

Exploring Information Technology Industry Programming Language Trends with Non-Negative Matrix Factorization Topic Modelling

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Abstract

The study aimed to determine the preferred programming language among information technology professionals using non-negative matrix factorization topic modelling technique. The results showed that the majority of participants were software developers and programmers who commonly used C#, Java, and Python, and agreed that Java, C, or C++ would be the best language to start with when learning programming. The application of topic modelling revealed key themes such as online video tutorials as effective learning resources, hands-on activities as key to learning programming, importance of feedback, effective teaching strategies, and problem-solving skills as crucial for success in programming. Results of the study may serve as baseline data for the improvement of curricular offerings.

Keywords Topic Modelling, NMF, T, Industry, Programming

INTRODUCTION

Information and Communication Technology (ICT) has become a ubiquitous and indispensable tool in our daily lives, revolutionizing the way we interact with others and organizations we are part of [1]. A survey conducted by the Philippines Statistics Authority (PSA) in 2017 revealed that nearly 99% of the ICT sector uses computers and communication tools for work-related purposes, making ICT a core and essential part of many organizations. Breakthroughs in the ICT industry were largely sourced, created, or put into practice using computing tools and computer programming. Computer programming is the process of creating an executable computer program to achieve a particular computational result or to carry out a particular task. It encompasses activities including analysis, algorithm generation, profiling the precision and resource usage of algorithms, and algorithm implementation in a programming language of choice [2]. The need to implement, utilize and maintain computer programs both in large and small companies has been highlighted during the pandemic. The demand for computer programs and software and the engineers who develop it rises as technology plays a bigger role in organizations across all industries. A business may employ software engineers to assist in the development of systems and software when it spots a potential area for improvement. For those who have received training as software engineers, this opens up a wide number of job choices [3]. In 2021, demand for software engineers surged as the pandemic made programming skills shortage worse [4]. Business Insider mentions that 7 out of the top 10 in demand jobs in 2022, which includes jobs in artificial intelligence, data science, robotics engineering, full stack development and javascript development, all involves computer programming [5].

Computer programming is a skill that is increasingly important across a wide range of industries and disciplines in the global economy. A recent study by Burning Glass Technologies [6], found that programming is essential to almost every element of the advanced and modern lives of humans. According to the study, this has increased the demand for individuals with computer coding skills, including business professionals who work with data, website designers and marketers, engineers who build products and technologies, and scientists who conduct research. Because of this, many nations are considering making information technology (IT) and computer science (CS) a requirement for inclusion in the curricula of various educational institutions. To introduce programming at all school levels, the US government, for instance, started the "Computer Science for All" initiative in 2016 which has also been adapted in numerous places in South America, Asia, and Europe [7]. In the Philippines, computer programming is core course in computing programs such as BS Information Technology, Computer Science, Information System and Multimedia Computing [8]. Choosing the appropriate programming language to be taught in the classroom is vital for it will be the foundation of the students when they enter the IT industry. Zhang [9] explained that the improvement of programmers' working efficiency and the attainment of maximum efficiency are directly influenced by the proper choice of programming language. When choosing a programming language, important factors such the language's characteristics and programmers' current mastery situation should be taken into account. This has prompted the researchers to investigate and conduct a research with the aim of eliciting responses from IT practitioners as to what programming language are being utilized in the industry. The researchers utilized a non-conventional way to analyze data using text mining, and topic modelling specifically the Non-Negative Factorization Matrix Topic Modelling technique. This research primarily aims to determine the programming language preference of IT practitioners in the industry using Non-negative matrix factorization topic modelling technique to extract meaningfully various sentiments, thoughts, and written expressions and utilize it as inputs in the improvement of computing curricula being offered in Eastern Samar State University. Specifically this study aims to: (1) preprocess the collected responses from IT Practitioners through stemming and tokenization, (2) Determine the frequently occurring words in the preprocessed responses through a word cloud, (3) identify themes in the collection of responses using the Non-negative matrix factorization topic modelling technique, (4) recommend improvement measures to computing curricula based on the analysis of the themes.

MATERIALS AND METHODS

Research Design

The researcher followed an exploratory sequential design by utilizing a corpus collated from the responses of IT industry practitioners. Creswell [10] explains that in a three-phase mixed methods design known as an exploratory sequential design, the researcher first gathers and analyzes qualitative data before moving on to construct an approach or instrument that will be tested quantitatively. This indicates that the method or instrument will be based on the opinions of the participants. The main goal of an exploratory design is to create and use new variables, surveys, interventions, digital tools, or quantitative measures that are based on qualitative data.

This study used content analysis and relational analysis (Semantic analysis) to provide answers to the research questions, and it was strengthened by examining the concepts that the researcher had already preselected. This study also used logical procedures for gathering qualitative information from the participants, processing the information, and developing the themes. Themes validation was used to interpret hidden information in the text corpus. The same method was used in the study of Albuero et al., [11].

Text Processing and Cleaning

A set of open-ended questions will be sent to all graduates of BSIT and BSCS who were identified to be working in the IT industry in the 2021 graduate tracer study of the college. The first part of the form contained a data privacy notice to comply with the Data Privacy Act of 2012 on confidentiality. The second part will be a textbox where IT practitioners can freely express themselves as to how they understood the

question. They also requested to answer each questions exhaustively. Each response remained anonymous and were named as part1, part2, part3 and so on. The responses will be downloaded in a excel sheet and will be loaded into Orange Data Mining Software. All responses will text preprocessing and cleaning. In the preprocessing stage, information extraction from the documents is performed to identify keywords and relationships within the text this is also known as pattern matching. This technology is very advantageous when dealing with large volumes of text. The preprocessing and cleaning methods that will be performed in this research are:

Stopwords Removal: In natural language processing, stopwords are common words that do not contribute significantly to the meaning of a text. These words, such as articles, prepositions, and pronouns, are often removed from a text to reduce its dimensionality and make it easier for analysts to process. Removing stopwords helps to simplify the text and make it more focused on the essential information [12].

Stemming: Stemming is a method used to identify the root or stem of a word. For example, words such as "connect," "connected," "connecting," and "connections" can all be traced back to the root word "connect" [13]. The goal of stemming is to reduce the number of words in a text, improve the precision of matching stems, and conserve time and memory resources [12].

Term Frequency-Inverse Document Frequency (TF-IDF): TF-IDF is a numerical statistic used to assess the importance of a word in a collection of documents. It is widely used in information retrieval and text mining and is calculated by taking into account the frequency of a word in a document and balancing it with its frequency in the entire corpus. A word with a high TF-IDF score is considered to be important and relevant to the collection of documents [12].

Non-negative matrix factorization (NMF)

Topic modeling is a technique used to process the enormous amount of data produced in corpora and extract the interesting and intriguing concepts, practical features, and latent variables from data that are dependent on the application context. This research will implement a non-probabilistic model based on linear algebra called non-negative matrix factorization (NMF). The dimension of the input corpora can be decreased using a statistical technique called non-negative matrix factorization. It use the factor analysis method to give the words with less coherence comparatively less weight.

Non-negative matrix factorization is classified as an unsupervised topic modelling technique. It is capable of performing clustering and dimension reduction simultaneously. Matrix factorization is utilized in the Ensemble Method for topic modeling. NMF Techniques can be used to create a topic model for the body of an unstructured document that is more particular. Ensemble generation and ensemble integration are two components of matrix factorization that are combined with ensemble learning for topic modeling. Without any prior knowledge of the original data, the NMF model may extract pertinent information about topics. The original data are divided into two non-negative matrices, U and V [14] as shown in the equation below:

$$\begin{array}{ccc}
 \text{U} & & \text{D} \\
 \left[\begin{array}{|c|c|c|c|} \hline & & & \\ \hline & & & \\ \hline & & & \\ \hline & & & \\ \hline & & & \\ \hline \end{array} \right] & \times & \left[\begin{array}{|c|c|c|c|c|c|} \hline & & & & & \\ \hline & & & & & \\ \hline & & & & & \\ \hline & & & & & \\ \hline & & & & & \\ \hline \end{array} \right] & \approx & \left[\begin{array}{|c|c|c|c|c|c|} \hline & & & & & \\ \hline & & & & & \\ \hline & & & & & \\ \hline & & & & & \\ \hline & & & & & \\ \hline \end{array} \right] \\
 & & \text{D} \approx UV
 \end{array}$$

Figure 1 NMF Visualization

where U and V are Non-negative element such as $U \geq 0$, and $V \geq 0$. NMF measures the distance between D and UV by the squared Frobenius norm, and formulates the topic modeling problem as the following optimization problem:

$$(U, V) = \arg \min_{U \geq 0; V \geq 0} \|D - UV\|_F^2$$

Formula 1 Formula showing U and V Matrices as non-negative

where the nonnegative constraints make the solution interpretable. Under the anchor-word assumption, the word distribution U is enforced to be a block diagonal matrix, which guarantees a consistent solution.

Data Source

The research was based on a dataset comprised of responses from 23 IT industry practitioners. The participants were asked a series of questions, including their preferred programming languages, recommendations for introductory programming tools, object-oriented programming and web development, as well as their opinions on the most effective methods for teaching programming in universities based on their own experiences in the industry. The answers to these questions provided a rich corpus of information that was analyzed and studied in detail to gain insights into the current state of programming preferences, practices and trends in the IT industry.

Data Interpretation

In the interpretation of the results, the researchers will aim to provide a comprehensive description of the findings and engage in a thorough discussion about the phenomena revealed and supported by the literature. The discussion will strive to address the gaps identified in the introduction, delving into the underlying reasons behind the observed results, and suggesting potential solutions. This will be achieved by answering questions such as how the findings came about, why they happened, and what can be done to address them.

Tools and Software Used

This study will make use of the Orange Data Mining Software for text processing, topic modelling, sentiment analysis, and word cloud generation. Orange is an open-source machine learning and data visualization software that enables the creation of data analysis workflows through a visually appealing and user-friendly interface, with a large and diverse range of tools and features [15].

Ethical Considerations and Reflexivity

Conducting research, particularly research that involves the responses of individuals, requires strict adherence to ethical standards. To maintain the confidentiality and privacy of the IT practitioners, their names will be transformed into codes (e.g. part1, part2, part3, etc.) before the preprocessing of the documents. Only the contents of the documents/responses will be utilized in this study. The researchers' primary objective in conducting this research is to uncover the underlying sentiments and preferences of IT industry practitioners regarding programming languages, and no other motives are involved.

RESULTS AND DISCUSSION

Word Cloud

After conducting a thorough and exhaustive series of data analysis procedures, utilizing various techniques such as sentiment analysis and topic modeling, the researchers were finally able to obtain the following results, which provide a comprehensive and in-depth understanding of the programming language preference of IT Industry Practitioners.



Figure 2 Common IT Industry Jobs

It can be gleaned in the word cloud that the prominent job of most of the participants were software engineers, programmers and developers. This data is supported by Preston [3] which mentioned that as the significance of technology continues to increase in the global business landscape, the demand for cutting-edge software and the professionals who can create it has skyrocketed. In this digital age, businesses of all sizes and across a wide range of industries are recognizing the need to embrace technology in order to remain competitive. When a company identifies a potential area for improvement through the implementation of technology, it often turns to the expertise of software engineers to develop and implement the necessary systems and software solutions. This presents a wealth of job opportunities for individuals who have received training and education in software engineering. These individuals possess a highly valued set of skills that allow them to design, develop, test, and maintain software systems for a variety of applications. With the continued growth and expansion of technology, the career prospects for software engineers remain promising and exciting, offering a broad range of opportunities for growth and advancement.

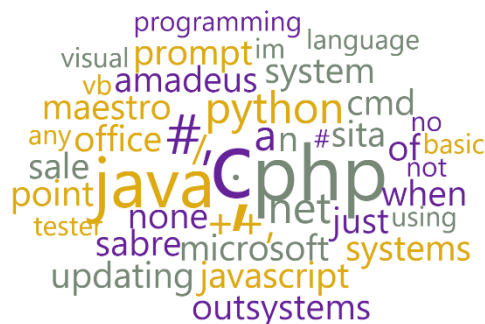


Figure 3 Common IT Industry Programming Languages Used

It is evident in the word cloud that most of the participants use C#, Java, PHP and Python as the primary programming tool in their jobs. Cass [16] mentioned that the popularity of programming languages is constantly evolving and changing in response to new trends and developments in the tech industry. Currently, Python is the leading language in terms of popularity, but it is closely challenged by the C programming language and its derivatives, including C++ and C#. These combined languages would even surpass Python in terms of popularity if considered together. Java, another widely used language, also continues to hold its place as a popular programming language. Meanwhile, the rise of complex websites and in-browser tools has boosted the popularity of Javascript and PHP. Furthermore, C#, Java, PHP and Python were among the most used programming languages of 2022 on the recent survey of Statista [17].

Themes

Online video Tutorial as an effective learning resource

Learning programming involves acquiring complex skills in a short period, which presents challenges for students. This is not only due to their limited problem-solving abilities and superficial understanding, but also their inability to visualize the program's execution process. As a result, they struggle to identify and resolve problems when the code doesn't produce the desired outcome. One solution to this is to use helpful learning aids, such as visualization tools [20]. This theme is in line with the findings of Mazariri et al. [21] who confirmed that a student's perception of the usefulness and ease of use of YouTube has a positive and significant impact on their attitude towards using the platform. Furthermore, the study found that a student's positive attitude towards using YouTube also positively and significantly affects their intention to actually use it. The study of Okechukwu's [22] found that incorporating multimedia into the teaching process has a positive impact, particularly on students' achievement and engagement. The study is noteworthy in its examination of computer programming, a crucial subject any computing subject. With the abundance of educational videos on YouTube from experts around the world available for free, today's learners have access to a wealth of high-quality information, regardless of geographical or other limitations. Kadruai [23] mentions programming as a highly desirable skill that often results in a fulfilling career. Over the past decade, the demand for programmers and student interest in the field has risen significantly, and online programming tutorials have become more widespread. However, new learners are confronted with a vast array of programming languages, leading to confusion about where to start. YouTube offers many opportunities for self-expression through video, making content readily available for anyone interested. Additionally, social networking features bring users together and create a supportive community for learning and sharing ideas.

Participant 6: "Although teachers tackle topics in the classroom, watching videos and tutorials in youtube can aid you in topics that you don't understand."

Participant 15: "In my opinion, it would be best to use new/latest instruction materials such as books and informative videos which is related to the subject itself, in order for the students to get a grasp of the knowledge that they need"

Hands-on activities as main driver in learning programming

Von Hausswolff [24] conducted a controlled study showed that hands-on learning reduced stress and helped with long-term learning. However, its effectiveness in improving learning outcomes right after initial exposure to programming couldn't be confirmed. It's believed that the benefits of hands-on learning over time is due to emotional factors playing a mediating role. According to Kadar [20], modifications are essential in both students' study approaches and attitudes, as well as in traditional teaching methods. To spark students' interest in programming, hands-on programming practice and innovative teaching techniques must be incorporated into instruction. According to Bosse [5], a way to enhance students' knowledge and skills is by providing them with more practice exercises, and then carefully choosing and working through these exercises. In their study, Yang et al. [26] employed a hands-on approach to instruct Hardware and Systems Security. The approach involved allowing students to carry out ethical hacking on a computing system using a dedicated hardware module. The study provides a brief overview of the experiments conducted with the module and emphasizes their importance in the field of Hardware Security. The research concluded, based on the results of a course evaluation survey, that the course was successful in capturing students' interest in the subject matter and achieving a balance between their expectations and the required effort.

Participant 19: "All programming lectures should be hands on, and students should be able to code together with the teacher during lectures. Computers in the computer lab should be 1:1. Less writing on the whiteboard and all should be explained by the teacher."

Participant 23: "Students will be more inspired and be more productive etc. if they do always do hands-on activities, because they can see the result of their codes and compare it with their classmates"

Importance of Feedback in Teaching Programming

The importance of providing feedback in teaching programming is reflected in the research of Bosse et al. [25], which stated there are programming tools available that enable students to remove the obstacles to learning programming and provide instant feedback on their code, covering not only syntax errors but also semantic issues in the program. The study also included statements from teachers which mentions that they give feedback to students immediately after they coding and discuss it to the class. Brown and Wilson [27] indicated in their article that One-to-one tutoring is considered an optimal form of teaching because the teacher can concentrate all of their attention on a single student and adapt their teaching approach to the individual's needs. This enables the teacher to provide personalized feedback and adjustments through a mutual exchange of ideas with the student.

Participant 2: "Immediate feedback from the professors is vital in learning programming for students to correct their errors and improve their coding".

Participant 11: "As much as possible, teachers must ensure that all students learn the subject before moving to the next topic. Providing feedback to queries is also important".

Programming Teaching Strategies

The systematic research review of Alammary [28] mentioned Flipped Classroom model as the most well-known form of blended learning. In introductory programming courses, it involves teaching programming concepts through online resources outside of class and using in-class time for hands-on coding and problem-solving activities. The research by Figueiredo and García-Peñalvo [29] aimed to explore the use of game design elements in non-game contexts as a method to inspire and engage students in learning programming. To evaluate the effect of gamification on the learning experience, they compared data from a gamified and non-gamified year. The results showed substantial enhancements in class attendance, participation, and proactivity. Additionally, the study indicated that their approach could decrease the high rate of students failing. In conclusion, the authors successfully demonstrated that incorporating elements of gamification can boost motivation and success in programming by promoting feelings of passion, beauty, joy, and awe. Lopez-Pernas et al. [30] introduced the use of an educational escape room in a programming course at a higher education institution and provided the first evidence on the effectiveness of this approach for teaching programming. The study revealed that the proper use of educational escape rooms can significantly enhance student engagement and learning in programming courses. The findings also indicate that students prefer this type of activity over conventional computer lab sessions.

Participant 1: "Learning programming can be fun through the use of gamification, digital field trips, and social media integration".

Participant 8: "Brainstorming, group activities and programming in pair can significantly help student understand programming topics"

Problem-solving skills as a critical factor in learning programming

Programming involves complex ideas and rules that can be difficult for beginner programmers to understand and use in their coding. It requires a combination of skills such as critical thinking, abstraction, generalization, understanding of programming languages, problem-solving ability, and familiarity with programming tools [28]. According to Nouri et al. [31], programming is a way to innovate in the digital world, address challenges, and bring ideas to life. They also referenced Skolverket [32], who described programming as primarily a problem-solving activity, but also emphasized that it should be considered in a wider context that encompasses creativity, simulation, and democratic aspects. According to Koehler [33] problem-solving is a valuable skill for programmers to possess. Many developers concentrate on syntax and language, but not on solving problem. He further explained that programming is a problem-solving profession, and it's a crucial soft skill for success in the industry. The main task of a programmer is to develop solutions for the various industries, write codes, and create programs. They also have to identify and resolve any problems that may arise in the programs. This can be challenging because even minor errors can cause major disruptions in a program.

Participant 5: “Learning programming opens career opportunities, as it is one of the high paying job worldwide. It also help improve problem solving skills and logical ability, to solve problems encountered daily and even complex issues”

Participant 7: “A core skill a computing student must have is problem-solving. There are more than 7 programming subjects in BSIT, all of it requires extensive problem solving skills”

CONCLUSION

The study aimed to investigate the preferred programming languages among information technology professionals. Results showed that the majority of participants were software developers and programmers who commonly used C#, Java, and Python. The majority agreed that Java, C, or C++ would be the best language to start with when learning programming. The application of non-negative matrix factorization revealed several key themes: (1) online video tutorials as effective learning resources, (2) hands-on activities as key to learning programming, (3) importance of feedback, (4) effective teaching strategies, (5) and problem-solving skills as crucial for success in programming. These findings suggest that hands-on experience and problem-solving skills are essential for becoming a successful programmer and can be attained through online tutorials and varied teaching strategies. The results of the research can serve as a baseline data for the improvement of curricular offerings of computing programs. Furthermore, the themes that emerged in the research can be integrated in the current teaching strategies of computing educators.

REFERENCES

- [1] Mercado, P. A., Granadino, G. A., Pasco, E. M., & Rosete, M. A. (2021). The Impact of ICT on Service Sector’s Productivity and Employment in the Philippines. *Journal of Economics, Finance and Accounting Studies*, 3(2), 288-299.
- [2] Adene, G., Mbonu, C. E., Alade, S. M., & Mba, C. J. Programming Language Preference among Undergraduate Students in Nigeria.
- [3] Preston, R. (2020). Why Demand of Software Engineers Is High (Plus Job Tips). Retrieved from <https://www.indeed.com/>: <https://www.indeed.com/career-advice/finding-a-job/demand-of-software-engineers>
- [4] Scott, C. (2022). Demand for software developers doubled in 2021. Retrieved from <https://www.infoworld.com/>: <https://www.infoworld.com/article/3654480/demand-for-software-developers-doubled-in-2021.html>
- [5] Fernández, E., & Rennolds, N. (2022). Jobs in these 10 industries will grow most in demand in 2022, from 'behavioral health' to cybersecurity. Retrieved from <https://www.businessinsider.com/>: <https://www.businessinsider.com/10-jobs-that-will-be-growing-in-2022-have-openings-2021-12>
- [6] Burning Glass. (2016). Why Should Students Learn to Code? Retrieved from Oracle: <https://academy.oracle.com/pages/infographics/why-learn-code.html>
- [7] Fedorenko, E., Ivanova, A., Dhamala, R., & Bers, M. U. (2019). The language of programming: a cognitive perspective. *Trends in cognitive sciences*, 23(7), 525-528.
- [8] CHED Memorandum Order 25 series of 2015
- [9] Zhang, J. (2016). Selection and Improvement of Computer Programming Language. *ISME 2016 - Information Science and Management Engineering IV (ISME 2016)*, pages 242-245
- [10]
- [11] Creswell JW, Clark VL. 2017. *Designing and conducting mixed methods research*. 2nd ed. Thousand Oaks, CA: SAGE Publications; 2017. p. 1-520.
- [12] Alburo, H. R., Romana, C. L. C. S., & Feliscuzo, L. S. (2021). Sentiment analysis of the academic services of ESSU salcedo campus using plutchik model and latent dirichlet allocation
- [13] S. Vijayarani, M. J. Ilamathi, and M. Nithya, “Preprocessing techniques for text mining-an overview,” *International Journal of Computer Science & Communication Networks*, vol. 5, no. 1, pp. 7-16, 2015
- [14] C. Ramasubramanian and R. Ramya, “Effective pre-processing activities in text mining using improved porter’s stemming algorithm,” *International Journal of Advanced Research in Computer and Communication Engineering*, vol. 2, issue 12, December 2013.
- [15] George, S., & Vasudevan, S. (2020). Comparison of LDA and NMF topic modeling techniques for restaurant

- reviews. *Indian J. Nat. Sci*, 10 Algorithm. *International Journal of Recent Technology and Engineering*, 9(6), 176-183.
- [16] J. Demsar, T. Curk, A. Erjavec, C. Gorup, T. Hocevar, M. Milutinovic, M. Mozina, M. Polajnar, M. Toplak, A. Staric, M. Stajdohar, L. Umek, L. Zagar, J. Zbontar, M. Zitnik, and B. Zupan, "orange: data mining toolbox in python," *Journal of Machine Learning Research*, vol. 14, pp. 2349–2353, 2013.
- [17] Cass Stephen. (2022, August 23). Top Programming Languages 2022. Retrieved from *IEEE Spectrum*: <https://spectrum.ieee.org/top-programming-languages-2022>
- [18] Statista. (2022, August 9). Most used programming languages among developers worldwide as of 2022. Retrieved from *Statista*: <https://www.statista.com/statistics/793628/worldwide-developer-survey-most-used-languages/>
- [19] Rodrigues, G., Monteiro, A. F., & Osório, A. (2022). Introductory Programming in Higher Education: A Systematic Literature Review. In *Third International Computer Programming Education Conference (ICPEC 2022)*. Schloss Dagstuhl-Leibniz-Zentrum für Informatik.
- [20] Zhan, Q., Wang, J., Pan, X., Ding, Y., & Liu, Y. (2022). Teaching Model Design of Computer Programming Courses for Digital Media Technology Students. *Wireless Communications and Mobile Computing*, 2022, 1-5.
- [21] Kadar, R., Wahab, N. A., Othman, J., Shamsuddin, M., & Mahlan, S. B. (2021). A study of difficulties in teaching and learning programming: a systematic literature review. *International Journal of Academic Research in Progressive Education and Development*, 10(3), 591-605.
- [22] Maziriri, E. T., Gapa, P., & Chuchu, T. (2020). Student Perceptions towards the Use of YouTube as an Educational Tool for Learning and Tutorials. *International Journal of Instruction*, 13(2), 119-138.
- [23] Okechukwu, O., Orie, M., Eziokwu, P., Onovo, N., Okeke, H., & Ukeh, B. (2020). Integrating YouTube Tutorials in teaching of Computer Programming course: Effects on Students' Achievement and Interest. *International Journal of Integrated Research in Education (IJIRE)*, 111-117.
- [24] Kadriu, A., Abazi-Bexheti, L., Abazi-Alili, H., & Ramadani, V. (2020). Investigating trends in learning programming using YouTube tutorials. *International Journal of Learning and Change*, 12(2), 190-208.
- [25] von Hausswolff, K. (2022). Practical thinking in programming education: Novices learning hands-on (Doctoral dissertation, *Acta Universitatis Upsaliensis*).
- [26] Bosse, Y., Redmiles, D., & Gerosa, M. A. (2019, July). Pedagogical content for professors of introductory programming courses. In *Proceedings of the 2019 ACM Conference on Innovation and Technology in Computer Science Education* (pp. 429-435).
- [27] Yang, S., Paul, S. D., & Bhunia, S. (2021). Hands-On Learning of Hardware and Systems Security. *Advances in Engineering Education*, 9(2), n2.
- [28] Brown NCC, Wilson G (2018) Ten quick tips for teaching programming. *PLoS Comput Biol* 14(4): e1006023. <https://doi.org/10.1371/journal.pcbi.1006023>
- [29] Alammary, A. (2019). Blended learning models for introductory programming courses: A systematic review. *PloS one*, 14(9), e0221765.
- [30] Fueiredo, J., & García-Peñalvo, F. J. (2020, April). Increasing student motivation in computer programming with gamification. In *2020 IEEE Global Engineering Education Conference (EDUCON)* (pp. 997-1000). IEEE.
- [31] López-Pernas, S., Gordillo, A., Barra, E., & Quemada, J. (2019). Examining the use of an educational escape room for teaching programming in a higher education setting. *IEEE Access*, 7, 31723-31737.
- [32] Nouri, J., Zhang, L., Mannila, L., & Norén, E. (2020). Development of computational thinking, digital competence and 21st century skills when learning programming in K-9. *Education Inquiry*, 11(1), 1-17.
- [33] Skolverket. (2017). Få syn på digitaliseringen på grundskolenivå. Commentary material. Retrieved from <https://www.skolverket.se/publikationer?id=3783>
- [34] Koehler, J. (2019, May 1). 5 Skills to Help You Thrive in Computer Programming. Retrieved from *University of Arkansas Grantham*: <https://www.ua-grantham.com>