digital literacy, which is essential to meeting the difficulties of the modern period [2]. In addition, several writers have stressed the need to assess students' digital competencies to improve their skills [3].

According to [4], educators and academics have acknowledged that digital literacy is crucial for vocational education and the contemporary workforce. The rise of digital literacy has dramatically affected education worldwide, as people constantly learn new digital skills to keep up with the ever-changing technology world [5]. Research has also examined how digital literacy and technology in the classroom affect student achievement, emphasizing the many skills that make up digital literacy [6]. Competencies in computer science are in high demand due to the expanding IT sector worldwide and the fact that they provide students a leg up in the job market. Numerous digital technologies and computer applications rely on an in-depth understanding of numerical systems, from simple programming to intricate system design.

Asas Sains Komputer (ASK) is a new course in Malaysia's Secondary School Standard Curriculum (KSSM) that aims to teach pupils computer science fundamentals. However, early studies show that pupils face significant challenges when learning to convert between different number systems. One of the biggest problems in teaching and learning about this topic is the complexity and abstract nature of the conversion process, especially when dealing with decimal, binary, octal, and hexadecimal systems. This is where the proposed application can play a crucial role in providing interactive learning resources to help students understand and master these converters.

Programs to improve students' digital literacy levels may significantly boost their academic performance. According [1], Academic output and teamwork may be enhanced by incorporating digital literacy training into the school curriculum and providing readily available digital resources [7]. Success in 21st-century skills requires digital literacy and environmental literacy, with mathematical reasoning abilities being essential [8].

The literature has investigated frameworks and tactics that promote digital literacy in educational contexts where teachers are central figures [9]. To advocate for digital literacy, one must assess goals for enhancing digital literacy and creating more customized learning environments for students and teachers [10]. As a result of developments in ICT, the term "digital literacy" has come to cover a more generalized understanding of literacy [11].

Due to the importance of literacy in developing curricula and attaining educational goals, students enrolled in teacher preparation programs must acquire digital literacy abilities [12]. For pupils to successfully gain their digital literacy abilities, educators and institutions may need to provide training and assistance [13]. Enhancing digital literacy as a learning resource for teacher candidates has been shown to impact several skill indicators, including computational thinking favourably affected by improving digital literacy as a learning resource for teacher candidates [14].

Research has shown that students' digital literacy correlates with their cognitive abilities across various topics, underscoring the importance of digital literacy in gaining access to high-quality learning materials and enhancing academic achievement [15]. The significance of digital literacy in educational settings is shown by the fact that it affects the efficacy of learning via classroom management [16]. Improving people's computer and numbers of skills may pave the way for more interactive and practical educational materials for young children [17].

The synthesis of these sources underscores the need for students to comprehend and convert between multiple number systems, with digital literacy being a crucial aspect of this education. In line with Sustainable Development Goal 4 and the needs of computer science education in Malaysia, the proposed software has the potential to significantly enhance students' understanding of the subject by using exciting and efficient teaching methods. This application could be a game-changer in digital literacy and computer science education.

Conducting a thorough requirements analysis before developing an application for converting number systems is crucial. With its engaging and effective learning tools, this app has the potential to significantly enhance students' knowledge and skills in this area. The research will evaluate the need to develop the application, focusing on improving students' learning and aligning with the SDG4 objectives and the requirements of computer science education in Malaysia.

The goal of creating an appropriate application for converting number systems is to help students grasp this fundamental idea better; this, in turn, should equip them to face the difficulties of an ever-evolving digital world.

RESEARCH AIMS

To build the Numflex applications, the researcher felt forced to conduct this study to acquire expert agreement. Analysing needs is the first step in any design and development study. According to [18], data collection is the focus of this application's development and design study. Our goals for the research's requirements analysis phase are as follows:

- Analyze the need to develop the NumFlex application for Form 2 students for Asas Sains Komputer: Data Representation (number system conversion).

METHODOLOGY

The primary research strategy for this study is the Nominal Group Technique (NGT). Five ASK experts participated in the research. Using Google Meet, researchers organized a virtual NGT session. A two-hour meeting was held. We convened a panel of experts and held NGT-focused brainstorming sessions to generate ideas and potential solutions. The researcher used the NGT approach to do targeted computations at the session's conclusion, yielding data that addressed the study's aims. The NGT-PLUS program is used to determine the session's result. The results are discussed at the study's conclusion.

In addition to the NGT, Focus Group Discussions (FGDs) were conducted to collect detailed feedback from students on their experiences in the number learning system. The FGD involved five student participants and was held in person. Before the session, each student is given an invitation, and consent form, a research information sheet, and a draft outline of the topic to be discussed. These preparatory materials allow students to familiarize themselves with the content and reflect on their experiences before the discussion.

The FGD session, which lasted about three hours, was recorded using audiovisual equipment, with prior permission obtained from all participants. The discussion was structured based on a Microsoft PowerPoint presentation, which serves as a guiding tool to keep the conversation focused and relevant to the study objectives.

A. Thematic Analysis

Following the FGD, thematic analysis was conducted using a deductive qualitative approach. The audio recording of the FGD was transcribed verbatim to capture the actual words of the participants. To ensure the accuracy and reliability of the data, the content of the discussion summary was reviewed with students for verification and clarification. The transcript was returned to the participant, allowing them to verify and, if necessary, correct or revise any information they felt was not accurately represented.

This combined methodology of NGT and FGD provides a comprehensive understanding of both expert opinions and student experiences, leading to a thorough analysis of potential challenges and solutions in the teaching and learning number system in the ASK curriculum.

The integration of the Nominal Group Technique (NGT) and Focus Group Discussion (FGD) methodologies, as proposed by [19] and [20], can offer a comprehensive understanding of expert opinions and student experiences. Researchers can gather diverse perspectives by incorporating NGT, a method aimed at consolidating opinions into group consensus, and FGD, a well-known qualitative research technique for eliciting insights through interactive group discussions. This methodology is in line with the approach taken by [21] in their examination of perceptions of online and face-to-face sessions among medical students and faculty, where FGDs were utilized to capture experiences and opinions.

Furthermore, [22] underscored the significance of evidence-based guidelines developed through expert opinions, further advocating for the integration of NGT to synthesize expert views in analysing challenges and solutions in teaching and learning the number system in the ASK curriculum.

By merging NGT to establish group consensus among experts and FGD to explore participants' personal experiences and attitudes, researchers can attain a holistic understanding of the subject matter. This integrated approach facilitates a thorough analysis of potential challenges and solutions in teaching and learning the number system within the ASK curriculum, ensuring that expert insights and student experiences are considered in the research process.

B. NGT techniques step

The Nominal Group Technique (NGT) is a method for systematically identifying the opinions held by a group on a given topic. Social planning scenarios involve exploratory research, citizen engagement, multidisciplinary expert recruitment, and evaluation of recommendations. Initially, it was understood as a "participatory technique for social planning scenarios" [23] and has since been used in various group settings like empirical social science research.

The Nominal Group Technique (NGT) has been widely applied in various fields, including education, research, and healthcare services, to facilitate consensus-building and idea generation [24],[25],[26],[27] and [28]. Originally presented as a method for identifying strategic problems and developing innovative solutions [24], NGT has proven to be an effective tool for brainstorming ideas in research [25], obtaining group consensus [26], and advancing educational innovations [28]. It is commonly used in medical research studies [28] and nursing education [27].

[29] employed it in their educational study, although it is more often used in social science studies of health concerns. This approach makes finding problems, researching solutions, and prioritizing tasks easier, particularly in "groups of strangers" situations.

There are typically four stages to the NGT:

- Brainstorming: Participants work alone to jot down ideas for answers to a stimulus question.
- Round-robin session: Participants pitch in and record one suggestion on a large flipchart without discussing the topics. The finished papers are then displayed for everyone to see.
- Discussion: Participants discuss each item on the list to ensure mutual understanding.
- Voting: Participants identify crucial ideas, rank their selections (optional), and vote on the flipchart, discussing the voting pattern.

Honest outcomes and commitment are fostered when voting anonymously and following the regulations above. NGT provides an irretrievable record of the group's procedure and results by recording all inputs and approved edits on flipchart pages. This allows meetings to be quickly resumed and documents to be presented to those unable to attend in person or online [30],[31].

C. Sampling

Research disagrees on an adequate sample size for Nominal Group Technique (NGT) investigations. It is possible to do NGT with either a small or big group, depending on the study goals [31]. On the other hand, if people want to talk to one other more, they may form smaller groups. From 5 to 9 experts or participants were suggested by [32]. Using these sources as a guide, the researcher recruited five experts to participate in the NGT technique. This amount is considered appropriate for the study because the present circumstances restrict the number of encounters. NGT has been shown to be effective in quickly validating elements and obtaining expert consensus by developing elements based on literature review, discussing them, and voting for agreement [31].

Furthermore, NGT provides a platform for participants to freely discuss ideas and express their opinions without fear of judgment, making it a valuable tool for determining key implementation factors in various fields such as healthcare [33].

In the context of the present circumstances that restrict the number of encounters, the decision to recruit five experts for the NGT technique aligns with the guidance provided by the researchers mentioned. While some studies, such as those by [34] and [35], aimed to recruit larger groups of experts ranging from 12 to 24 participants, the decision to have a smaller expert group of five individuals can be justified based on the specific needs and constraints of the study. This smaller group size may facilitate more focused discussions, efficient decision-making, and easier coordination, especially when face-to-face interactions are limited.

Furthermore, selecting experts for participation in the NGT technique, as outlined by [36], involves a systematic approach to identifying relevant disciplines, organizations, and experts, ranking them based on expertise, and inviting them in a prioritized manner. This structured approach ensures that the chosen experts bring diverse perspectives and valuable insights to the study, enhancing the quality of the consensus-building process.

In conclusion, while the optimal number of experts for the NGT technique may vary depending on the research context and objectives, recruiting five experts aligns with the recommendations provided by established researchers. The systematic selection of experts following a structured process can help ensure the richness and validity of the outcomes obtained through the NGT technique.

Table 1 Experts chosen from the computer science education field

Participant	Role	Year of experiences	Expertise Area
Expert 1	Teacher	20	Information Technology and Computer Science
Expert 2	Teacher	16	Information Technology and Computer Science
Expert 3	Teacher	15	Computer Science
Expert 4	Teacher	23	Computer Science
Expert 5	Teacher	25	Information Technology and Computer Science

FINDINGS

The Focus Group Discussion (FGD) revealed several key themes that underline the challenges students face in learning number systems, along with their preferences for potential solutions.

Theme 1: Understanding and Engagement in Learning Number Systems

Sub-theme 1.1: Difficulty in Grasping Basic Concepts

Students expressed significant difficulty in understanding the foundational concepts of number systems, such as binary, octal, decimal, and hexadecimal. As *Student A* remarked, *"I really struggle with understanding how the different number systems work. The textbook explanations just aren't enough."* This highlights the inadequacy of traditional textbooks in catering to the diverse learning needs of students. The

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feedback indicates a clear need for more comprehensive explanations and alternative learning resources that can provide a deeper understanding of these essential concepts.

Sub-theme 1.2: Confusion in System Conversion

Another major challenge identified was the confusion students experience when converting numbers between different systems. *Student B* noted, *"Converting from one number system to another is really confusing, especially when I have to remember all the different rules and steps."* This sub-theme underscores the necessity for clearer instructional guidance and tools that can simplify the conversion process. Students require resources that can demystify the complexities of number system conversions and offer more intuitive learning pathways.

Theme 2: Preference for Interactive and Visual Learning Tools

Sub-theme 2.1: Need for Interactive Learning Resources

There was a strong preference among students for interactive learning tools that provide real-time feedback and step-by-step guidance. *Student C* stated, *"I think an interactive app would really help. Something that can show me where I went wrong and guide me through the steps."* This feedback suggests that students would greatly benefit from a digital application that allows them to practice and receive immediate feedback, reinforcing their learning and understanding through an interactive experience.

Sub-theme 2.2: Desire for Visual Aids

Students also expressed a desire for visual aids to help them better comprehend abstract concepts. As *Student D* mentioned, *"If there were animations or visual guides, I think I'd understand the concepts a lot better."* This recurrent theme highlights the importance of incorporating visual representations, such as animations, diagrams, and videos, into educational tools. Students believe that these visual aids would make the learning process more tangible and accessible, especially for complex topics like number systems.

Theme 3: Practical Application and Reinforcement

Sub-theme 3.1: Application of Theoretical Knowledge

Students reported difficulties in applying theoretical knowledge to practical exercises. *Student E* expressed frustration, saying, *"Even when I understand the theory, I mess up when I try to apply it in exercises. It's frustrating."* This sub-theme indicates a gap between theoretical understanding and practical application. To address this, there is a clear need for an application that not only teaches theoretical concepts but also provides practical examples and exercises that help bridge this gap.

Sub-theme 3.2: Need for Frequent Practice with Immediate Feedback

The importance of frequent practice coupled with immediate feedback was strongly emphasized. *Student A* shared, *"I need more practice, but with feedback. Otherwise, I keep making the same mistakes without knowing why."* This feedback highlights the necessity for an application that offers regular, structured practice sessions with real-time feedback, enabling students to learn from their mistakes and improve their accuracy.

The Nominal Group (NGT) technique used in this study has prioritized the key challenges and corresponding solutions for the learning system among Asas Sains Komputer (ASK) students. The focus is understanding and switching between binary, octal, decimal, and hexadecimal systems—fundamental yet complex areas requiring targeted instructional interventions. The NGT session, conducted virtually with five

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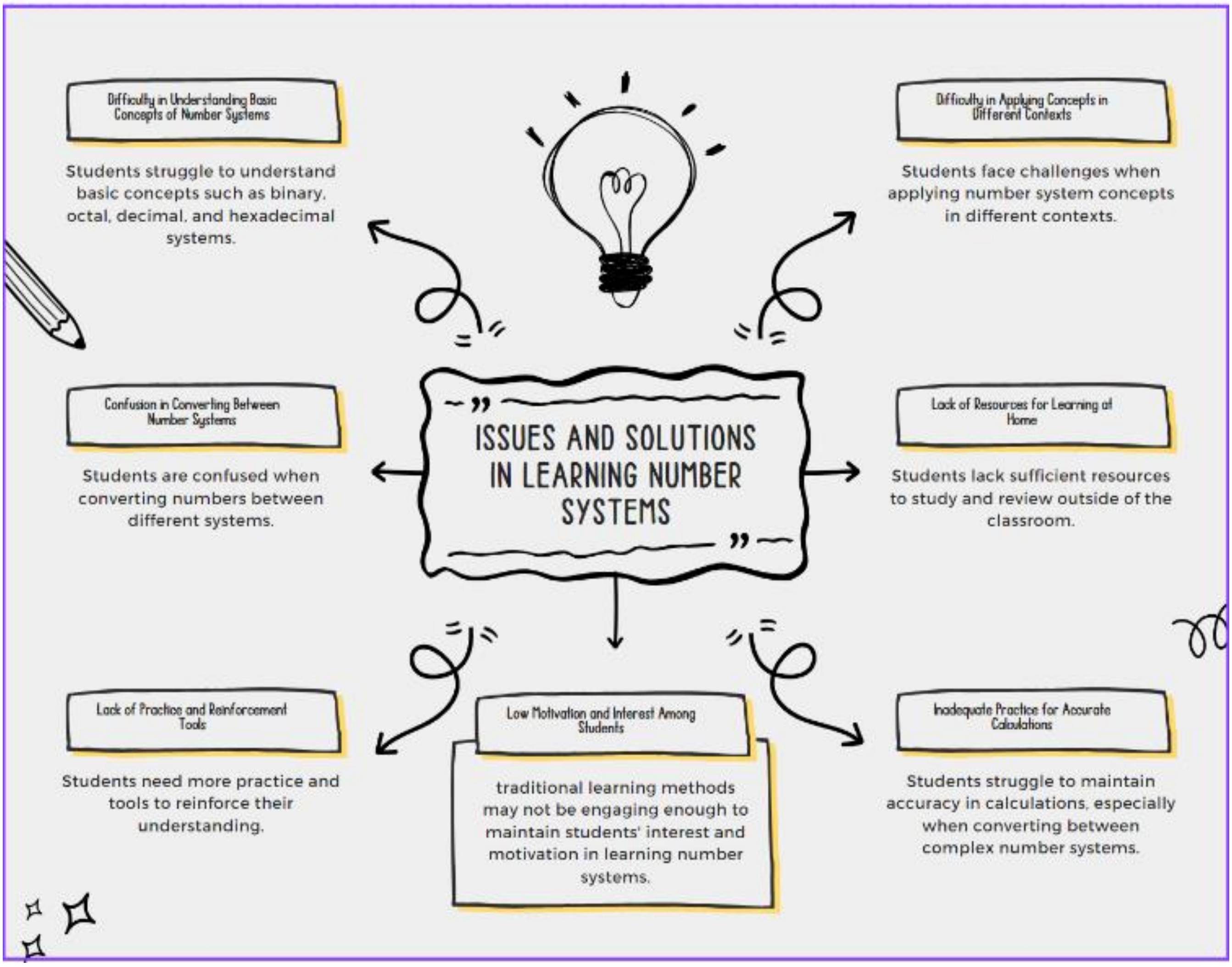
ASK experts via Google Meet, facilitated structured dialogue to identify and position critical issues. NGT-PLUS software ensures a systematic and unbiased positioning process, prioritizing the most pressing concerns and providing a clear roadmap to address teaching and learning number systems challenges.

Fig. 1. Issues and Solutions in Learning Number Systems



The findings revealed several key issues. First, experts unanimously identified students' difficulty understanding the distinctions and relationships among different number systems as the highest priority. This issue highlights the crucial need for instructional clarity and coherence in teaching these concepts. The unanimous identification by experts of students' difficulty in understanding the distinctions and relationships among different number systems as the highest priority underscores a critical issue in mathematics education. This recognition emphasizes the essential need for instructional clarity and coherence in teaching these concepts effectively. The integration of expert opinions through methodologies such as the Nominal Group Technique (NGT) and Focus Group Discussion (FGD) can provide a comprehensive understanding of the challenges faced by students in grasping these fundamental mathematical concepts.

Drawing on the insights from experts, as highlighted by [37], instructional clarity plays a pivotal role in promoting students' understanding by enhancing interaction, coherence, and reducing cognitive load. The study by [38] further emphasizes the importance of designing teaching patterns based on students' lived experiences to address educational challenges effectively. Additionally, the work of [39] underscores the significance of instructional materials that exhibit characteristics such as accuracy, clarity, and suitability in enhancing learners' proficiency.

Moreover, the utilization of expert opinions, as demonstrated in the study by [40], through methodologies like the Fuzzy Delphi Consensus Methodology can enrich the approach by incorporating subjective judgments as fuzzy numbers. This approach aligns with the need to address the complexities and uncertainties associated with expert opinions, as discussed by [41], in practical examples of fuzzy number aggregation.

In conclusion, the unanimous recognition of students' struggles with understanding number systems by experts highlights the critical need for instructional strategies that prioritize clarity and coherence. By integrating expert opinions through methodologies that capture diverse perspectives and insights, educators can develop effective teaching approaches to address these challenges comprehensively.

Similarly, there was consensus on the necessity for enhanced training and more effective tools to aid students in mastering number system conversions, reflecting a critical gap in current pedagogical resources. Another top concern was the lack of skill in binary operations, such as addition and subtraction, suggesting that foundational skills in binary arithmetic require significant reinforcement. Frequent errors in the steps required to convert between different number systems were also highlighted, pointing to the need for more explicit instructional guidance and practice opportunities.

While striving for accuracy in conversions was recognized as a critical concern, it ranked slightly lower than the issues related to understanding and applying fundamental concepts, indicating that this might be a symptom of more profound foundational misunderstandings. Additionally, applying theoretical knowledge of number systems in practical exercises was identified as a significant challenge, underscoring the importance of bridging the gap between theory and practice in the curriculum. The difficulty in grasping the basic concepts of number systems was also noted, though with slightly less consensus, reflecting the need for a stronger foundation before advancing to more complex topics.

The challenge of applying theoretical knowledge of number systems in practical exercises and the difficulty in grasping basic concepts underscore the importance of bridging the theory-practice gap in mathematics education. The study by [42] on visual reasoning in arithmetic word problem solving and the research by [43] on bridging the theory-practice gap in nursing education provide insights into addressing these challenges. By incorporating visual reasoning and practical solutions, educators can enhance students' understanding and application of mathematical concepts, fostering a stronger foundation for learning study [42] revealed that while most participants correctly represented the problem situations through drawing, about half struggled to determine the numeric solutions research [43] emphasizes the importance of theoretical knowledge in nursing practice and how the practice environment influences the application of this knowledge.

Based on these prioritized findings, the Numflex Application is proposed as an innovative solution tailored to address the identified challenges. This application will feature interactive learning resources designed to increase engagement and deepen understanding of number systems through dynamic, interactive content. It will also provide step-by-step conversion guidance, offering clear, structured pathways to accurately convert between different number systems, thereby reducing errors. Additionally, instant feedback mechanisms will reinforce learning and correct misunderstandings in real time, aiding in the development of accuracy and confidence in calculations. Including additional learning materials beyond textbooks, such as visual aids and animations, will cater to diverse learning styles and enhance comprehension.

To enhance the teaching and learning of mathematics, particularly in the context of number systems, incorporating instant feedback mechanisms and utilizing additional learning materials beyond textbooks, such as visual aids and animations, can significantly benefit students. Instant feedback systems, as discussed by [44], [45], and [46] allow for real-time correction of misunderstandings, reinforcing learning and boosting accuracy and confidence in calculations. This immediate feedback mechanism aids in addressing misconceptions promptly, thereby facilitating a deeper understanding of mathematical concepts.

Moreover, the integration of visual aids and animations, as highlighted by [47], [48], and [49] caters to diverse learning styles and enhances comprehension. Visual representations, animations, and interactive tools can make abstract mathematical concepts more tangible and accessible to students, thereby improving engagement and knowledge retention. By leveraging technology and innovative teaching materials, educators can create a more interactive and immersive learning environment that fosters a deeper understanding of mathematical principles.

Furthermore, the use of augmented reality in mathematics learning, as explored by [50] and the application of GeoGebra for teaching geometric transformations, as studied by [51], exemplify how technology can enhance the learning experience by providing interactive and visual learning opportunities. These tools not only make learning more engaging but also help students grasp complex mathematical concepts more effectively.

In conclusion, by incorporating instant feedback mechanisms, visual aids, animations, and technology-based tools in mathematics education, educators can create a dynamic and interactive learning environment that promotes understanding, engagement, and proficiency in mathematical concepts, including number systems.

Tables 2 and 3 present these elements' comprehensive scoring and prioritization, reflecting the expert consensus on the most effective strategies for improving number system education. The development of the Numflex Application is strongly supported by this analysis, indicating its potential to significantly improve learning outcomes in the ASK curriculum.

Table 2: Voting Result of NGT Analysis for Challenges in Learning Number Systems

Items / Elements	V1	V2	V3	V4	V5	Total item score	%	Rank Priority	Voter Consensus
1. Difficulty Understanding Basic Concepts.	3	2	3	2	3	13	86.67	3	Suitable
2. Difficulty with System Differences and Correlations	3	3	3	3	3	15	100	1	Suitable
3. Challenges in Applying Concepts	3	2	3	2	3	13	86.67	3	Suitable
4. Need for More Training and Tools	3	3	3	3	3	15	100	1	Suitable
5. Lack of Skill in Binary Operations	3	3	3	3	3	15	100	1	Suitable
6. Striving for Accuracy in Conversions	3	2	3	3	3	14	93.33	2	Suitable
7. Mistakes in Conversion Steps	3	3	3	3	3	15	100	1	Suitable

Table 3: Voting Result of NGT Analysis for Learning Materials and Tools for Number System Conversion

Items / Elements	V1	V2	V3	V4	V5	Total item score	%	Rank Priority	Voter Consensus
1. Additional Learning Materials	3	2	3	3	3	14	93.33	2	Suitable
2. Interactive Learning Resources	3	3	3	3	3	15	100	1	Suitable

3. Use of Learning Aids Beyond Textbooks	3	3	3	3	3	15	100	1	Suitable
4. Interactive Learning App	3	3	3	2	2	13	86.67	3	Suitable
5. Ease of Understanding with Interactive Resources.	3	3	3	3	3	15	100	1	Suitable
6. Confidence in Calculations with Apps.	3	2	3	3	2	13	86.67	3	Suitable
7. Importance of Non-Textbook Learning Materials.	3	3	3	3	3	15	100	1	Suitable

DISCUSSION

The results of the Nominal Group Technique (NGT) voting give a thorough outline of the need for and possible effects of creating a program to convert between different number systems, particularly between binary, octal, decimal, and hexadecimal systems, as part of the Asas Sains Komputer course. Several important issues need further debate since the experts strongly support them.

First, students need help grasping and using the most fundamental ideas of number systems and how to convert them according to the statistics. Subjects like “students often make mistakes in conversion steps” and “students require more training and tools to understand number system conversions” were deemed appropriate and earned good rankings. This indicates that conventional educational practices and resources can only meet the needs of students with these learning difficulties. Interactive and practical learning tools assist students in transitioning from theoretical ideas to their real-world applications, which I’ve seen firsthand in my role as an educator.

Second, the universal consensus on the need for learning resources outside textbooks shows the changing demands of contemporary education. Items such as “additional learning materials will help students understand conversions better” and “interactive learning resources can enhance students’ understanding and interest in number system conversions” were unanimously agreed upon by all researchers. These results align with [31] which support the idea that incorporating varied and interactive teaching materials may boost student involvement and understanding.

According to the NGT’s overall approval and evaluation ratings, well-designed software that facilitates engaging and fruitful educational experiences is crucial. The proposed application’s essential characteristics are viable and well-received, as the expert agreement on all topics exceeds 70%. The program has the potential to improve learning significantly by giving students the tools they need to become experts in number system conversions, as shown by the high level of agreement.

The analysis’s use of a modified NGT technique—an alternative to the more laborious Delphi method—is a successful and time-efficient way to collect expert views. According to the findings, the suggested application meets both students’ and teachers’ expectations and needs in the classroom. Finally, the results prove that an interactive tool for converting number systems into the Asas Sains Komputer course can be included. The application is designed to improve to the number system. This instructional tool would be a great asset to the learning materials offered to students in Malaysia, as the high agreement among experts confirms its need and potential efficacy.

CONCLUSION

This study demonstrates the critical need for an interactive application to facilitate the understanding and application of number system conversions, specifically for binary, octal, decimal, and hexadecimal systems, within the Asas Sains Komputer curriculum in Malaysia. The Nominal Group Technique (NGT) revealed substantial challenges students face using traditional teaching methods, with unanimous expert consensus highlighting the necessity for supplementary and interactive learning materials. The proposed application, supported by high consensus scores and existing research, promises to bridge educational gaps, enhance student engagement, and improve learning outcomes. The modified NGT method proved to be a time-efficient and effective approach for gathering expert opinions and confirming the feasibility and acceptance of the application. Thus, developing this educational tool aligns with global educational standards and significantly enhances the quality of computer science education in Malaysia.

The focus group discussion (FGD) offered valuable insights into the challenges that students encounter when learning number systems. It became clear that many students struggle with grasping the foundational concepts, applying theoretical knowledge to practical scenarios, and navigating the complexities of converting between different number systems. These challenges are not just isolated difficulties but are interconnected, leading to a broader sense of frustration and confusion among students.

Moreover, the discussion highlighted a strong and consistent demand for a learning tool that goes beyond traditional methods. Students expressed a clear preference for an application that integrates interactive learning resources, utilizes visual aids like animations and diagrams, and provides ample opportunities for practice, all while offering immediate feedback to guide their learning process. They want a tool that not only teaches but also engages, making difficult concepts more accessible and easier to understand.

Considering these findings, the development of the Numflex Application should prioritize several key features. Firstly, it should include comprehensive, interactive modules that explain the basics of number systems in a way that is both engaging and easy to understand. These modules should be designed to actively involve students in their learning, making the content more relatable and less abstract. Additionally, the application should offer step-by-step guides for number system conversions, which would help reduce confusion and enhance students’ understanding of the processes involved. Visual aids, such as animations and diagrams, should be an integral part of the application, helping students to better visualize and grasp complex ideas. Finally, the application should incorporate practical exercises that provide immediate feedback, allowing students to learn from their mistakes in real-time and gradually build their confidence and competence in number system conversions.

By focusing on these aspects, the Numflex Application has the potential to transform how students learn number systems, making the process more intuitive, engaging, and effective. This approach not only addresses the challenges identified in the FGD but also aligns with the students’ expressed needs and preferences, promising a significant improvement in learning outcomes.

FURTHER RESEARCH

Future research should focus on developing and implementing the proposed interactive application, followed by comprehensive testing and evaluation in real-world classroom settings. Longitudinal studies are recommended to assess the sustained impact of the application on student learning outcomes and engagement over time. Additionally, exploring the integration of such applications with other educational technologies and their scalability across different academic levels and regions could provide valuable insights. Investigating the potential for adapting the application to include other fundamental computer science concepts could further enhance its utility and effectiveness. Collaboration with educators and stakeholders will be crucial to refine the application and ensure its alignment with curriculum standards and student needs.

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