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The impact of personality traits and knowledge collection behavior on programmer creativity

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ABSTRACT

Context: Creativity is one of the essential ingredients in successful software engineering. However, majority of the work related to creativity in software engineering has focused on creativity in requirement engineering. Furthermore, there are very few studies that examine programmer creativity and the impact of individual and contextual factors on it.

Objective: The objective of the study is to analyze the impact of the big five personality traits including extraversion, agreeableness, conscientiousness, neuroticism and openness to experience, as well as knowledge collection behavior on a programmer's creativity intention.

Method: A quantitative survey was conducted and data from 294 programmers, working in offshore software development projects, was collected. The data was later analyzed using Smart-PLS (3.0).

Results and Conclusions: The results indicated that openness to experience, extraversion, conscientiousness and knowledge collection behavior positively predicted a programmer's creativity intention. On the other hand, neuroticism negatively predicts creativity intention of the programmer. The study also concluded that all of the independent variables, except the agreeableness trait, significantly predict creativity intention which in turn significantly predicts creativity. As a result, our conclusions indicate that programmer's personality traits and knowledge collection behavior play a key role in shaping their intention to be creative. Hence, personality traits and knowledge collection behavior should be given due attention during the hiring process of creativity-oriented software companies.

1. Introduction

Software engineering is a knowledge-based human work, which capitalizes on the knowledge and creativity of humans [1] [2]. The central role of humans in software engineering is aptly described by Capretz et al. [3] in the words that, *"software is developed by people and for people"*. However, despite its importance, factors related to humans in software engineering are often ignored and not given equal attention compared to the technical factors [4]. One such human factor is creativity, which has been emphasized in today's knowledge-centric workforce as a driving force and leading factor for the competitive advantage of any organization [5]. Furthermore, innovation and problem solving, which are pertinent to software engineering, also require creativity [6]. Hence, creativity becomes one of the critical factors for the success of software development endeavors [7] [8] [9]. However, despite the great importance of creativity in software engineering, generally the topic has been neglected in prior research [10].

It has been reported that within software development, every task / phase requires a different type of creativity [11]. Therefore, it is important to investigate creativity in all of the phases of software development [6]. However, prior research has focused mainly on creativity in the requirement engineering phase [12] [13] and there is consequently a lack of research work addressing creativity in other phases of software development [14] [15]. Programming is considered to be one of the most creative and fun endeavors [15] [16]. However, prior research on programmer creativity is minimal [13].

In addition, in an organizational setting, creativity is thought to have influenced or resulted from the interaction of individual and contextual factors [17] [18] [19]. Thus, it becomes pertinent to determine and explain these factors as well as their impact on the development process [20]. The existing literature lacks the investigation of the factors which can potentially influence the creativity of software engineers [8]. The

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present research attempts to fill these research gaps by identifying programmer's creativity relevant factors and examine their impact on creativity intention of the programmer.

Personality is one of the most important factors influencing creativity. According to the componential theory of creativity, personality characteristics are one of the factors that can spur on or impede creativity [21]. Moreover, personality traits of developers are highly pertinent to the issues which arise during the software development process [22]. However, the research work on personality in software engineering is incomplete, immature, insufficient and inconclusive [22] [23] [24] [25] [26]. Therefore, the first objective of the present research is to examine the impact of big five personality traits on creativity intention of the programmer.

Furthermore, it is widely acknowledged that software development is a knowledge-based collaborative activity [9]. Similarly, for creativity also, knowledge is considered to be a pre-requisite [21] [27]. In addition, it is not only knowledge, but collaborative knowledge which guarantees creativity [8] [9] as well as effective software development [7] [9]. Hence, another objective of the present study is to understand the relationship between one of the forms of knowledge collaboration—namely knowledge collection behavior— and creativity intention. As per the author's knowledge, there is no present study which has examined this relationship.

In a nutshell, the aim of this research is to address programmer creativity and answer the following three research questions: (1) What is the impact of the big five personality traits on a programmer's creativity intention? (2) how does the knowledge collection behavior of programmers impact their creativity intention? And (3) how does creativity intention predict creativity of the programmer?

2. Literature review

2.1. Programmer's Creativity

Creativity has recently been emphasized in software / Information Technology (IT) development [28]. As mentioned earlier, it is commonly understood that software engineering depends on the creativity and knowledge of humans [2]. This is because complex problem solving and innovation are fundamental requirements for software engineering, and both of the aforementioned facets absolutely require creativity [12] [29]. Moreover, software engineers are also found to be inclined towards working on the particular phases of development which they perceive to be creative [14] [15] [30].

As reported by Mohanani et al. [31], there are only a handful of studies which have attempted to understand creativity in the software engineering context. Over the years, more emphasis has been placed on creativity in the requirement engineering phase of software engineering [12] while ignoring other phases [14] [15].

Within these phases, programming is considered to be one of the most creative tasks of software engineering [14] [32]. Creativity of the programmer can be defined as *"one's ability to develop new, surprising and valuable ideas, artifacts or outcomes of platforms, components or programs by flair"* [33, pp 109]. In the past, programming was perceived as the work of a technician whose primary responsibility was to simply implement the design of others [32]. However, it is now considered a creative task [32] which requires ingenuity to solve problems [29]. Hence, creativity is now believed to be one of the important pre-requisites of programming [34].

This research work endeavors to probe the research into the creativity of programmers and the factors which can affect their creativity. The upcoming section sheds light on the development of the framework which aided in forming the hypotheses.

2.2. Personality Traits

Personality not only affects a software engineer's judgment and decision making [35], it also influences his choice of processes, techniques and methods [36]. Moreover, since software projects are carried out in teams, the effectiveness of the interaction between team members also relies on the personality traits of developers [37].

There are various personality models which are available in the literature, such as the Myers-Brigg Type Indicator (MBTI) and the Big Five Model (BFM). These models aid in measuring the personality type or traits of an individual. Despite the widespread use of the MBTI model, BFM model has gained popularity as an alternative of MBTI. In software engineering, the BFM has been prominent in the last decade [25] [26]. Furthermore, in the domain of programming (such as pair programming) the majority of researchers have used the BFM [26]. Similar results were found by Wiesche and Kremar [25].

BFM is made up of five trait dimensions including Agreeableness, Conscientiousness, Neuroticism, Extraversion and Openness to Experience [25] [38] [39].

2.3. Big five Personality Traits and Creativity

In the recent past, research on the relationship between personality and creativity has grown and has showed consistent findings [40]. At the same time, it is also believed that researchers have not paid sufficient attention to personality as a predictor of creativity [19]. The present research attempts to study this relationship in the context of software engineering. In the forthcoming subsections, the literature regarding the relationship between the five personality traits and creativity is presented.

2.3.1. Extraversion and creativity

The extraversion trait consists of characteristics such as being talkative, friendly, active, assertive, ambitious, and seeking inspiration [25] [41] [42] [43]. Extraverted individuals are comfortable in socializing, unlike those individuals who are low in the extraversion trait [25] [44].

Studies such as Sung and Choi [19] argue that researchers have paid less attention to the impact of extraversion on creativity. According to majority of the studies, a positive relationship exists between extraversion and creativity [45]. Some researchers have indicated that extraversion is the strongest predictor of creative behavior [19]. Similar results were found by Hoseinifar et al. [46] and Bledow et al. [47]. Based on the literature, the present research proposes the following hypothesis.

H1: Extraversion is positively correlated with the creativity intention of the programmer.

2.3.2. Agreeableness and creativity

Agreeableness signifies an individual's cooperation with his colleagues [25]. Individuals, who demonstrate high levels of the agreeableness trait, are empathetic, kind, trustworthy, cooperative, warm and considerate towards fellow beings [42] [43].

As for the relationship between agreeableness and creativity, the research is divided and lacks consensus. As argued by Wolfradt and Pretz [48] and Abdullah et al. [49], the relationship is unclear and controversial. There are studies which show a negative relationship between the two variables i.e. ([50] [51] [52]), a positive relationship (i.e. [40] [46]) and no relationship (i.e. [50] [53]). Based on the literature it is difficult to take a definite position on the relationship. Hence, the following non-directional hypothesis is proposed in the present research.

H2: Agreeableness effects the creativity intention of the programmer

2.3.3. Conscientiousness and creativity

Conscientiousness refers to an individual's characteristic of controlling and directing impulses [25]. Individuals with this trait show attributes such as persistence, purposefulness, attentiveness, ambitiousness, thoroughness and reliability [38] [42] [43].

Despite much research, the relationship between conscientiousness trait and creativity is unclear and inconsistent [54]. There is evidence that conscientiousness is negatively linked with creativity. Several traits of conscientious individuals, such as risk aversion, a highly structured and organized way of doing things, intolerance towards uncertainty and ambiguity are a hindrance to creativity [41] [55] [56] [57]. Similarly, researchers such as Feist [45] and Batey et al. [52] also found a negative relationship between conscientiousness and creativity.

There is also evidence of no relationship between both of the constructs. The study conducted by King et al. [58] found no relationship between conscientiousness and creativity while studying creativity among American university students. Similar results were found by McCrae [59].

On the other hand, some of the studies have also found a positive correlation between conscientiousness trait and creativity. As in [46] found that conscientiousness trait has a positive relationship with creativity. Furthermore, Chen [54] also found a medium but positive relationship between both constructs in Chinese context. Lastly, Makhija et al. [60] suggested that affective and cognitive engagements are positively linked with conscientiousness trait. Whereas, affective engagement is a predictor of creativity [61].

Due to the unclear and inconsistent findings of the prior research on the relationship between conscientiousness trait and creativity, the present research suggests a non-directional relationship between the constructs.

H3: Conscientiousness effects the creativity intention of the programmer

2.3.4. Openness to experience and creativity

Openness to experience refers to an individual's propensity towards originality, broad mindedness, intellect, scope of his imagination, creativity and independence [25] [42] [43] [62]. It is considered to be one of the broadest of the big five personality traits, encompassing various sub traits [61]. Despite criticism of the trait as synonymous with creativity by researchers like Martindale [63], according to McCrae [59] the openness to experience trait is a mean towards creativity and cannot be considered as synonymous to it. The rebuttal by McCrae [59] has been accepted by the research community. Hence, openness to experience has been treated as a separate constraint and a strong predictor of creativity [18] [64]. Studies such as [19] [46] [47] [52] [53] and [57] discovered that creativity and openness trait have a positive relationship. Consequently, the following hypothesis has been proposed in the present research.

H4: Openness to experience is positively correlated with the creativity intention of the programmer.

2.3.5. Neuroticism and creativity

Neuroticism corresponds to an individual's emotional instability, composure and temperament towards negative feelings, as well as his control over impulses [25] [65]. Neurotic individuals show signs of moodiness, agony, frustration, loneliness, insecurity, anxiety and self-pity [38] [42] [43] [66] [67].

Some studies have found that the neuroticism trait has an insignificant impact on creativity (i.e. [19] [68]). However, there are more studies which found a negative relationship between both variables (i.e. [46] [53] [69] [70] [71]). Hence it is safe to assume that neuroticism has a negative impact on creativity of the programmer.

H5: Neuroticism is negatively correlated with creativity intention of the programmer

2.3.6. Knowledge collection behavior

Knowledge collection is part of the knowledge sharing process and involves individuals who donate and collect their knowledge to create new knowledge [72]. Knowledge collection can increase an individual's existing knowledge, which is vital for software engineering as well as creativity.

Knowledge within software engineering, which is in the form of artifacts, codes, lessons learned and documents, is typically dispersed among software engineers who have diverse skills [9] [73]. Moreover, since no single developer possesses all of the knowledge, there is a clear need for knowledge collaboration and communication within software teams [74]. As a result, knowledge collaboration is essential to effective software engineering because it facilitates the seamless flow of knowledge between software engineers [7] [9].

In reference to creativity, it is important that individuals collect external knowledge and integrate it with their existing knowledge base [8] [9]. This collection and application of diverse knowledge leads an individual to generate creative solutions [75]. The same principle applies to software engineering, where sharing and collection of knowledge enables software engineers to see the problem from different perspectives, which then leads to creative solutions [8]. Hence, we believe that from an individual's perspective, knowledge collection will contribute more towards a diverse knowledge base than knowledge sharing and will eventually lead to creative solutions. Hence, the present study proposes the following hypothesis.

H6: Knowledge collection behavior is positively correlated with creativity intention of the programmer.

2.3.7. Creativity intention

The present research incorporates behavioral intention from the perspective of the Theory of Planned Behavior (TPB) as the factor connecting the personality traits and creativity of the programmer. According to TPB, a planned behavior is the outcome of behavioral intention [76]. The theoretical basis of creativity intention was discussed in one of the earlier publications of the authors of the present research [33]. Creativity intention can be described as an individual's intention to be creative in producing new, surprising and valuable ideas and artifacts [33]. Previous researchers posited that individual and contextual factors impact creativity through intrinsic motivation [77]. However, Shalley et al. [78] and Choi [79] emphasized the need for a new factor that can explain the interaction between individual / contextual variables and creativity. Hence, similar to Choi [79], who has proposed that creativity intention is an alternative to intrinsic motivation, the present study has included creativity intention and expects the individual and contextual factors to predict creativity intention which, in turn, will predict the creativity of the programmers.

H7: Creativity intention is positively correlated with the creativity of the programmer.

2.4. Theoretical basis for the proposed framework

The componential theory of creativity and the Theory of Planned Behavior (TPB) were used to develop the theoretical framework for this research work.

The componential theory of creativity [21] is one of the major theories used to holistically understand creativity in an organizational setting. The theory examines creativity from an interactional perspective as it suggests three intra-individual and one contextual component which can affect creativity. The individual factors include:

1) Domain relevant skills: Factors such as knowledge, technical skills, expertise and talent in the domain in which the individual is working.
2) Creativity relevant process / skills: Factors such as personality characteristics and the cognitive style of the individual.
3) Intrinsic task motivation: An individual's internal motivation to carry out a task without any external form of motivation, such as reward or punishment.
4) Apart from the above three individual factors, the componential theory of creativity also suggests an external component, namely the work environment, which includes all the extrinsic factors which can stimulate or inhibit individual's creativity.

The theory does not provide the specific set of individual and contextual factors; however, researchers have identified various individual as well as contextual factors which can encourage or hinder creativity in an organizational setting. In the context of this research, the individual factors are knowledge collection behavior (domain relevant skill), personality traits (creativity relevant skill), and creativity intention (in place of intrinsic motivation).

The variable named creativity intention has been adopted from the Theory of Planned Behavior (TPB). The theory states that a planned behavior is the outcome of behavioral intention [76]. Hence, creativity, which is a planned behavior, should be the outcome of creativity intention.

Table 1 lists the proposed hypotheses, whereas Fig. 1 illustrates the proposed framework.

3. Research methodology

The present research is quantitative in nature. A survey questionnaire was used to gather data from programmers working in a GSD environment in software companies in Pakistan. The questionnaire was distributed to programmers in person by the researcher himself, through email and with the help of an enumerator.

3.1. Sampling

According to the official website of the Pakistan Software Export Board (PSEB), there are nearly 1500 software companies working in 8 major cities in Pakistan. Since the population is naturally divided into 8 geographically distinct areas, cluster sampling was used to acquire the sample. This was done in two steps. In the first stage, based on simple random sampling, 6 geographical areas (out of 8) were selected. In these 6 clusters, the total number of software companies is 1105, whereas the total number of purely GSD based companies, in these six areas, is 379. Moreover, there are 1045 programmers working in these companies, which are the unit of analysis for this study. All of the programmers working in these companies were approached for data collection.

Table 1
Proposed Hypotheses.

Hypothesis No.	Hypotheses Statement
H1	Extraversion is positively correlated with the creativity intention of the programmer.
H2	Agreeableness effects creativity intention.
H3	Conscientiousness effects the creativity intention of the programmer
H4	Openness to experience is positively correlated with the creativity intention of the programmer
H5	Neuroticism is negatively correlated with creativity intention of the programmer.
H6	Knowledge collection behavior (KCB) is positively correlated with creativity intention of the programmer.
H7	Creativity intention is positively correlated with the creativity of the programmer.

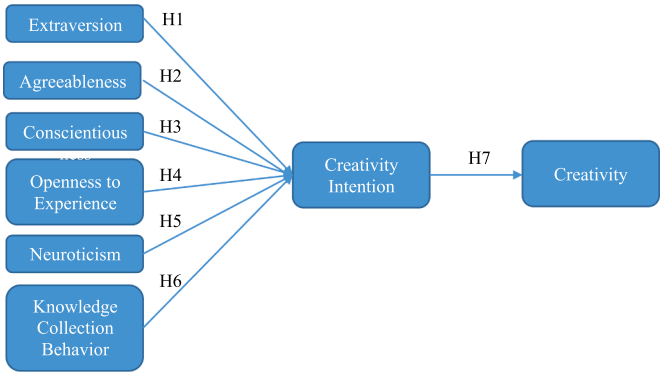

Fig 1. Proposed Framework.

3.2. Questionnaire development

The scales for all the variables were adopted from previous studies and were tailored to the context of the present study. All the scales were in English language and were not translated in Urdu language as the respondents of the study are well-versed in English language. Furthermore, all the questions were asked on a 5-point Likert scale.

3.2.1. Scale for big five personality traits

To measure the big five personality traits, various scales are available [80]. From the available scales, the frequently cited ones are Goldberg's [38], Big Five Inventory (BFI) by John et al. [81] and Neuroticism-Extraversion-Openness (NEO) instrument by Costa and McCrae [44]. The present study has adopted the Big Five Inventory (BFI) by John et al. [81], due to its robustness [57] [80] [82], reliability and accuracy [47], ease of understanding, simplicity, brevity in terms of the use of small and understandable statements, efficiency in terms of time and resources and finally a higher alpha value [80].

3.2.2. Scale for creativity

To measure creativity, the self-reporting scale developed by Tierney et al. [83] was adopted due to its briefness, wide usage, acceptable validity and reliability [78] [84]. However, the questions were tailored to the context of the present research. The tailored questions looked like *"I develop my own algorithms and logics to write a program" and "I find new uses (by modification / merging) for existing methods and techniques* (i.e. *from libraries) to solve programming problems"*.

3.2.3. Scale for creativity intention

Moreover, to measure the creativity intention, the word 'intend' was added in the questionnaire of Tierney et al. [83]. It is the same approach that was adopted by previous studies using TPB (i.e. [85] [86] [87]. The questions looked like *"I intend to generate new and innovative ideas."* and *"I intend to find new uses for existing methods and techniques* (i.e. *from libraries) to solve programming problems"*.

3.2.4. Scale for knowledge collection behavior

The scale to measure knowledge collection behavior was adopted from the pre-validated questionnaires developed by [72] and [88]. The questions were tailored to fit the programmers. Examples of questions are *"I frequently collect knowledge from other organizational members about program syntax and logic (when coding components or programming)" ".... about solving similar problems based on their experience"*.

The complete questionnaire for all the variables can be found in Appendix 1.

4. Results and discussion

The data was analyzed by using the Structural Equation Modeling

(SEM) technique of Partial Least Square (PLS). The choice of PLS for the present research stems from a few important and distinguishing considerations including:

1) In contrast to the 1st Generation (1 G) techniques (i.e. regression), PLS, like other SEM techniques, enables the researcher to simultaneously model the relationship between multiple independent and dependent constructs and answer the research questions in single, systematic and comprehensive analysis [89].
2) Moreover, PLS suits this research as it is considered to be appropriate for structural models which are complex and examine a large set of relationships between constructs [90] [91].
3) Examples of some of the latest studies, in the domain of software engineering, which have used PLS-SEM are [92] [93] [94] [95].

According to Chin [96], the analysis on PLS should be presented in two stages including the measurement model evaluation as well as the structural model evaluation. In the measurement model, the reliability analysis, construct validity, including convergent and discriminant validity, were used. For structural model evaluation, structural path significance, coefficient of determination (R^2) and estimates of path coefficients were obtained.

4.1. Measurement model evaluation

4.1.1. Demographic profile

As mentioned earlier, the questionnaire was distributed to all of the 1045 programmers working in the GSD- based software companies in the six selected clusters. The total number of valid responses was 294. The sample size is sufficient. According to Saunders et al. [97] a sample of 278 is sufficient from a population of 1000 with a margin of 5% error. Table 2, which was also published as in [13], shows the profiles of the respondents in the present study.

4.1.2. Data normality

Skewness and kurtosis tests were applied to measure the normality of the collected data. The results depicted approximate normal distribution of the data based on skewness and kurtosis results. According to George and Mallery [98], the values within the range of +1 and −1 illustrate approximate normal data whereas the values between +2 and −2 can also be considered as satisfactorily normal data.

4.1.3. Internal consistency

Cronbach's Alpha and Composite reliability are two of the common measures of internal consistency. Table 3 shows that all the variables of the present study achieved a satisfactory value of Cronbach's Alpha as well as composite reliability. According to Henseler et al. [99], 0.70 is a satisfactory internal consistency value. To achieve a reliable internal consistency value, some items were deleted from the scale of personality traits.

TABLE 2
DEMOGRAPHIC DETAILS.

	Number	Percentage
Gender		
Male	238	80.9%
Female	56	19.04%
Education Level		
Diploma / Certification	91	30.9%
Bachelors	167	56.8%
Masters	36	12.2%
Experience		
1–3 years	78	25.1%
4–7 years	113	38.4%
8–10 years	57	19.4%
More than 10 years	46	15.6%
Experience		
1–3 years	218	74.2%
4–7 years	76	25.8%

Table 3
Reliability Statistics .

Variables	Cronbach's Alpha	Composite Reliability	Original No. of Items	Final No. of Items
Conscientiousness	0.893	0.921	9	5
Creativity Intention	0.943	0.954	7	7
Extraversion	0.755	0.844	8	4
Creativity	0.901	0.922	7	7
Openness to Experience	0.954	0.961	10	9
Neuroticism	0.940	0.952	8	6
Knowledge Collection Behavior	0.899	0.922	6	6
Agreeableness	0.909	0.933	9	5

4.1.4. Indicator reliability

The indicator reliability is measured through outer loadings. Similar to internal consistency measures, 0.70 is a satisfactory indicator reliability value [99]. Table 4 shows the results for indicator reliability through outer loadings. According to the results, all the items have achieved satisfactory indicator reliability.

4.1.5. Multicollinearity

In a multiple regression equation, multicollinearity is the degree of correlation between two independent variables. It is measured through the VIF values. A VIF value greater than or equal to 10 shows a multicollinearity issue [100]. According to the results presented in Table 5, all the VIF values of the variables of the present research showed no multicollinearity issues.

4.1.6. Validity analysis

To assess the validity of the data, two methods were applied including convergent and discriminant validity analysis. Convergent validity is assessed through Average Variance Extracted (AVE) values. It is said to be satisfactory if the AVE value is above 0.5 [99]. Table 6 demonstrates the results for convergent validity. As can be seen from the results, all of the variables achieved a satisfactory convergent validity value.

The second measure of validity is discriminant validity. One of the criterions through which it is measured in PLS is the Forner-Lorcker criterion. Table 7 illustrates the results for Fornell-Larcker criterion for discriminant validity. According to Fornell and Larcker [101] If the square root of the AVE of each variable is higher than the correlation among the variables, then it is safe to assume that the data has achieved a satisfactory discriminant validity [99] [102]. As illustrated in Table 7, all the variables achieved a satisfactory discriminant validity value. The diagonal values (highlighted in green) are the square roots of the corresponding variable, whereas the values below the square root are the correlation values among variables. In layman terms, the diagonal values should be greater than the values below the diagonal values.

4.1.7. Model fitness

PLS provides several measures of model fitness such as SRMR, NFI and rms_Theta. Table 9 illustrates the results for these measures.

In PLS, bootstrap based Standard Root Mean Square (SRMR) is equivalent to chi-square in other techniques [103] [104]. An SRMR value which is above 0.1 illustrates problematic model fitness [103]. According to the results shown in Table 8, the SRMR value is below 0.1, which indicates the fitness of the proposed model. Furthermore, the NFI value is also above 0.50, which is closer to the value of 1 and hence considered a good fit. In addition, the value of rms_Theta indicates a good fit too as the value is closer to 0.

Table 4
Indicator Reliability through Outer Loadings.

	Agree..	CI	Conscien..	Creativity	Extra	KCB	Neuro	Openness
Agree1	0.871							
Agree2	0.800							
Agree3	0.861							
Agree4	0.888							
Agree5	0.862							
CB1				0.813				
CB2				0.866				
CB3				0.744				
CB4				0.711				
CB5				0.731				
CB6				0.844				
CB7				0.835				
CI1		0.853						
CI2		0.901						
CI3		0.869						
CI4		0.846						
CI5		0.828						
CI6		0.903						
CI7		0.843						
Cons5			0.856					
Consc1			0.842					
Consc2			0.794					
Consc3			0.809					
Consc4			0.878					
Extra 3					0.735			
Extra 6					0.716			
Extra 7					0.710			
Extra2					0.864			
KCB1						0.822		
KCB2						0.811		
KCB3						0.836		
KCB4						0.859		
KCB5						0.800		
KCB6						0.762		
Neuro 4							0.864	
Neuro1							0.861	
Neuro2							0.918	
Neuro3							0.843	
Neuro5							0.850	
Neuro6							0.923	
Open1								0.861
Open10								0.843
Open2								0.873
Open3								0.877
Open4								0.839
Open5								0.864
Open6								0.844
Open8								0.844
Open9								0.852

Table 5
Multicollinearity Values.

Independent Variables	Creativity Intention	Creativity
Agreeableness	3.877	
Openness to Experience	2.432	
Creativity Intention		1.000
Conscientiousness	4.745	
Neuroticism	1.280	
Knowledge Collection Behavior	2.760	
Extraversion	1.063	

Table 6
AVE Values of Latent Variables.

Variable	Average Variance Extracted (AVE)
Agreeableness	0.735
Creativity Intention	0.746
Conscientiousness	0.700
Creativity	0.631
Openness to Experience	0.732
Extraversion	0.576
Knowledge Collection Behavior	0.665
Neuroticism	0.769

4.2. Structural model evaluation

In the second stage of PLS based results, the proposed hypotheses are tested with the help of their effect and significance. Bootstrapping is used for evaluating the degree (estimate values), significance (P Values and T-statistics) and R^2 measure of the structural model [103]. T-statistics is considered significant if its value is greater than 1.96 (with significance level = 5%) or 1.65 (significance level = 10%). In the forthcoming subsections, each relationship will be analyzed based on parameter estimates (beta values) and T- statistics. Table 9 shows the results for the structural model evaluation. Fig. 2 illustrates the causal structural model results.

4.2.1. Extraversion and creativity intention

As per the results presented in Table 9, the impact of extraversion on creativity intention is significant (P-Value: 0.000; T-value: 4.260) and positive (Beta value: 0.138). It indicates that with every unit increase in the extraversion trait, creativity intention increases by 0.138 unit. This supports the proposed hypothesis 1 (H1).

Table 7
Fornell-Larcker Criterion for Discriminant Validity.

	1	2	3	4	5	6	7	8
Agreeableness (1)	0.857	-	-	-	–	–	–	–
Creativity Intention (2)	0.695	0.864	-	–	–	–	–	–
Conscientiousness (3)	0.847	0.783	0.837	-	–	–	–	–
Creativity (4)	0.818	0.788	0.832	0.794	-	–	–	–
Extraversion (5)	0.078	0.288	0.128	0.088	0.759	-	–	–
Knowledge Collection Behavior (6)	0.736	0.721	0.759	0.781	0.112	0.816		
Neuroticism (7)	−0.379	−0.466	−0.442	−0.452	−0.207	−0.337	0.877	-
Openness to Experience (8)	0.680	0.829	0.732	0.721	0.161	0.694	0.343	0.855

Table 8
Model Fitness.

	Saturated Model	Estimated Model
SRMR	0.068	0.086
NFI	0.569	0.561
Rms_Theta	0.198	

4.2.2. Agreeableness and creativity intention

According to the results presented in Table 9, the relationship between agreeableness and creativity intention is insignificant as the T-value is 0.457 (P-Value: 0.647). Moreover, the beta value for the relationship is −0.023, which indicates a negative relationship between both variables. Hence, as per the results of the present study, agreeableness is not a significant predictor of creativity intention. Furthermore, the results do not support hypothesis 2 (H2).

4.2.3. Conscientiousness and creativity intention

The results indicate that conscientiousness is a significant predictor of creativity intention with a T-value of 4.088 (p-value: 0.000). Moreover, the beta value indicates that the impact of conscientiousness on creativity intention is strong and positive (beta value: 0.271). It indicates that with the increase of each one unit in the conscientiousness trait, creativity intention increases by 0.271 units. Therefore, it is safe to assume that conscientiousness positively and significantly predicts creativity intention. The results support the proposed hypothesis 3 (H3).

4.2.4. Neuroticism and creativity intention

As per the results, neuroticism has a negative and significant impact (Beta value: −0.111: T-Value: 3.818: p-Value: 0.000) on creativity intention. It indicates that with every 1 unit increase in the neuroticism trait, creativity intention decreases by 0.111 units The results conclude that the neuroticism trait negatively predicts the intention of programmers to be creative, which supports the proposed hypothesis 4 (H4).

4.2.5. Openness to experience and creativity intention

Openness to experience, according to the results, substantiated to be the strongest, positive and significant predictor of creativity intention (Beta value: 0.487; T value: 9.538: P-value: 0.000). It indicates that with every 1 unit increase in the openness to experience trait, creativity intention increases by 0.487 units. These results support the hypothesis 5 (H5).

4.2.6. Knowledge collection behavior and creativity intention

The results show that knowledge collection behavior positively and significantly predicts creativity intention (Beta value: 0.142; T-Value: 2.268: P-value:0.023). It indicates that with every 1 unit increase in the knowledge collection behavior, creativity intention increases by 0.142 units Hence, the results support the proposed hypothesis 6 (H6).

4.2.7. Creativity intention and creativity

According to the results, creativity intention significantly and positively predicted the creativity of a programmer. The beta value (0.788) showed a very strong impact of intention to be creative on creativity behavior. It indicates that with each one unit increase in the creativity intention, self-reported creativity increases by 0.788 units. Furthermore, the relationship is also statistically significant (T-value: 27.058; P-value: 0.000) The results supported the proposed hypothesis H 7 (H7).

4.2.8. The R^2 for the endogenous latent variables

The R^2 value shows the variance that independent variables brought to the dependent variable. Table 10 illustrates the R^2 value for endogenous latent variables.

The results clearly show that the R^2 value for the path between exogenous variables, including big five personality traits and knowledge collection behavior, and the endogenous variable, including creativity intention, is substantial and significant with the R^2 value of 0.794 and T-value of 32.623. This indicates that the big five personality traits and knowledge collection behavior, together, amount to a significant (79.4%) change in creativity intention. According to Senapathi and Srinivasan [92], a R^2 value above 0.75 is considered substantial. Furthermore, the R^2 value for the path between creativity intention and creativity is significant and moderate with R^2 value of 0.620 and T-value of 13.555. This leads to the conclusion that creativity intention produces a 62% change in creativity. In the upcoming sections, the results will be discussed.

Table 9
Bootstrap Results for Causal Structural Model.

	Parameter Estimate	Sample Mean	Standard Deviation	T Statistics	P Values
Extraversion → Creativity Intention	0.138	0.138	0.032	4.260	0.000
Agreeableness → Creativity Intention	−0.023	−0.024	0.049	0.457	0.647
Conscientiousness → Creativity Intention	0.271	0.268	0.066	4.088	0.000
Openness to Experience → Creativity Intention	0.487	0.487	0.051	9.538	0.000
Neuroticism → Creativity Intention	−0.111	−0.110	0.029	3.818	0.000
Creativity Intention → Creativity	0.788	0.789	0.029	27.058	0.000
Knowledge Collection Behavior → Creativity Intention	0.142	0.144	0.062	2.268	0.023

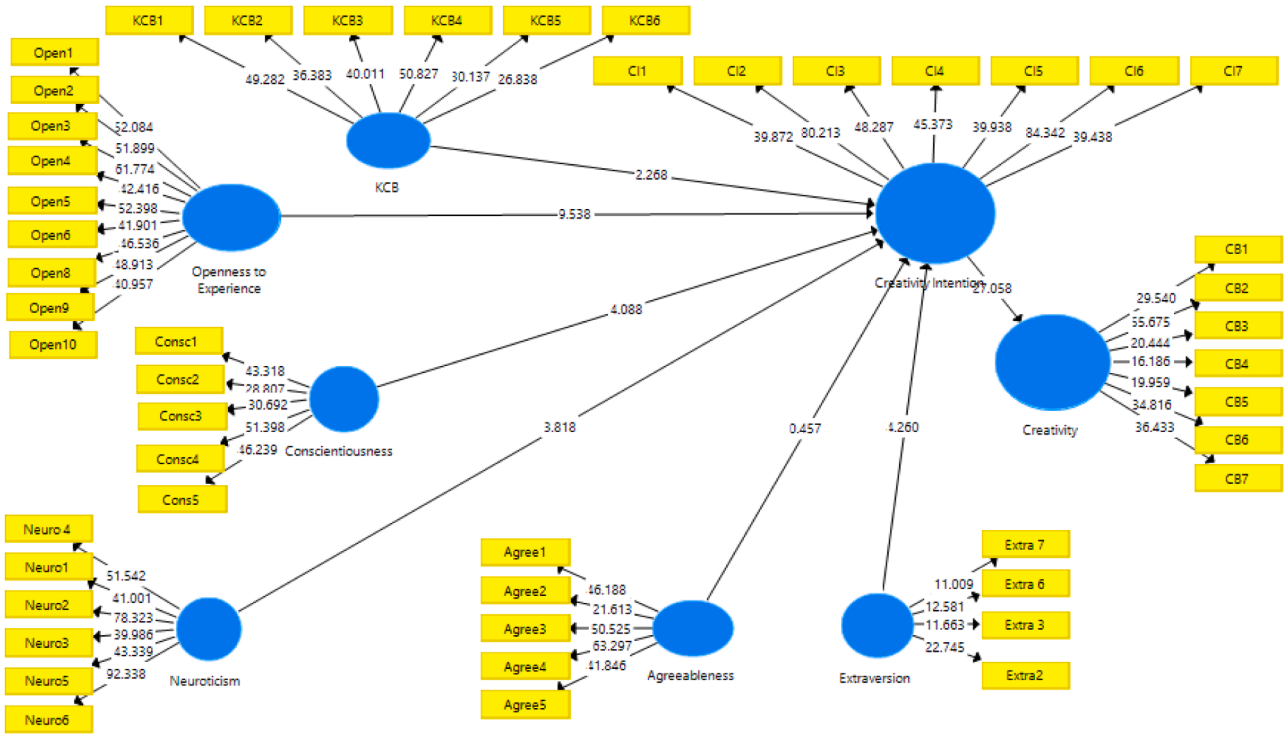

Fig 2. Structural Model Evaluation .

Table 10
R^2 value for endogenous latent variables.

	Original Sample	N	SD	T Stat.	P Val.
CI	0.794	0.800	0.024	32.623	0.000
Creativity	0.620	0.623	0.046	13.555	0.000

5. Discussion

5.1. Extraversion and creativity intention

H1: Extraversion is positively correlated with the creativity intention of the programmer.

According to the results of the present research, extraversion is a significant and positive predictor of creativity intention (T-value: 4.260: P-value: 0.000). The results show that with each unit increase in the extraversion trait, creativity intention increases by 0.138 units.

The reason behind the results can be found in the characteristics associated with the extraversion trait. It is characterized by a proactive behavior where an individual actively engages himself in a task and tries out different ideas. Furthermore, individuals with a high extraversion trait tend to be enthusiastic and hence curious, which also leads to creativity. [19]. In addition, extraverts are assertive and strive for achievement [70], which are also requirements for creativity [105]. Furthermore, the findings of the present research agree with studies such as [19] [46] and [47]. Hence, we believe that due to the characteristics of the extraversion such as outgoing, trying different ideas, assertiveness and strive for achievement, make this trait a strong predictor for creativity.

5.2. Agreeableness and creativity intention

H2: Agreeableness affects the creativity of the programmer

As for the relationship between agreeableness and creativity intention, the present study proposed a non-directional hypothesis due to the lack of consensus among scholars on the said relationship. However, the findings did not support the proposed hypothesis. According to the findings of the present research, the agreeableness trait does not predict creativity intention because the relationship is statistically insignificant (T-value: 0.457: P-value: 0.647) and hence inconclusive.

One of the possible explanations of the findings can be observed in the characteristics associated with the agreeableness trait such as kindness, empathy, trust and warmth. According to Sung and Choi [19], these traits are insignificant for creativity and it is believed that an individual with high agreeableness can be creative only if the extrinsic rewards are lesser. Based on personal experience, we believe that the presence of extrinsic rewards for programmers working in a GSD environment in Pakistan, can also be one of the probable reasons behind the findings of the present research for the above hypothesis.

As mentioned earlier, the literature is also inconclusive about the relationship between agreeableness and creativity. However, the results of the present study closely align with other studies that also pointed towards no relationship between agreeableness and creativity (i.e. [19] [45] [50] [53] [58] [106]. Hence, we believe that the results of the present research are justified and inclined towards majority of the research outcomes for the relationship between agreeableness and creativity intention.

5.3. Conscientiousness and creativity intention

H3: Conscientiousness effects the creativity intention of the programmer.

The findings of the present study showed that conscientiousness positively and significantly predicts creativity intention (Beta Value: 0.271; T-value: 4.088: P-value: 0.000). This supports the hypothesis (H3). The findings of the present research also side with the authors who suggested a positive relationship between conscientiousness trait and creativity.

One of the reasons behind such results could be the field of study. According to some authors the conscientiousness trait improves creativity in a scientific field (compared to arts) [40] [48] [58]. Since,

Table 11
Summary of Results.

Hypothesis	Findings
H1: Extraversion is positively correlated with the creativity intention of the programmer.	Supported.
H2: Agreeableness effects creativity intention	Not supported.
H3: Conscientiousness is negatively correlated with the creativity intention of the programmer	Not supported.
H4: Openness to experience is positively correlated with the creativity intention of the programmer	Supported
H5: Neuroticism is negatively correlated with creativity intention of the programmer	Supported
H6: Knowledge collection behavior (KCB) is positively correlated with creativity intention of the programmer.	Supported
H7: Creativity intention is positively correlated with the creativity of the programmer	Supported

software engineering is a scientific field, it can be argued that conscientiousness will be positively associated with a programmer's creativity.

Another rationale behind the results may be the context of the study. Most of the prior research has been conducted in a western setting. According to George and Zhou [18], the impact of conscientiousness on creativity relies on environmental and situational factors. The present study was conducted on programmers from a collectivist society of Pakistan. When the same relationship was tested in Iran, which is another collectivist society, the results also showed a positive relationship between conscientiousness and creativity [46] [106].

Furthermore, the method of investigation, self-rated creativity, may also be one of the reasons behind the findings. For studies which employed self-rated creativity instruments (i.e. [59] and [107]), the results showed that conscientiousness has a positive relationship with creativity.

Based on the above, the author of the present research believes that the impact of conscientiousness on creativity intention can also be affected by the field of study, context, as well as the method of investigation.

5.4. Openness to experience and creativity intention

H4: Openness to experience is positively correlated with the creativity intention of the programmer

The findings of the present research show that openness to experience is the most significant and strong predictor of creativity intention (beta value: 0.487; T-value: 9.538; P-value: 0.000). The results coincide with the proposed hypothesis (H4).

The results reported in this paper agree with the ones found in prior literature. The openness to experience trait is characterized by flexibility towards new and unfamiliar ideas, which is the basis of creativity [19]. Individuals with the openness to experience trait look for unusual situations and eventually achieve access to new ideas and experiences [34]. Furthermore, many earlier studies have found a strong relationship between openness to experience and creativity (i.e. [19] [46] [47] [52] [53] [57].

Based on the above explanation, we believe that openness to experience is very closely associated with creativity. It can be considered as a pre-requisite for creativity as without openness to different experiences, how could one be creative?

5.5. Neuroticism and creativity intention

H5: Neuroticism is negatively correlated with creativity intention of the programmer.

The findings of the present research comply with the proposed hypothesis that neuroticism has a negative effect on creativity. According to the results, neuroticism is significantly and negatively associated with creativity (Beta: 0.111; T-value: 3.818; P-value: 0.000).

The findings are in congruence with the existing literature on this relationship. It is argued that individuals who score high on neuroticism have low tolerance towards failure and are prone towards avoiding risk and taking initiative in social as well as task related matters [41] [68] [108]. Possessing these traits is important for coming up with creative solutions. Moreover, creativity is also linked with general satisfaction in life [109], which is contrary to the suffering nature of neurotic individuals [58]. Prior research has also found a negative relationship between the above variables (i.e. [46] [49] [53] [71].

5.6. Knowledge collection behavior and creativity

H6: Knowledge collection behavior (KCB) is positively correlated with creativity intention of the programmer.

The present study attempted to comprehend the relationship between knowledge collection behavior and creativity. As knowledge is essential for creativity, and knowledge collection behavior increases one's knowledge, it was proposed that an increased knowledge collection behavior will positively affect creativity.

Our findings have supported the hypothesis indicating that knowledge collection behavior positively and significantly predicts the intention of the programmers to be creative (Beta value: 0.142; T-value: 2.268; P-value: 0.023).

Knowledge is essential for creativity [21] because in order to come up with creative solutions one needs to collect external knowledge and integrate it with existing knowledge [8] [9]. Currently, there is no prior study that tested this relationship. However, the findings follow the theoretical assumptions of the componential theory of creativity [17] as well as the cognitive network model of creativity [110].

5.7. Creativity intention and creativity

H7: Creativity intention is positively correlated with the creativity of the programmer.

The findings suggested that creativity intention strongly, positively and significantly predicts the creativity of programmers (Beta: 0.788; T-value: 27.058; P-value: 0.000). Hence, the findings support the proposed hypothesis that the intention to be creative is important for coming up with creative solutions.

Intention is a strong predictor of a planned behavior [76]. It is not a surprise to find the same outcome for the relationship between creativity intention and creativity (behavior). Furthermore, the result also confirms that creativity is a planned behavior which requires the person to intend to be creative. The present study has not tested the mediating role of creativity intention because the study is cross sectional in nature and according to Maxwell and Cole [111], mediation is not suitable for cross sectional studies, as "mediation consists of causal processes that unfold over time" and cross-sectional efforts to estimate mediation will be biased and potentially seriously misleading.

Table 11 shows the summary of the results. Five out of seven hypotheses of the present research were supported by the findings.

6. Conclusion

The primary aim of this research was to understand the relationship between two individual variables, namely personality traits and knowledge collection behavior, and the creativity of the programmer. The primary respondents of the present research were programmers, particularly those who are working in a GSD based software companies in Pakistan. For this purpose, data was retrieved from 294 programmers.

The findings of the present research have shown that personality traits including conscientiousness, extraversion and openness to experience positively predict a programmer's intention to come up with creative solutions. However, the neuroticism trait was found to have a negative effect on the intention of the programmer to be creative. Lastly, it was found that agreeableness does not predict creativity intention and

that the relationship between both variables is statistically insignificant.

Furthermore, the research also endeavored to cognize the relationship between the knowledge collection behavior of the programmer and his intent to be creative. As expected, it was found that knowledge collection behavior is a positive predictor of the intention of programmer to be creative. Moreover, the findings of the present research also showed that creativity intention strongly predicts the creativity of the programmer.

6.1. Limitations of the work

Like any other human endeavors, the present research comes with limitations. First and foremost, the present research attempts to understand the impact of the aforementioned factors on creativity intention which in turn effects creativity. However, the correlation is not always transitive in nature. Hence, one should be careful to deduce that the impact of these factors on creativity intention will transit to creativity behavior, transitively. Furthermore, as the respondents of the study are from Pakistan, caution should be observed in generalizing the conclusions. Moreover, the present study has only examined personality traits and knowledge collection behavior in relation with creativity. Creativity is a complex psychological construct and it is important to understand its relationship with other important factors in order to holistically understand creativity of the programmers and its antecedents.

6.2. Contribution

In terms of the theoretical contributions of the study, it is the first study, as per the author's knowledge, to examine the creativity of the programmer in relation with the personality traits as well as knowledge collection behavior. Secondly, the study has also extended the use of componential theory of creativity as well as theory of planned behavior in software engineering domain. Thirdly, the present study has also provided useful insight for the relationship between conscientiousness trait and creativity, which is largely disputed in the prior research. Same is the case for the relationship between knowledge collection behavior and creativity intention. Prior research has not explored the aforementioned relationship in depth.

The outcome of the research will enable the software development companies to form effective and creative teams based on the personality traits [13]. With the help of the findings of this research, the software companies can pay close attention to programmer's knowledge collection behavior as well as their personality traits.

6.3. Future work

In future, the research should be expanded to include contextual factors such as organizational, technological and geographical [112] to achieve a holistic analysis of the interaction between individual and contextual factors to predict the creativity of programmers. Moreover, other phases of software development should also be included in future research. Furthermore, the future work should also attempt to qualitatively explore the programmer's creativity and different aspects of it. There is a lot of room for research in this area of research.

7. Credit author statement

Dr. Aamir Amin. The research work is part of Dr. Aamir's PhD thesis. He conceptualized the whole research work along with his supervisors. At the same time, he selected the methodology, performed formal analysis, wrote and visualized the original draft. He is also the corresponding author.

Dr. Shuib Basri. Dr. Shuib Basri was the main supervisor for this research work. He supervised the work from beginning (conceptualization) until the final thesis submission and viva voce. He also helped in acquiring resources, funds and scholarships during the PhD work. He also reviewed the research work.

Dr. Mobashar Rahman. Dr. Mobashar Rahman was the field supervisor for this research work. His-primary contribution was in data collection, curation as well as formal analysis.

Dr. Luiz Fernando Capretz. Dr. Luiz Fernando Capretz helped in great deal in terms of review and editing of the research work. He also provided useful feedback in the formation of the research work and analysis.

Dr. Rehan Akbar. Dr. Rehan Akbar provided useful insight in terms of conceptualizing programmer's creativity. From his experience in industry, his input was crucial in conceptualizing the creativity of the programmer.

Dr. Abdul Rehman Gilal. Dr. Abdul Rehman Gilal provided useful insight in terms of the methodology as well as literature review. He was also instrumental in terms of project administration.

Mr. Muhammad Farooq Shabbir. Mr. Muhammad Farooq Shabbir entered the author's list in later stages of manuscript preparation. He helped in proof reading as well as making revisions in the manuscript.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests:

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Appendix 1

Questionnaire

Gender	○ Male ○ Female
Highest Education	○ Diploma / Certificate ○ Bachelor ○ Masters
Experience	○ 0–3 years ○ 4–7 years ○ 8–10 years ○ 10 years and above
Employment status	○ Full Time ○ Part Time

How strongly you **AGREE or DISAGREE** with the following statements? In the following set of questions:
SD= Strongly Disagree, DA= Disagree, N=Neutral, A= Agree, SA=Strongly Agree

…I am someone who is..	SD	DA	N	A	SA
1….talkative.	1	2	3	4	5
2….reserved.	1	2	3	4	5
3….full of energy.	1	2	3	4	5
4….sometimes shy, inhibited.	1	2	3	4	5
5….outgoing, sociable.	1	2	3	4	5
6….helpful and unselfish with others.	1	2	3	4	5
7….generally trusting.	1	2	3	4	5
8….considerate and kind to almost everyone.	1	2	3	4	5
9….a reliable worker.	1	2	3	4	5
10….sometimes rude to others.	1	2	3	4	5
11….easily distracted.	1	2	3	4	5
12….depressed, blue.	1	2	3	4	5
13….relaxed, handles stress well.	1	2	3	4	5
14….emotionally stable, not easily upset.	1	2	3	4	5
15….original comes up with new ideas.	1	2	3	4	5
16….curious about many different things.	1	2	3	4	5
17….ingenious, a deep thinker.	1	2	3	4	5
18….inventive.	1	2	3	4	5
19….sophisticated in art, music, or literature.	1	2	3	4	5
…I am someone who..	SD	DA	N	A	SA
20….generates a lot of enthusiasm.	1	2	3	4	5
21….tends to be quiet.	1	2	3	4	5
22….has an assertive personality.	1	2	3	4	5
23….tends to find fault with others.	1	2	3	4	5
24….starts quarrels with others.	1	2	3	4	5
25….has a forgiving nature.	1	2	3	4	5
26. …can be cold and aloof.	1	2	3	4	5
27….likes to cooperate with others.	1	2	3	4	5
28….does a thorough job.	1	2	3	4	5
29….can be somewhat careless.	1	2	3	4	5
30….tends to be disorganized.	1	2	3	4	5
31….tends to be lazy.	1	2	3	4	5
32….perseveres until the task is finished.	1	2	3	4	5
33….does things efficiently.	1	2	3	4	5
34….makes plans and follows through with them.	1	2	3	4	5
35….can be tense.	1	2	3	4	5
36….worries a lot.	1	2	3	4	5
37….can be moody.	1	2	3	4	5
38….remains calm in tense situations.	1	2	3	4	5
39….gets nervous easily.	1	2	3	4	5
40….has an active imagination.	1	2	3	4	5
41….values artistic, esthetic experiences.	1	2	3	4	5
42….prefers work that is routine.	1	2	3	4	5
43….reflect, play with ideas.	1	2	3	4	5
44….has few artistic interests.	1	2	3	4	5
…I frequently collect work reports and official documents from…	SD	DA	N	A	SA
… members of my organization	2	3	4	5	
1					
…others that they prepare by themselves.	2	3	4	5	
1					
I frequently collect knowledge from other organizational members	SD	DA	N	A	SA
..about program syntax and logic (when coding components or programming)	1	2	3	4	5
..about solving similar problems based on their experience	1	2	3	4	5
..about know-where (i.e. libraries or where to find a specific solution to a problem) or know-whom (i.e. who in the organization can have the solution)	1	2	3	4	5
..about program language tools or paradigms (i.e. Modular, structured, object oriented and assembly language)	1	2	3	4	5
In the following set of questions, you are requested to report your intent to perform the tasks asked in the questions. It is to remember that it is not the actual behavior but the intend which you are supposed to mention.					
I intend to develop my own algorithms and logics to write a program.	SD	DA	N	A	SA
	1	2	3	4	5
I intend to take risk in terms of using new techniques, approaches or paradigms (i.e. assembly language, functional or object oriented) to solve a problem and find solution.	1	2	3	4	5
I intend to find new uses for existing methods and techniques (i.e. from libraries) to solve programming problems	1	2	3	4	5
I intend to solve problems that had caused difficulty to others.	1	2	3	4	5
I intend to generate new and innovative ideas.	1	2	3	4	5
I intend to identify opportunities for new products / processes.	1	2	3	4	5
I intend to generate novel, but applicable approaches and techniques	1	2	3	4	5
In the following set of questions, you are requested to report your actual behavior and not the intent. Whether you are actually able to perform for what you intend?					
I develop my own algorithms and logics to write a program.	SD	DA	N	A	SA
	1	2	3	4	5
I take risk in terms of using new techniques, approaches or paradigms (i.e. assembly language, modular or object oriented) to solve a problem and find solution.	1	2	3	4	5
I find new uses (by modification / merging) for existing methods and techniques (i.e. from libraries) to solve programming problems	1	2	3	4	5
I solve problems that had caused difficulty to others.	1	2	3	4	5

(*continued on next page*)

(*continued*)

I generate new and innovative ideas.	1	2	3	4	5
I identify opportunities for new products / processes.	1	2	3	4	5
I develop applicable approaches or techniques that are novel in nature	1	2	3	4	5

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