

Exploring the Programming Skills, Compensation, Gender, and Experience of Software Engineers

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Abstract - *Exploring software engineering in the world view describes it as a relevant profession for the 21st century and jobs for the future where the programming skills are needed to be updated, compensation packages are competitive, gender disparity is not anymore an issue and number of years of experience is considered a factor to master the required skills to become proficient. This article reviewed some relevant websites like payscale, and published research database like Google Scholar to answer the objective on presenting the common programming languages required by most countries, the average world salary for software engineers, gender break down for different countries under study and the years of experience required for various career levels. Results showed that the estimated annual salary of software engineers in the world average based on the 24 countries is US\$36,078.68. There is a large disparity between male (85%) software engineers and females (15%) where the Philippines has the highest percentage of females with more than 20 percent while Italy has the lowest percentage of less than 4 percent. Java, Java Script, Structured Query Language (SQL), C#, and C++ are considered the top programming languages as required skills by most countries. Six (6) in every ten (10) software engineers have early careers with 1-4 years of experience. The most common field of specialization of majority of software engineers came from computer science, based on the result of reviewed websites, followed by the graduates of mathematics and information technology. The demand for software engineers and developers grows continuously in every developed and developing country making it one of the priority areas or field of specializations that most countries would like to strengthen in the labor market.*

Keywords: *C++, C#, computer science, computer engineers, information technology, Java, SQL*

INTRODUCTION

There is a great demand for software engineers and developers in the midst of fourth industrial revolution where anything has the possibility to be automated and connected in the internet. Countries like Switzerland, Denmark, Australia and Canada have a high demand for software engineers, developers and IT employees [1]. Becoming a software engineer does not necessarily mean that someone is a graduate of engineering degree in college or computer related courses like computer science/engineering and information technology. But anyone who has computer programming skills and could able to join in a small or large group to develop and build projects for computer applications and system software could be considered as software engineer. This is a skill-based job where anyone from various disciplines could venture into computer programming like those graduates from business, multimedia arts, and electronics engineering and among others. Therefore, the competition for job opportunities is very high. There are times that those graduates from non-computer related courses, who just attended training, very motivated and enthusiastic about computer programming are being hired in the position. Alfrey and Twine [2] noted that the skills required for technical positions in the software and computing industries can be self-taught or learned on the job. There are some factors being considered that affect to unemployment of most computer science and computer engineering graduates due to job mismatch of graduates with the skills acquired from the university after graduation.

The changing needs of the society and the software industry bring major development in the

proficiency and skills required from the graduates. Most especially that software engineering is forecasted to be one of the fastest growing employment fields in the next decades according to Capretz [3]. Technology companies are now looking for job applicants who have skills in software development due to the rapid changes and growth for applications and platforms for various electronic devices [4]-[8]. The skills required five years ago would not be the same level of requirements needed because of the technological advancement in hardware, the software requirements must also adapt with these changes. There are common programming languages that most countries are currently using for their software development projects to build dedicated or embedded systems for specific company or as a software solution. Identifying these programming languages would provide a better view for those graduates who have recently joined the workforce to find their niche on what to focus on as their major skills. With so many programming languages developed and introduced, there are only few stand-outs and had been considered the most significant and beneficial for software development. The acquired certifications from different programming languages like Java, Java Script, SQL, Python, C++, C# provide the applicants with the learned expertise that needs to be supported by number of years of experience and sample portfolio of completed products or design of the completed project to heavily describe their proficiency.

Working in multidisciplinary teams through collaboration with different groups of professionals to accomplish a common goal [9]-[10] is one of the soft skill requirements for most graduates and even present members of the organization. Diversity of cultural background with different personalities affects the social relationships of every member in the team [11], [12]. Therefore, understanding behaviour and different roles in the project is necessary especially between males and females. Gender disparity in STEM graduates and employees particularly in the field of software engineering is quite large. But most studies showed consistent result of large discrepancy between the numbers of males against females in the software industry. The nature of computer programming and software development is not that attractive to most females. Even though there are many female graduates of computer science or computer engineering, they do not usually practice the profession but instead, they join the academe as

teachers or as corporate managers and other management level positions in the software companies rather than to become programmers and developers. It has something to do with the psychological aspects on the areas where they are good at like developing talents, managing people and leading active communication. Spertus [13] emphasized that the stereotypes of female engineers, subtle biases that females face with problems result from working in predominantly male environments, and sexual biases in language. Beede et al. [14] noted that although women fill close to half of all jobs in the U.S. economy, they hold less than 25 percent of STEM jobs.

Another important consideration in hiring software engineers aside from skills is the years of experience especially for highly skilled professionals. Large and multinational companies are enjoying the benefits of recruiting applicants with more than five (5) years of experience for mid-career positions because they have the capability to offer higher salaries for the accumulated experiences and skills of the developers. Meanwhile, problems exist when the fresh graduates joined the small companies and gained relevant skills and experience, they will be transferring to bigger companies while leaving the small software companies as training ground for fresh graduates. The compensation packages sometimes will depend on the years of experience and proficiency or expertise of the applicants.

Jobs related to software engineering can still flourish during the outbreak of COVID-19 because these jobs can be accomplished even remote working. Different countries have different salary scales for software engineers depending on the position, function, duties and responsibilities as well as skill, years of experience and expertise except for gender disparity where most countries have almost similar cases on the ratio of male software engineers against females.

This study reviewed the content of payscale.com to gather data from different countries regarding the gender breakdown of software engineers, annual salary, common programming languages and years of experience. This study also explores 24 websites discussing about the qualifications and requirements for software engineers where the collected data regarding the field of specialization that enter as software designer and developer was presented. The findings of the study may be added to the limited literature about employment characteristics of

software engineers focusing on the areas mentioned in this review.

OBJECTIVES

This study aims to determine the proportion of male and female software engineers and how countries from the world major economies in different continents and the ASEAN region compensate these engineers; and determine the most common skills or programming languages being used from these countries and the needed years of experience to be part of their workforce on this field.

METHODS

This study is a quantitative descriptive research using content and data analysis from the available data of payscale.com as of May 10, 2020 in terms of the posted annual salary of software engineers, gender breakdown, years of experience and common skills from 24 countries. Payscale.com was considered as one of the best salary information websites according to Bergen [15]. This was chosen because the needed data to answer the objectives of this study were all available in the Payscale. Other countries were not considered in the list due to limited number of respondents who answered any particular section in the website especially those with less than 10. Selection of countries is based on the major economies per continent and most countries from the ASEAN Region. There are 43,518 participants collected to generate the data for gender breakdown

while 3,166 participants were collected from 15 different studies.

This review article also explored the database of Google Scholar for studies conducted involving software engineers as respondents regardless of the year conducted, country, and the research problems that these studies would like to address. Research studies with students as respondents and qualitative research method with very limited participants were not considered in the review. To generate the data for fields of specialization for software engineers, there were 24 websites identified based on relevance of the content and posted within the last five years.

RESULTS AND DISCUSSION

The compensation packages or salaries of software engineers may vary from country to country as indicated in Figure 1. Those software companies from developed countries are expected to offer high salary than from those developing ones. This is also one of the reasons why other professionals from the third world countries migrate to some parts of Europe, America and Canada to look for better opportunities and high paying jobs. The United States (US\$85,307.00) has the highest annual salary for software engineering followed by Israel (US\$77,779.68) and Germany (US\$58,755.80) on the top 3 list while England (US\$57,051.47), Canada (US\$53,096.49) and Australia (US\$50,866.67) ranked 4th, 5th and 6th respectively.

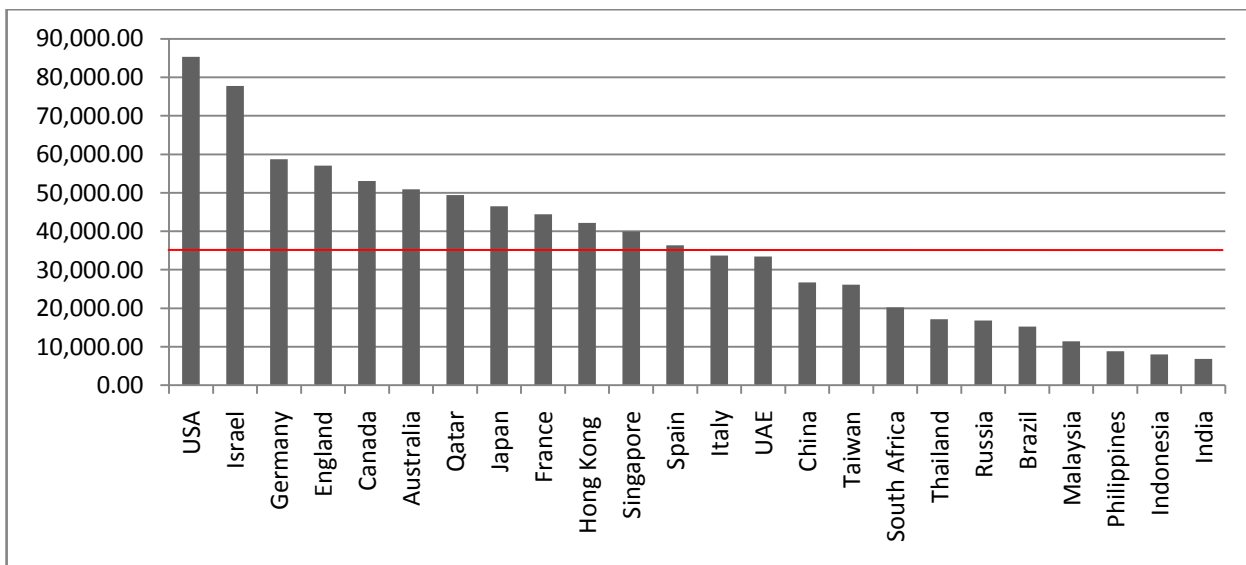


Figure 1. Annual Salary of Software Engineers in US\$ (Average: US\$36,078.68)
 Note: Data from Payscale.com and based on conversion rate as of May 10, 2020

Among the Asian countries, Japan (US\$46,524.89) has the highest annual salary for software engineers followed by Hong Kong (US\$42,132.63) and Singapore (US\$39,917.89). However, the Philippines (US\$8,791.31), Indonesia (US\$7,985.44) and India (US\$6,781.07) have the lowest annual salary among the countries included in the study. These figures may change over a very short period of time and based on the capacity of the companies to offer and negotiate wages. Beecham and Noll [16] noted that travel and salary may attract jobs among software engineers, however, it is the engagement and interest with the duties of computer programmers that may still keep and excite them to produce quality software.

There are many work arrangement as freelance programmers work from home where their clients came from different developed countries. Some companies are trying to outsource or offshore their projects with low labor cost countries because it would be more practical strategy as cost saving measure [17]. Software engineers from these countries could not be able to expect high salaries compared what other countries like USA, Canada and Australia

could offer for their programmers due to cost of living and other factors that influence compensation packages and benefits.

The top 3 most popular skills in majority of the countries included on this study for software engineers are Java (1.5), Java Script (2.5) and SQL (3.7) followed by C# (4.3) and C++ (4.5) and the least among these are Python (5.5) and .net (6.0). USA and Canada have the same three most popular skills but different from Australia where C# on the third rank while in South Africa, it is the number 1 most popular. Meanwhile, European countries are consistent for Java as the top 1 most common skills needed in the region followed by Java Script while on the third most popular for them is C++. In the part of the Middle East Asia, Java is still the top 1 most popular followed by C# and C++ and Java Script. Israel and Qatar are the only countries where C++ is considered the top 1 most common skill for software engineers. Moreover, the top 3 most common in the Southeast Asia are the same with the world's top3 skills except for Taiwan where its 2nd and 3rd common skills are C# and C++, respectively.

Table 1. Rank of Popular Programming Skills for Software Engineers

	Java	Java Script	SQL	Python	C#	C++	.net
USA	1	2	3	4	5		
Canada	1	2	3		5	4	
Australia	2	1	4		3	5	
South Africa	4	3	2		1		5
England	1	2	5	3		4	
Spain	1	2	3		5	4	
Germany	1	2	5	4		3	
France	1	2	5	4		3	
Italy	1	3	4		5	2	
Brazil	1	2	3		4		5
UAE	1	2	4		3		5
Israel	3	5		4	2	1	
Qatar	2	5	3		4	1	
India	1	3	2		4		5
Japan	1	2		4	5	3	
China	1	5			3	2	4
Indonesia	1	3	2				
Malaysia	4	1	2		3		5
Philippines	2	1	3		4		5
Singapore	1	3	2		4	5	
Thailand	1	3	2	5	4		
Vietnam	1	2	3	4			
Hong Kong	2	1	3	5		4	
Taiwan	1	4		5	2	3	
Average Rank	1.5	2.5	3.7	5.5	4.3	4.5	6.0

Note: Data from Payscale.com as of May 10, 2020

James Gosling in June 1991 started a project called “Oak” wherein the goals were to implement a virtual machine and a language that had a familiar C-like notation but with greater uniformity and simplicity than C/C++. This is now popularly known as Java with first public implementation as Java 1.0 in 1995. It is now owned by Oracle Corporation, and considered as the oldest but still in-demand programming language because of its highly recognized portability across multiple platforms. Meanwhile, Java script is considered the language of web developers with rich feature as prototype-based or object-based scripting language with scope chains and higher-order functions [18]. Likewise, having strong foundation on Structured Query Language (SQL) has significant contribution to the job placement for software engineers. SQL is the standard language for relational database management systems that is being used to communicate with the database.

(16.8%). Out of 43,518 respondents in the survey of Payscale.com as of May 10, 2020, 84.5 percent of them are males against the 15.1 percent of females. The open data of payscale.com provides substantial information to see the gender breakdown of those who participated in their survey. This is not actually the complete picture of the majority of the software engineers on these selected countries but it gives an estimate on how gender is divided by technology. The world of software engineering is still dominated by males. The countries with the lowest percentage of female software engineers include Italy (3.80%), Spain (6.30%) and China (6.70%). Alfrey and Twine [2] emphasized that the majority of women employed at tech companies work with other women in nontechnical positions such as sales, marketing, human resources, or recruiting where these positions do not carry the same prestige assigned to programmers or engineers.

Table 2. Gender Breakdown of Software Engineers

Country	Total	Male (%)	Female (%)	Prefer to self define (%)
USA	28,908	83.7	15.9	0.3
Canada	1,625	88.6	11.0	0.4
India	7,233	84.0	15.9	0.1
England	808	87.9	11.4	0.7
Australia	926	88.0	11.4	0.5
Japan	158	91.1	8.90	-
Germany	1,187	90.2	9.50	0.3
France	212	91.5	8.50	-
Italy	182	96.2	3.80	-
South Africa	461	90.0	9.10	-
Israel	67	89.6	10.4	-
Russia	50	92	8.00	-
Spain	205	93.2	6.30	0.5
UAE	111	85.6	14.4	-
China	30	93.3	6.70	-
Brazil	62	91.9	8.10	-
Philippines	305	77.7	21.6	0.7
Indonesia	47	91.5	8.50	-
Thailand	28	89.3	10.7	-
Vietnam	12	91.7	8.30	-
Singapore	504	81.9	18.1	-
Malaysia	292	82.9	16.8	0.3
Hong Kong	78	91	9.00	-
Taiwan	27	92.6	7.40	-
Total	43,518	84.5	15.1	0.4

Note: Data from Payscale.com as of May 10, 2020

It can be noted that the Philippines (21.6%) has the highest percentage of female software engineers followed by Singapore (18.1%) and Malaysia

Table 3. Reviewed Articles on the Number of Male and Female Software Engineers

Samples	Males	Females	Country	Year	Source
289	73%	27%	USA	1991	Rasch [19]
129	75%	25%	USA	1995	Turley & Bieman [20]
100	80%	20%	Canada	2003	Capretz [3]
154	89%	11%	USA	2004	Jiang et al. [21]
114	82%	18%	India	2007	Ilavarasan [22]
47	76.6%	23.4%	Sweden	2008	Feldt et al. [23]
80	93.75%	6.25%	Malaysia	2011	Rehman et al. [24]
306	83%	17%	Pakistan	2013	Asghar & Usman [25]
414	61.6%	38.4	India	2013	Verma [26]
209	81.3%	18.7	Brazil	2013	Júnior et al. [27]
129	77.5%	22.5%	India	2013	Darshan et al. [28]
384	81.7%	18.3%	Malaysia	2014	Rehman et al. [29]
276	79.2%	20.8%	Sweden	2016	Kosti et al. [30]
335	89%	11%	UK	2016	Philippe et al. [31]
200	65%	35%	India	2019	Sumi [32]
3,166	78%	22%			Total

A study conducted in USA in 1991 involved the 73 percent of males and 27% of females out of 289 software engineers (Rasch, 1991). Another study conducted in one company in the US during 1995 included the 75 percent of male software engineers while 25 percent of them are females [20].

Meanwhile, a study in Sweden during 2008 had 23 percent female software engineers against 77 percent of male subjects [23] and another study in 2016 with 79.2 percent males and 20.8 percent females [30].

Furthermore, one survey in UK among research software engineers was participated by 11 percent of females against the 89 percent male counterpart [31]. In addition, Brazil has 18.7 percent of female software engineers [27] and Pakistan has 17 percent [25].

From the reviewed studies, India has recorded higher percentage of female software engineers in 2013 with 38.4 percent and another study for the same year from different author with 22.5 percent and currently in 2019 with 35 percent. Among these countries, Malaysia obtained the lowest percentage of female software engineers during the 2011 study with 6.25 percent out of 80 participants, though this number is considered limited to represent the whole population of the female software engineers in Malaysia [24] but increases the percentage in 2014 from the same group of authors with 18.3 percent of females. Getting the estimate of software engineers

between male and female from 15 studies conducted in 1991 to 2019, there are 22 percent of females against the dominant 78 percent of males. This signifies that software engineers as respondents from different studies also showed large disparity between the two groups.

Years of experience is considered an important requirement or qualification to be considered in any specific highly skilled job like software engineering. It is believed that the skills and knowledge of workers can be associated to the number of years of experience doing the same job [33]-[35]. It gives the company an assurance that they do not need to spend too much for the training of the employees.

India (11.3%), USA (11.2%) and Singapore (10.6%) are the countries with more than 10 percent accepting entry level positions for software engineers. Indonesia (71%) has the highest percentage of software engineers in early career position among the countries with more than 100 respondents compared to Brazil (31.4%) with the lowest percentage on 1 – 4 years required experience.

Table 4. Years of Experience for Software Engineer Position

	n	Entry Level (<1 year)	Early career (1-4 years)	Mid Career (5-9 years)	Experienced (10-19 years)	Late Career (20 years & Above)
USA	63,247	11.2	57.5	19.7	8.6	2.9
India	21,815	11.3	69.6	15.7	3.1	0.3
England	1,918	6.6	58.2	25.4	8.3	1.5
Canada	3,909	6.7	52.9	24.9	12.5	3.0
Australia	2,513	5.4	52.0	23.5	16	3.1
South Africa	1,105	6.3	59.0	23.4	9.7	1.5
UAE	605	8.4	47.8	33.1	9.6	1.2
Israel	245	8.2	42.0	29.0	15.1	5.7
Germany	2,946	5.4	51.1	32.1	10.6	0.8
Japan	411	10.2	47.4	29.2	13.1	-
France	583	5.0	56.8	25.9	11	1.4
Italy	471	5.1	50.1	25.3	16.6	3
Russia	170		50.6	38.2	11.2	
Spain	557	4.7	46.3	30.2	16.9	2
Brazil	194	2.6	31.4	36.6	24.2	5.2
China	114	7.9	54.4	28.1	9.6	-
Philippines	1,070	8.2	57.8	27.1	6.4	0.5
Indonesia	155	6.5	71.0	18.1	4.5	
Thailand	106	6.6	49.1	32.1	12.3	
Vietnam	34		76.5	23.5		
Hong Kong	252	5.2	55.6	34.5	4.8	
Taiwan	128	3.9	61.7	23.4	10.9	
Malaysia	1,137	9.0	60.4	23.6	7	
Singapore	1,542	10.6	54.7	26.6	7.5	0.6
Total	105,227	10.4	59.3	20.2	7.9	2.1

Note: Data from Payscale.com as of May 10, 2020

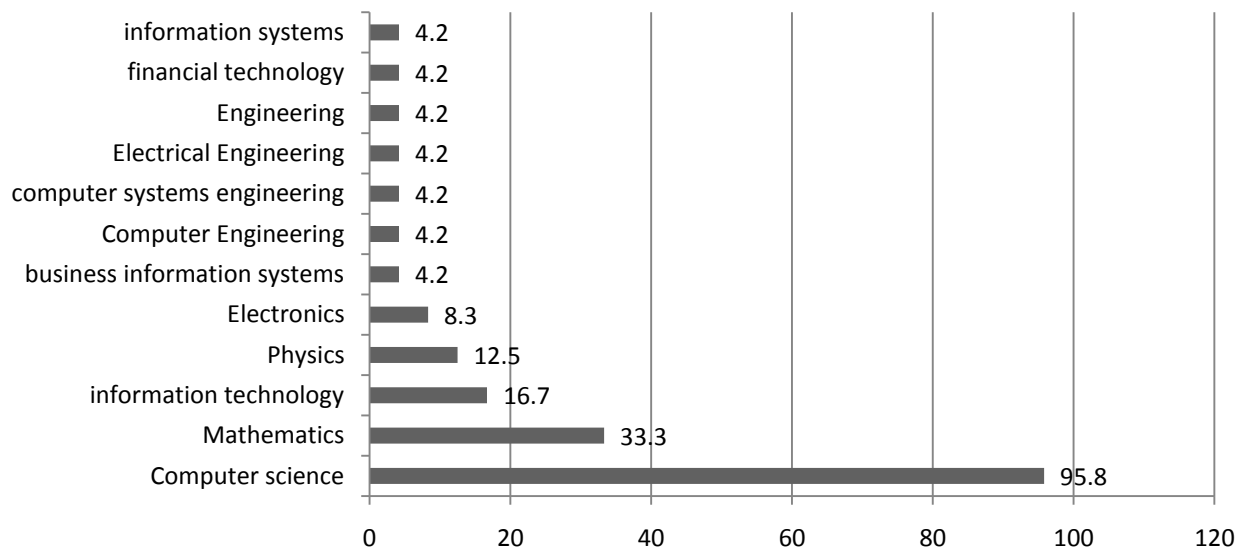


Figure 2. Field of Specialization for Software Engineer Position from Various Websites (n=24)

But it is good to note that Brazil has distributed percentage of software engineers across different career levels except for entry level with only 2.6 percent. Unlike Indonesia that majority of its software engineers are concentrated in early career position. Meanwhile, Hongkong (34.5%) has the highest percentage of software engineers in mid-career positions compared to India (15.7%) with the lowest percentage on positions requiring 5-9 years of experience. Furthermore, Israel (5.7%), Brazil (5.2%) and Australia (3.1%) are the countries with the highest percentage of software engineers in late career.

Overall, majority of the software engineers included in the survey or 59.3 percent of them have early careers with 1-4 years of experience followed by the group of Mid-career with 20.2 percent. Only 10.4 percent of them are still in entry level position while 7.9 percent comprised the group of well-experienced professionals with 10-19 years. Meanwhile, there are 2.1 percent of them who belong to late career with 20 years and above in the software industry.

Figure 2 shows the field of specialization for software engineer position from various websites. Because software engineering is considered a subfield or specialization of computer engineering, that is why, there is a high possibility that majority of the computer engineers are working as software engineers. Several websites were visited to determine the most commonly identified baccalaureate degree programs for the software engineer position. These 24 websites reviewed have mentioned that computer science

(95.8%) is commonly what the companies are looking for the job followed by the graduates from the field of mathematics (33.3%) and information technology (16.7%). Great emphasis on computer science is given to be considered as software engineer along with the other related disciplines like physics and electronics as well as information system and business administration graduates. This signifies that this position is accepting diverse applicants from different fields of specialization with specific skills and proficiency in computer programming. Only one site has considered computer engineering and computer systems engineering in the software engineer position. Although, they still believed that computer engineering graduates can still be part of the workforce as software developer, they have high regards for computer engineers to be considered in computer hardware design.

Table 5. Significant Difference on Number of Software Engineers between male and female

	n	%	t-value	p-value
Male	2469	78	-14.146367**	<.00001
Female	697	22		

**Highly Significant at $p < .001$

Significant difference exists on the number of software engineers $t = -14.15$, $p < .001$ between male and female. Result showed that male has significantly higher percentage across all countries included in the review than females as denoted by the computed

percentage of 78 percent of males against 22 percent of females. It shows that there is great percentage of gender disparity on software engineering industry where it is still dominated by males. According to Murphy et al. [37] that gender disparity in software engineering primarily emerges from personal choice rather than any discrimination or stereotyping. In the study of Seibel and Veilleux [38] noted that the gender disparity in technology related fields is well known and well documented where only 18 percent of computer science undergraduates and 26 percent of computer science professionals are women. Despite numerous interventions in the past decade, women are still underrepresented in the undergraduate pipeline. Buckley et al. [39] believed that the gender disparity indicates the existence of barriers to women entering technology and engineering education from a socio-cultural perspective. Finding of the study of Ioannis and Maria [40] also noted that a large gender disparity persists in higher education and careers in the STEM and Computer Science field. Furthermore, from the study of Thelwall et al. [41] emphasized that personal choice may also be a factor in gender disparity between fields, and the unpopularity of STEM amongst US/UK women.

CONCLUSION AND RECOMMENDATION

Staying relevant in the midst of the 21st century is the role of everyone who does not want to miss out the employment opportunities that offer competitive compensation packages and richness of benefits to get pleasure from the profession and the organization. Students and graduates from STEM degree programs would take advantage of the opportunity to learn software development because the demand for this skill will continue to thrive as the innovation in technology continues to grow rapidly.

However, encouraging women to be software engineer or developer should not be anymore an issue in the 21st century. It is well-understood that software engineering is one field of STEM which has a large gender disparity. But identifying the roles of males and females played in the software development industry would lead to better understanding of the reality and not to consider as inequality. There are many job opportunities open for female software engineers but there are only few takers. They opted to join management positions rather than becoming programmers or developers.

The following programming languages such as Java, Java Script, SQL, C#, and C++ must be

considered part of the curriculum of all computer science and computer engineering degree programs which are considered the top programming languages required by most countries. But mastering the programming skills is not enough to become successful in the field. Other soft skills like critical thinking with problem solving skill, lifelong learning skill are still necessary to communicate with peers and clients in the business and stay relevant in the organization. For software engineers, according to Capretz and Ahmed [36] that the need to communicate effectively with users and team members has been increasingly emphasized as necessary skill to develop.

The result of comparative analysis of gender disparity and annual salary among countries may serve as a good reference for future investigation. The big issue of brain drain from developing countries due to large migration of talents to developed countries is considered a problem for most government and private organizations from the low and middle income countries. Encouraging to stay these talents from their home country would be difficult due to lack of capability of most companies to give more than what they could able to provide as salary for software developers based on the economic condition of a certain country.

This review is only limited to 24 countries and analysis per region and adding more countries in the data would provide bigger picture of the salary and gender disparity. The number of sample studies reviewed for the gender disparity may still be strengthened by including more literature from other countries.

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