A STRUCTURAL MODEL FOR EVALUATING DEVELOPMENT SKILLS OF MEXICAN SOFTWARE DEVELOPERS

José Luis Cantú-Mata, Sergio Alcaraz-Corona, Fernando Torres-Castillo and José Nicolás Rodríguez-Flores

SUMMARY

The need to hire external software providers to satisfy any specific needs or requirements that cannot be resolved within organizations and companies has been a common practice for years because the many advantages and benefits it provides to such companies, namely it allows them to remain competitive in a fast-paced and globalized world. In particular, software related necessities require special attention due to the high importance and relevance software-based solutions have gained in recent years in virtually any practical case. Hence, it is very important to develop methods or procedures that can help identify the most relevant skills that engineers should possess in order to show adequate performances and successfully contribute in any business or commercial software development projects. The purpose of this work is to develop and validate a structural model to evaluate the set of skills that software developers in Mexico should have from the perspective of the client company. In our study we applied a questionnaire-based survey to 258 companies who subcontracted software related services to external providers or vendors. Our results and reliability of our model was validated using the SMART-PLS software.

Introduction

As science and technology continue to evolve at a fast pace, companies and organizations from all kinds of types and sizes are always looking to fulfill their most basic needs in order to be competitive in their own markets and beyond. At the same time, software based solutions are continuing to grow in a large number of applications. In fact, software demands have become more complex and challenging due to continuous technological advances in which specialized technical knowledge, tools, methodologies and experience are often required to satisfy such demands among other attributes (Ahuja, 2011; Giorgio, 2000). Clearly, advanced technical skills and specialized training are not the only attributes as several other key factors play a significant role in the outcome of software development projects. Nevertheless, the role of software development engineers has become more important than ever before because they usually require a particular set of skills and expertise in order to develop high-quality software products and services (Sommerville, 2010) and if exist long distance between provider and client, the principal problems are: communication, language cultural differences, time zone and knowledge management (Monasor *et al*., 2010).

On the other hand, a wide range of companies are relying on external software providers or suppliers given the lack of internal resources either human, technological or both to resolve their software related needs. Namely, software development outsourcing is a concept that has gained more acceptance in recent years in practically any situation that requires some sort of software system to solve or address a set of specific needs. Moreover, outsourcing companies have been growing and expanding rapidly in several regions, in particular, emerging countries such as India and China have experienced tremendous growth and are usually regarded as the main contributors.

One of the main objectives of such working practice is to provide client organizations, either foreign and domestic, an alternative to develop high quality software products and services at reduced costs without compromising quality and on time deliveries, among other benefits. In order to satisfy their clients' needs, outsourcing companies or simply providers need to work with some of the latest and more efficient technologies and procedures in order to remain competitive and expand their client base. In addition, these companies should always be looking for new and more effective ways to select the best candidates so that they can offer skilled professionals that very often client organizations do not have (Abraham *et al*., 1993; Arora *et al*., 2001; Claver *et al*., 2002). So far, quite a few selection criteria have been developed to attract and retain the better candidates for a given job position. For instance, Prathan and Ow (2020) proposed a technique based on Data Mining (DM) concepts and Bayes' Theorem to determine the best available programmers for software companies. The authors found that the integration of Bayes' theorem with an artificial neural network (ANN) produce effective results for predicting the best available programmers. On the other hand, Javeed *et al*. (2020) presented a method based on deep learning models to estimate the level of coding expertise among candidates for software development

KEYWORDS / Exploratory Factor Analysis / Software Developer Expertise / Software Development Skills /
Recibido: 04/17/2023. Modificado: 09/10/2023. Aceptado: 09/13/2023.

José Luis Cantú-Mata. (Corresponding author). Management Systems Engineer, M.IMB. and Ph.D. in Administration, Universidad Autónoma de Nuevo León (UANL), Mexico. Professor, UANL, Mexico. Address: Universidad Autónoma de Nuevo León. Pedro de Alba s/n, Ciudad Universitaria, San Nicolás de los Garza, Mexico. e-mail: jlcmata@gmail.com.
Sergio Alcaraz-Corona. Electronics Systems Engineer, Instituto Tecnológico y de Estudios Superiores de Monterrey (ITESM), Mexico. M.Sc. in Electrical Engineering, Illinois Institute of Technology, USA. Ph.D. in Information Technologies, ITESM, Mexico. Professor, UANL, Mexico. e-mail: salcaraz5820@gmail.com.
Fernando Torres-Castillo. Ph.D. in Administration, UANL, Mexico. Professor, UANL, Mexico. e-mail: fernando.torresc@uanl.mx.
José Nicolás Rodríguez-Flores. Ph.D in Education, UANL, Mexico. Professor, UANL, Mexico. e-mail: cpnicos3@hotmail.com.

MODELO ESTRUCTURAL PARA LA EVALUACIÓN DE HABILIDADES DE DESARROLLO DE DESARROLLADORES DE SOFTWARE MEXICANOS

José Luis Cantú-Mata, Sergio Alcaraz-Corona, Fernando Torres-Castillo y José Nicolás Rodríguez-Flores

RESUMEN

La necesidad de contratar proveedores externos de software para satisfacer cualquier necesidad o requerimiento específico que no pueda ser resuelto al interior de las organizaciones y empresas, ha sido una práctica común desde hace años debido a las múltiples ventajas y beneficios que proporciona a dichas empresas, es decir, les permite mantenerse competitivas en un mundo acelerado y globalizado. En particular, las necesidades relacionadas con el software requieren una atención especial debido a la gran importancia y relevancia que las soluciones basadas en software han adquirido en los últimos años en prácticamente cualquier caso práctico. Por lo tanto, es muy importante desarrollar métodos o procedimientos que puedan ayudar a identificar las habilidades más relevantes que los ingenieros deben poseer para mostrar un rendimiento adecuado y contribuir con éxito en cualquier proyecto de desarrollo de software empresarial o comercial. El propósito de este trabajo es desarrollar y validar un modelo estructural para evaluar el conjunto de habilidades que deben tener los desarrolladores de software en México desde la perspectiva de la empresa cliente. En nuestro estudio aplicamos una encuesta basada en cuestionarios a 258 empresas que subcontrataron servicios relacionados con software a proveedores o vendedores externos. Los resultados y la confiabilidad de nuestro modelo fueron validados utilizando el software SMART-PLS.

UM MODELO ESTRUTURAL PARA AVALIAR AS HABILIDADES DE DESENVOLVIMENTO DOS DESENVOLVEDORES DE SOFTWARE MEXICANOS

José Luis Cantú-Mata, Sergio Alcaraz-Corona, Fernando Torres-Castillo e José Nicolás Rodríguez-Flores

RESUMO

A necessidade de contratar provedores externos de software para atender a necessidades ou requisitos específicos que não podem ser resolvidos dentro das organizações e empresas tem sido uma prática comum há anos, devido às muitas vantagens e benefícios que proporciona a essas empresas, ou seja, permite que elas permaneçam competitivas em um mundo acelerado e globalizado. Em particular, as necessidades relacionadas a software requerem atenção especial devido à grande importância e relevância que as soluções baseadas em software ganharam nos últimos anos em praticamente todos os casos práticos. Por isso, é muito importante desenvolver métodos ou procedimentos que possam ajudar a identificar as habilidades mais relevantes que os engenheiros devem possuir para apresentar desempenhos adequados e contribuir com sucesso em qualquer projeto de desenvolvimento de software comercial ou de negócios. O objetivo deste trabalho é desenvolver e validar um modelo estrutural para avaliar o conjunto de habilidades que os desenvolvedores de software no México devem ter sob a perspectiva da empresa cliente. Em nosso estudo, aplicamos uma pesquisa baseada em questionário a 258 empresas que subcontrataram serviços relacionados a software para fornecedores ou vendedores externos. Nossos resultados e a confiabilidade do nosso modelo foram validados com o uso do software SMART-PLS.

positions. In the latter, the authors used three different deep learning models from which they obtained promising results with high accuracy measures. Even though such criteria and proposals, for the most part, have provided good results they have failed to identify other important qualities and attributes sought in the best-fit programmers and engineers that can only be developed after they have been working for some time.

Clearly, client companies not only consider product quality as the only reason to award contracts to providers, but also the quality of services they perceive from such providers is very important (Kim *et al.*, 2003; Mesnita and Dumitriu, 2005) . In general, it has been shown that both, the quality of products and services are always directly related to the level of competency and skills of the technical personnel responsible for developing software solutions (Kamma, 2014). Likewise, successful business or commercial software solutions require the right combination of technological and human resources that can produce the best possible solutions for specific needs or requirements. Hence, we think it is very important to employ the most qualified personnel as possible by identifying some of the most relevant technical skills and expertise they should possess. The objective of this work is to validate a structural model using an exploratory factor analysis (EFA) (Kaiser, 1974; Yong and Pearce, 2013) to determine which development skills are some of the most important in Mexican software engineers. In our case, we decided to perform an EFA study as it has been an effective technique to analyze the structure of a relatively large set of variables and their possible interrelations as a way to reach some valuable interpretations and conclusions about a given case study or experiment. Given the ubiquitous nature of software in a continuously growing number of applications, we think this kind of studies can provide valuable information to find some of the main qualities and attributes that software development engineers should possess in order to make significant contributions in all the assignments they participate.

Methodology

In this work, we propose the following model to identify some of the most relevant skills that we think software developers should possess so they can make significant contributions in their assignments that can produce high quality software products and services. The nature of our study is descriptive and correlational-causal based on a quantitative approach with a non-experimental trans-sectional design. For testing a set of hypothesis, we developed a questionnaire of 24 multiple choice questions (indicators), each one using a five-point scale (1. Totally disagree, 2. Disagree, 3. Neither disagree nor agree, 4. Agree, 5. Totally agree), as our main data collection tool (Lethbridge *et al*., 2005). Notice, however, that the questions are formulated from the perspective of a client company evaluating different aspects of the entire software development work cycle followed by some provider. The target population for this survey-based study consisted of 258 participants from various client companies, mostly small and medium-sized organizations, who subcontracted software related services to external providers and were responsible for approving and accepting the software products requested. Since we wanted to collect project-related data from experienced people, the majority of respondents were either technical managers, high-level executives or project managers. Hence, each participant responded all multiple choice questions based on their own background knowledge and experience.

A breakdown of the participants based on gender is 39.15% female, 59.30% male, and 1.55% did not answer. Meanwhile, these companies are classified based on the approximate time in years they have been operating from which we obtained that 33.3% have 16 or more years, 20.54% between 11 and 15 years, 18.99% between 6 and 10 years, 14.34% between 3 and 5 years, 11.63% have up to 2 years, and 1.16% did not provide answer. Finally, companies are also classified based on their main line of business and economic sector they participate on, in this case we obtained that 33.72% are industrial, 41.86% commercial, 24.03% services, and 0.39% gave no answer.

As part of our model's definition, the questions are then organized in constructs based on several variables that we think can provide us with relevant information about the set of skills that software developers should possess in order to show adequate performance. Moreover, for convenience each question is assigned a unique identifier or code to facilitate the graphical representation of the various dependencies that may exist among indicators and constructs. Table I shows the 24 items that form out questionnaire in conjunction with their corresponding constructs.

The data were analyzed using statistical tools such as, SPSS and SMART-PLS, in order to do the statistical analysis based on structural equations and exploratory factor analysis. This technique separates the relationship among variables for each group of dependent variables and at the same time defines non observable variables termed latent variables.

Below we present the set of hypothesis tests that were defined based on the proposed constructs, and the data that were collected and analyzed.

H_1: Infrastructure (X_1) is significant for Cognitive abilities (Y_1).

H_2: Technical abilities (X_2) are significant for Cognitive abilities (Y_1).

H_3: Communication (X_3) is significant for Cognitive abilities (Y_1).

H_4: IT response time (X_4) is significant for Cognitive abilities (Y_2).

H_5: IT cost savings (X_5) are significant for Cognitive abilities (Y_1).

H_6: Infrastructure (X_1) is significant for Performance (Y_2).

H_7: Technical abilities (X_2) is significant for Performance (Y_2).

H_8: Communication (X_3) is significant for Performance (Y_2).

H_9: IT response time (X_4) is significant for Performance (Y_2).

H_{10}: IT cost savings (X_5) is significant for Performance (Y_2).

H_{11}: Cognitive abilities (Y_1) is significant for Performance (Y_2).

Figure 1 presents the complete graphical representation of our model including all the relationships between constructs and indicators.

Analysis of Results

In order to validate the efficiency of our model, the following tests were carried out: First, a multicollinearity analysis is performed in which Table II shows the values corresponding

TABLE I
CONSTRUCTS AND SURVEY QUESTIONS (INDICATORS)

Construct	Code	Indicators
Infrastructure X_1	f1	Adequate information technologies infrastructure
	f2	Adequate information sharing infrastructure
	f3	Information systems and technological equipment satisfy clients' necessities
Technical abilities X_2	f4	Ability to implement and maintain computer networks
	f5	Ability to diagnose and maintain computer networks
	f6	Ability to evaluate and design information systems
	f7	Ability to use different types of information technologies
Communication X_3	f8	Efficient IT communication services
	f9	Willingness to communicate and attend clients' necessities
	f10	Promptly communicate project status
	f11	Clients' satisfaction with provider's communication abilities
IT Response time X_4	f12	Software-based solutions reduce delivery times of new products and services
	f13	Software-based solutions improve response times of clients' necessities
IT cost savings X_5	f14	Software-based solutions reduce development costs of products and services
	f15	Software-based solutions contribute to financial stability
	f16	Software-based solutions reduce administrative costs
	f17	Software-based solutions help reduce personnel related costs
Cognitive abilities Y_1	f18	Ability to acquire, develop and implement IT-based solutions for businesses' problems
	f19	Ability to recognize and comprehend clients' necessities
	f20	Ability to work with personnel from various areas to develop IT solutions
	f21	Ability to share project information with clients to ease decision making
Performance Y_2	f22	Provider's performance meet clients' expectations
	f23	Project's information/documentation meet clients' expectations
	f24	End product or service quality meet clients' expectations

Source: Authors.

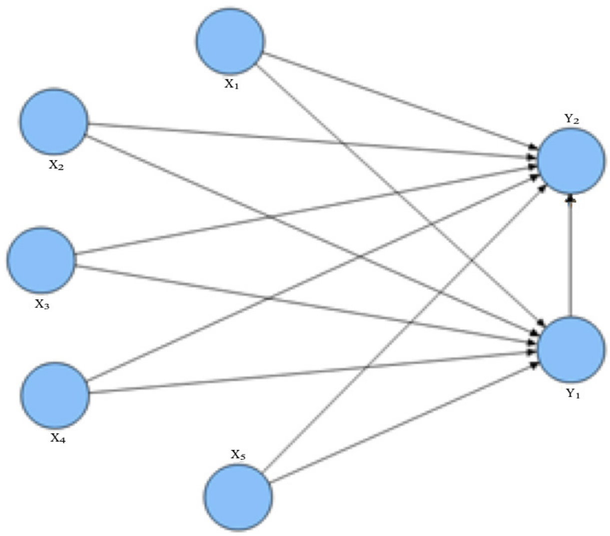

Figure 1. Graphical view of the model.

to the Variance Inflation Factor (VIF) for each latent and dependent variables in which all of them have values less than four and their tolerance values are within acceptable levels, i.e., the values are neither close to 0 nor above 1 (Hair *et al.*, 2011). Therefore, from the results we can conclude that there is no multicollinearity among these variables.

Meanwhile, Table III shows the results obtained for the quality criteria analysis. First, we present the average variance extracted (AVE) which represents the average amount of variation that a latent variable or construct has on other observable variables (Farrell, 2010). According to Hair *et al.* (Hair *et al.*, 2011), values above 0.5 are acceptable which in this case all values comply, and therefore, the analysis also satisfies the convergent validity (CV) (Hair *et al.*, 2011; Farrell, 2010).

The next column represents the Composite Reliability (CR) which refers to the internal consistency of a latent variable without assuming that the indicators are reliable, but instead it assigns them priorities. Any values between 0.6 and 0.7 are considered appropriate as inferior limit (Hair *et al.*, 2011). As shown in Table III, all CR values are above 0.8.

On the other hand, Discriminant Validity proves that a construct measures a concept distinct from other constructs. In order to prove the latter validity, we first compared the squared value of the highest correlation (0.664) against the AVE for each variable based on the Fornell-Larcker method. It can be shown that the AVE values are superior which allowed us to obtain the average cross loading values for each latent variable and compare it to the composite reliability values (Fornell and Larcker, 1981). Notice that for each latent variable, the composite reliability values are higher than the average cross loading values as shown in Table III.

Also, Table III contains the R^2 results for dependent variables Y_1 (0.749) and Y_2 (0.725). Any values above 0.750 are considered "substantial" whereas values above 0.500 are considered "moderate", and values above 0.250 are "weak" (Hair *et al.*, 2011).

Moreover, Cronbach's alpha represents the internal correlation or reliability of a set of indicators that measure either a non-observable or directly measured variable. In this case, each of the proposed variables have been measured with their corresponding indicators, and the results are acceptable based on the fact that they all satisfy the lower limit of 0.6 for an exploratory factor analysis (Hair *et al.*, 2011). In this case, the lowest value was 0.724 whereas the highest was 0.890.

Lastly, Content Validity (CV) evaluates each of the latent variables and verifies their association performing the Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy. This test can show whether the analysed variables can be grouped and form a single variable (Kaiser, 1974). In addition, we performed Bartlett's test of sphericity to validate our previous analysis and to determine whether it is significant based on the obtained p-value (significance). As shown in Table III, all KMO values are above 0.5 and Bartlett's test of sphericity is significant.

Hypothesis testing

In order to prove the hypotheses ($X_i \rightarrow Y$) we used a "t"

TABLE II
MULTICOLLINEARITY STATISTICS

	Y_1		Y_2	
Variable	Tolerance	VIF	Tolerance	VIF
X_1	0.601	1.665	0.571	1.752
X_2	0.496	2.015	0.335	2.982
X_3	0.433	2.312	0.369	2.714
X_4	0.376	2.658	0.376	2.658
X_5	0.323	3.098	0.322	3.103
Y_1	–	–	0.251	3.984

Source: Analysis of results using SPSS.

TABLE III
QUALITY CRITERIA

	AVE	Composite Reliability	Average Cross Loadings	R^2	Cronbach's Alpha	KMO	Sig.
X_1	0.712	0.881	0.482		0.799	0.706	0.000
X_2	0.742	0.920	0.564		0.884	0.835	0.000
X_3	0.745	0.921	0.590		0.886	0.775	0.000
X_4	0.782	0.878	0.505		0.724	0.500	0.000
X_5	0.745	0.921	0.569		0.886	0.830	0.000
Y_1	0.753	0.924	0.593	0.749	0.890	0.831	0.000
Y_2	0.734	0.892	0.521	0.725	0.818	0.698	0.000

Source: Analysis of results using SMART-PLS.

statistic on a two-queue test with an inferior limit of 1.96 for a 95% confidence level (Hair *et al*., 2011). The latter statistic can show which variables are significant for a dependent variable, and therefore, can determine their impact on developers' set of skills. In other words, by comparing the theoretical "t" (1.96) against the practical "t" we are able to determine the relevance between latent and dependent variables (Table IV).

Complementary Analysis

Infrastructure (X_1). The relationship between infrastructure and cognitive abilities was significant given that personnel indicated that the infrastructure used to do their work is adequate.

Technical abilities (X_2). The relationship between technical and cognitive abilities was significant since all work related activities were successfully achieved due to the right synergy between technical and cognitive abilities displayed by personnel working on a project, and consequently, the relationship between technical abilities and performance was also significant.

Communication (X_3). As expected, the relationships communication and cognitive abilities as well as communication and performance are both significant as the communication services in conjunction with the cognitive abilities improve the overall performance of project personnel and promptly attend all customer demands and inquiries.

IT response time (X_4). This construct is not relevant against cognitive abilities as project personnel is not able to interpret or measure response times related to clients' businesses, hence, there are no parameters. However, the relationship between IT response time and performance was relevant.

IT cost savings (X_5). This variable was not significant against cognitive abilities since there is no way to measure the amount of cost savings a particular IT solution will provide to its users. However, an adequate performance is regularly associated to cost savings, therefore, the relationship between IT cost savings and performance was significant.

Finally, we obtained that the relationship between cognitive abilities (Y_1) and performance was not significant because according to our survey results it was determined that project personnel cognitive abilities are not enough to fulfil clients' expectations about project development.

As with any empirical study, our model is not freed from a number of threats of validity, both internally and externally as well as the construct itself. First, internal validity reflects the extent to which the proposed model supports its outcome. The criteria analyzed in section 4 provide support for a general assessment of the internal and construct validity of our method. On the other hand, external validity is concerned with the generalization of the obtained results to other environments or practical cases. In this case, our study involved 258 respondents from the same geographical region which represents a sample that somehow limits any attempts to generalize the results to any software development projects. However, our model is capable of producing effective results for samples of size 30 or more to comply with normality tests.

Given the large diversity of practical scenarios, we realize the list of dependent and independent variables presented in this case study are not comprehensive because each respondent may come up with several more factors based on their own experiences. Nevertheless, we are confident the set of indicators and constructs that were defined provide a fair description of most current outsourced software development projects, and therefore, we consider this kind of experimental studies can be valuable as they can show other ways to approach and analyse certain aspects related to efficient ways to identify the most common traits that effective software development engineers should have in order to be successful in their work duties and achieve their goals in the development of software products or services.

TABLE IV
RESULTS OBTAINED FOR OUR "t" TEST

	t-statictic (practical "t")	t-statistic (theoretical "t)	Hypothesis
$X_1 \rightarrow Y_1$	3.629		H_1: Accept
$X_2 \rightarrow Y_1$	10.995		H_2: Accept
$X_3 \rightarrow Y_1$	6.619		H_3: Accept
$X_4 \rightarrow Y_1$	0.124		H_4: Reject
$X_5 \rightarrow Y_1$	0.637		H_5: Reject
$X_1 \rightarrow Y_2$	-2.236	1.96	H_6: Reject
$X_2 \rightarrow Y_2$	2.203		H_7: Accept
$X_3 \rightarrow Y_2$	2.140		H_8: Accept
$X_4 \rightarrow Y_2$	10.013		H_9: Accept
$X_5 \rightarrow Y_2$	5.039		H_{10}: Accept
$Y_1 \rightarrow Y_2$	-1.044		H_{11}: Reject

Source: Analysis of results using SMART-PLS and SPSS.

Conclusions

In this work, we have presented a model that can be useful to determine some of the most relevant skills and competencies that software engineers should possess in order to perform their tasks and assignments as software development companies expect from them whenever they are assigned to work in any business or commercial projects. Our methodology is mainly based on executing an exploratory factor analysis on a model that was designed from the responses collected from a survey applied to Mexican companies who recently requested the development of software products and services to software companies.

The proposed model is designed to work with quantitative data only, and requires qualitative data to be transformed into some form of numerical representation prior to its application. In general, several factors such as cross-cultural differences, work practices, and work values in the case of offshore software development can also have a strong impact on the results of studies such as this one. Likewise, technical characteristics of each project, e.g., whether it is a small, medium or large-sized project could play a major role in the outcome. Clearly, business software development is a complex task that involves several factors that need to be properly addressed and managed, in particular, the ones that can become the source of major risks and jeopardize the development of the end product. The decision to use an EFA-based study proved to be an effective and reliable way to identify such relevant factors behind selection criteria methods for software development positions. Finally, we consider this kind of case studies can be very valuable as the software industry will continue to evolve and expand as well as their development methodologies.

REFERENCES

Abraham K G, Taylor SK (1993) Firms' use of outside contractors: theory and practice. *Journal of Labor Economics 14*: 394-424.

Ahuja I (2011) Managing research and development for core competence building in an organization. *Journal of Technology Management 6*: 58-65.

Arora A, Arunachalam VS, Asundi J, Fernades R (2001) The Indian software services industry. *Research Policy 30*: 1267-1287.

Claver CE, Gonzalez RM, Gasco GJ, Llopis TJ (2002) Information systems outsourcing: reasons, reservations, and success factors. *Logistics Information Management 15*: 294-308.

Farrell AM (2010) Insufficient discriminant validity: A comment on Bove, Pervan, Beatty, and Shiu. *Journal of Business Research 63*: 324-327.

Fornell C, Larcker DF (1981) Structural equation models with unobservable variables and measurement error: Algebra and statistics. *J. Market. Res. 18*: 382-388.

Giorgio G (2000) How technology should be managed in the post-Fordist era. *International Journal of Technology Management 3*: 1-9.

Hair J, Ringle C, Sarstedt M (2011) PLS-SEM: Indeed a Silver Bullet. *Journal of Marketing Theory and Practice 19*: 139-151.

Javeed F, Siddique A, Munir A, Shehzad B, Lali MIU (2020) Discovering software developer's coding expertise through deep learning models. *IET Software 14*: 213-220.

Kaiser HF (1974) An index of factorial simplicity. *Psychometrika 39*: 31-36.

Kamma D (2014) Study of task processes for improving programmer productivity. ICSE *Companion 2014: Companion Proceedings of the 36th International Conference on Software Engineering*. pp. 702-705.

Kim DR, Cheon MJ, Beugré CD, Coverdale TK (2003) Information systems outsourcing: Exploration on the impact of outsourcing service providers' service quality. *Issues in Information Systems 4*: 528-534.

Lethbridge TC, Elliot SS, Singer J (2005) Studying software engineers: data collection techniques for software field studies. *Empirical Software Engineering 10*: 311-341.

Mesnita G, Dumitriu F (2005) Trends of information systems outsourcing: A Romanian perspective. *Social Science Research Network*. 1-28. https://ssrn.com/abstract=906090; http://dx.doi.org/10.2139/ssrn.906090

Monasor MJ, Vizcaíno A, Piattini M (2010). An educational environment for training skills for global software development. *10th IEEE International Conference on Advanced Learning Technologies*. IEEE. pp. 99-101.

Prathan S, Ow SH (2020) Determining the best-fit programmers using Bayes' theorem and artificial neural network. *IET Software 14*: 433-442.

Sommerville I (2010) *Software engineering*. 9a ed. Addison Wesley Longman Publishing Co. Inc., USA. 773 pp.

Yong AG, Pearce S (2013) A beginner's guide to factorial analysis: Focusing on exploratory factor analysis. *Tutorials in Quantitative Methods for Psychology 9*: 79-94.