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Jan Guynes Clark
University of Texas at San Antonio, jgclark@utsa.edu

Diane B. Walz
University of Texas at San Antonio, dwalz@utsa.edu

Judy L. Wynekoop
Florida Gulf Coast University, jwynekoo@fgcu.edu

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IDENTIFYING EXCEPTIONAL APPLICATION SOFTWARE DEVELOPERS:
A COMPARISON OF STUDENTS AND PROFESSIONALS

JAN GUYNES CLARK
DIANE B. WALZ
Department of Information Systems, College of Business
University of Texas at San Antonio
dwalz@utsa.edu

JUDY L. WYNEKOOP
Department of Information Systems, College of Business
Florida Gulf Coast University

ABSTRACT

Exceptional application software developers are a scarce resource. It is therefore important for employers to identify, retain, and cultivate individuals who exhibit this capacity. This study compared the personality characteristics of exceptional, experienced application software developers with the personality characteristics of junior and senior level IS and CS students (who can be seen as entry-level, or pre-entry level, IT developers). We used the Adjective Checklist to measure personality characteristics for all subjects, then mapped the resultant scales to the Five Factor Model of Personality. The results of this study suggest that exceptional application software developers exhibit significantly higher levels of Extraversion and Conscientiousness. Exceptional students (as determined by GPA), however, were actually found to be introverted. Thus, when GPA is used to pre-screen or filter for entry-level positions, recruiters may actually be excluding some of those candidates who are most likely to become exceptional application software developers. These results have implications for understanding and managing the recruiting of IT personnel and their progression from entry level (novice) to more experienced positions.

KEYWORDS: IS personnel, IT personnel, IS developers, IT developers, experts, novices, personality characteristics, software development.

I. INTRODUCTION

Software is one of the world's largest and fastest-growing industries. Its role expanded well beyond basic operational applications to include both tactical and strategic systems. Software supports a spectrum of activities, from the recording of transactions, to monitoring and control, to innovation. At the heart of this diversity is the integration and correlation of technology

and innovations in business organizations and practice. The two are inexorably entwined; they move, and rise, and fall, together [Quinn *et al.* 1996; Cohen, DeLong, and Zysman 2000].

> *Software is the engine of innovation in our Internet-connected world. Research yields new ideas that software transforms into new products. Unlike traditional industries such as the automotive industry, software requires no factories for manufacturing, no costly distribution system, and hence no large infrastructure investment. But it does require skilled software engineers.*
> Stephen E. Cross (2002), Director & CEO, Software Engineering Institute (SEI), CMU, 2002.

As markets expand and system complexity grows, quality and productivity in software development become increasingly important [Niederman, Brancheau & Wetherbe 1991; Pressman 1992; Ravichandran & Rai 2000]. It is well accepted that the capabilities of the software developers are primary determinants of the quality of a finished product. Individual skills, abilities, and talents were identified as primary determinants of differences in software productivity and product quality. Exceptional software developers, however, remain a significantly scarce resource. It is therefore important to identify and actively cultivate such individuals [Brooks, 1987; Curtis, Krasner & Iscoe 1988; Agarwal & Ferratt 1999, 2002; DeMarco & Boehm 2002].

While methods for individual and team process training reported initial successes, evaluations are mixed [Young *et al.* 2001; DeMarco & Boehm 2002]. Schenck *et al.* [1998] reported differences in problem understanding and/or problem-solving style between novices (MBA IS majors) and high-rated experienced systems analysts. Differences were evident in domain-specific knowledge, problem-structuring, hypothesis generation, goal setting and strategizing.

Experienced IT professionals can be classified according to performance levels from below average to outstanding. Entry-level IT professionals (novices) can also be classified, although the data are based on limited experience. This study specifically compared the characteristics of working IT professionals and students intending to enter the IT field. We focused on software developers, which involve a broad category of IT related jobs: systems analyst, programmer/analyst, and system and project managers. The purpose of this study was to extend studies of experts versus novices by investigating the similarities and differences between novice application software developers and experienced application software developers with respect to personality characteristics.

These results are relevant for evaluating screening and recruiting processes. Are we selecting those novices most capable of becoming expert software developers? If not, how can we change our criteria for selection to better meet this need?

We believe these results are significant both to IT academics and practitioners who are concerned with identifying and nurturing exceptional software developers. The identification of traits which characterize outstanding design personnel at the entry-level stage can lead to the development of formal methods for the identification, mentoring, education, and training of such personnel.

II. IT DEVELOPERS

THE NATURE OF EXPERTISE – DESIRABLE QUALITIES

While individual abilities are the most important factors in explaining differences in performance among software developers, personality dimensions may also play a role [Brooks 1987; Rasch & Tosi 1992]. Curtis, Krasner & Iscoe [1988] identified an important set of traits associated with exceptional performance:

- dependability,
- good communication skills,

- superior application (domain) and technical knowledge,
- the ability to integrate knowledge areas,
- the ability to translate requirements into computational structures,
- the ability to manage a project,
- the ability to develop and simulate complex models of a system mentally, and
- the ability to envision the interactions of system components.

While experts are clearly more experienced than novices, years of experience is not the sole indicator of expertise [Lord & Maher 1990]. Individuals acquire experience over time, through repeated feedback. However, Bereiter and Scardamalia [1993] argue that not all experience leads to expertise. Current theories of expertise expand upon the central role of information and knowledge. They distinguish high performers by the way they organize their knowledge and the way they think and solve problems, rather than simply by levels of knowledge [Anderson 1985; Dreyfus & Dreyfus 1986; Chi *et al.* 1988].

Prior researchers studied experienced developer/analyst characteristics and traits. For example, Vitalari [1985] concluded that exceptional systems analysts rely on organizational knowledge and are more people-oriented than other analysts. Stolterman [1991] described exceptional designers as creative, logical, and organized, whereas Smits *et al.* [1993] suggest that high performing analysts value autonomy, prefer challenging work, and tend to work hard.

Walz and Wynekoop [1997] conducted semi-structured interviews with IT managers who, in general, attributed outstanding software developers with being self confident, highly motivated, and creative problem solvers, who had good communication skills, and the ability to organize. In a follow-up study, they used Delphi analysis to determine a consensus set of characteristics [Wynekoop & Walz 2000]. Experienced subjects contend that top performing IT developers possess technical and business knowledge, think abstractly and creatively, work with, and lead teams. In addition, they view top performers as analytical, logical, motivated, dependable, and organized.

PREDICTING POTENTIAL

Recruiters need to determine both actual and potential contributions of novice applicants. Hiring and retaining good employees can be an expensive, time-consuming process. Therefore, it is best to do it right the first time.

When the applicant pool is high, recruiters are far more selective, resorting to a multistage process in which some minimal criteria must be met before candidates are considered further. Academic achievement (as measured by GPA) is often used as a pre-selection criteria. Potential candidates whose GPA falls below some minimum are never considered for a given position, regardless of their other traits or skills.

Historically, college recruiters for IT areas rely upon GPA and technical skills (usually identified by a history of training or experience) as their initial criteria for hiring. Only those candidates who meet the GPA threshold and technical skill requirements are pursued further. However, no clear link exists between GPA and job performance. Prior studies compared academic performance with job success, as indicated by salary. In a meta-analytic study, Bretz [1989] found no overall significant relationship between GPA and job success.

Communication and interpersonal skills can, to a limited extent, be evaluated in personal interviews. Personal recommendations may provide insights into many qualities: a candidate's motivation, initiative, leadership abilities, character, work ethic, etc. These insights, however, are not always reliable and are not comparable across candidates.

Organizations also attempted to evaluate candidates' personalities by use of standardized tests [Bell 1999; Hurwitz & Ippel 1999]. A l997 AON Consulting/Society For

Human Resource Management survey of the association's 130,000 members showed that 18 percent of U.S. companies use behavioral and personality testing for screening non-management candidates; 22 percent, for management. While personality assessment surveys are becoming more common, a variety of instruments are used, with little standardization, especially with respect to the specifics of software development.

III. PERSONALITY FACTORS

Personality is generally defined as a set of characteristics that influence an individual's perceptions, motivations and behaviors [Lau & Shaffer 1999; Lee, Dougherty & Turban 2000]. A discussion of personality theories is beyond the scope of this paper. However, some theories support a biological basis of personality, while others give more importance to the influence of experiences and context [Lau & Shaffer 1999].

Research suggests that personality is relatively stable over time. When looked at in relation to others, an individual's personality traits tend to remain constant [Costa & McRae 1997]. Personality attributes of business students were found to be essentially the same as those of business managers [Jarlstrom 2000]. This result implies that novices and experienced professionals should not differ with respect to personality characteristics. Computer professionals in general are characterized as people motivators (empathetic), conceptualizers (planners, a systems view), administrators (orderly) and problem-solvers [Teague 1998].

Until recently, personality was not considered a valid predictor of job performance [Schmitt *et al*. 1984]. However, these studies were based upon poorly defined methods of classifying personality traits [Barrick & Mount 1991]. There is currently wide agreement that five factors can be used to classify personality attributes [Digman 1990; Barrick & Mount 1991].

The five-factor model of personality (FFM) is well accepted and used extensively. It represents personality traits along five dimensions:

- Extraversion (degree of gregariousness and sociability),
- Conscientiousness (amount of organization, commitment and persistence),
- Agreeableness (degree of trust in others and friendliness),
- Negativity (level of personal adjustment and tolerance for stress), and
- Openness (degree of openness to new experiences and ideas) [Digman 1990; Costa & McCrae 1992; Berr, Church & Waclawski 2000].

The five dimensions (FFM, or "Big Five") are presented in Table 1.

The Big Five is generalizable across virtually all cultures [McCrae & Costa 1997; Salgado 1997] and remains fairly stable over time [Costa & McCrae 1997]. Barrick and Mount [1991] studied the relation between the FFM personality dimensions and job performance. They examined the following occupational groups: professionals, managers, sales, police, and skilled/semi-skilled. Meta-analysis results showed that Conscientiousness was a consistent valid predictor for all occupational groups, whereas Agreeableness and Openness were not valid predictors for any occupational groups. Extraversion was a valid predictor for managers and sales.

Mount *et al*. [1998] conducted a later study of the FFM personality dimensions and their relation to performance in jobs involving interactions with others. They concluded that Agreeableness, Conscientiousness, and Emotional Stability were each predictors of performance. Further, jobs that required interaction with one's coworkers, as in teams, demanded greater Agreeableness and Emotional Stability than jobs that required interaction with customers.

Table 1. Five Factor Model Personality Dimensions (OCEAN)

Personality Dimension	Characteristics of Low Levels	Characteristics of High Levels
Extraversion	Reserved, cautious, retiring, introverted	Active, talkative, gregarious, exhibitionist, ambitious, assertive
Conscientiousness	Irresponsible, disorganized, sloppy, chaotic	Dependable, organized, responsible, achievement-oriented, self-disciplined, conscientious
Agreeableness	Irritable, uncooperative, suspicious, rigid	Likable, friendly, courteous, flexible, good-natured, forgiving, tolerant, trusting, altruistic, gentle, hopeful
Emotional Instability (aka Negativity) (r)	Calm, secure, poised, collected, enthusiastic, stable	Anxious, depressed, embarrassed, emotional, worried, insecure
Openness	Insensitive, narrow, practical	Imaginative, curious, cultured, intelligent, broad minded, original, sensitive

(r) identifies dimensions whose sign is reversed
Source: McRae and Costa [1996] and Costa and McRae [1997]

Judge *et al.* [1999] conducted a longitudinal study to examine the relationship between cognitive ability (measured with the Stanford-Binet intelligence test), the Big Five personality dimensions, and career success. Career success was examined both intrinsically (e.g. job satisfaction) and extrinsically (e.g. salary and job status). Cognitive ability was a strong predictor of extrinsic career success, but not intrinsic career success. These results are similar to those of Ganzach [1998]. However, the researchers found little support for the interaction between cognitive ability and personality in regard to career success.

The results reported by Wynekoop & Walz [2000], described above, were not studied in relation to the FFM. We propose, however, that these results can be interpreted to suggest that top performing IT developers are Conscientious (motivated, dependable, and organized) and Extraverted (motivated, able to lead and work on teams) and Agreeable (work well with others).

ACADEMIC PERFORMANCE

Research in the education literature does not focus on personality type as a determinant of productivity or quality of learning. Instead, the majority of research in this area considers personality types with respect to methods for tailoring instruction to cover the spectrum. Prior researchers identified a broad set of personality types for Computer Science students [Teague 1998]. For example, Bishop-Clark [1995] proposed a model that identifies favorable/unfavorable personality characteristics with respect to the specific requirements of the subtasks involved in software development.

Information Systems (IS) and Computer Science (CS) are two major disciplines for IT professionals. Although their graduates may pursue the same, or similar jobs, IS and CS programs differ in focus and nature. IS programs include programming, but focus on problem-solving, design, development, organizational applications, and implementation. They also include courses from a variety of business disciplines and encourage group work. CS programs tend to be more technical and less organizational, with fewer group projects and a more structured curriculum. They tend to focus on algorithms, theories of computation, and model building. In addition, IS and CS students possess different levels of creativity [Wynekoop & Walz 1996]. These findings suggest that, *ceteris paribus*, the higher performing IS students may be more Extraverted.

When we reviewed the content of study skills courses, we noted that they consistently stressed reading efficiency, time management, note-taking, test-taking and organizational skills. Some study skills courses offer methods for better communication, although this topic is largely related to writing. Thus, we expected conscientiousness to be the most important personality dimension in distinguishing high performing (GPA) students, in general.

For privacy reasons, we collected only limited data related to Emotional Stability. Therefore, we did not study this personality dimension.

IV PROBLEM STATEMENT

For IT students, some researchers suggest that extraverted and conscientious personality types may perform better in school [Teague 1998]. Prior researchers suggest that Conscientious students perform better in school, across majors. Thus, we compared exceptional (based on GPA) students to non-exceptional students with respect to these personality dimensions.

The differences between IS and CS programs (which largely feed the entry level candidate pool) may be reflected in differences in the types of students who excel. Thus, IS and CS majors were compared across the personality dimensions. We expected that the IS majors would be more Extraverted, on average, than the CS majors.

Prior research (described above) suggests that exceptional IT developers can be distinguished by dimensions of their personalities. Specifically, we expected exceptional developers to be more Conscientious, Agreeable, and Extraverted than other developers.

A high GPA is often one of the first screening criteria for hiring IT graduates. However, researchers have not explored the link between general academic achievement (GPA) and personality types. If personality traits tend to remain stable over time, (as suggested by Costa & McRae [1997]) we can investigate the effectiveness of this screening by:

- examining the relationship between GPA and personality characteristics and
- comparing the characteristics of exceptional students with those of exceptional IT developers.

Then, if initial screening on GPA is valid, the personality factors that are associated with higher GPAs should not exclude those factors which are significant for exceptional IT professionals. Therefore, we compared the personality characteristics of exceptional students (as determined by a single screening factor, GPA) to those of exceptional IT professionals.

V HYPOTHESES

We tested the following hypotheses:

H1: The personalities of IT students with high GPAs differ from those of IT students with lower GPAs. Specifically, we expect that students with high GPAs will score higher, on average, on the Conscientious dimension than other students.

H1a: The personalities of CS & IS students differ. Specifically, we expect the IS students to be more Extraverted.

H2: The personalities of exceptional IT developers differ from those of non-exceptional developers. Specifically, we expect that exceptional individuals are more Extraverted, Conscientious, and Agreeable than non-exceptional professionals.

H3: The personalities of exceptional IT professionals are the same as the personalities of high GPA entry-level novices (IS and CS students).

VI RESEARCH METHOD

Recent research using natural language adjectives and theoretically grounded personality surveys suggests that the Five Factor Model (FFM) is comprehensive and applicable across subjects, observers, and cultures [McCrae & John 1992]. In addition, the FFM can be produced using the Adjective Check List (ACL) scales [Piedmont *et al.* 1991; Formy-Duval *et al*. 1995]. The Adjective Check List (ACL) is an adult personality test that consists of 300 adjectives which respondents mark to describe themselves. The results are scored according to 32 scales relating to a broad set of characteristics. The ACL shows high internal reliability and validity [Gough 1952; Gough & Heilbrun 1983]. Furthermore, Craig *et al*. [1998] provided strong evidence of construct validity.

The entire ACL personality test and a brief demographic questionnaire were administered to a set of IT professionals and a set of IT students. All ACL items were included. We scored subjects on 25 of the 32 scales. Scales that could be expected to affect work performance were included. For privacy reasons, we did not include the Transactional Analysis scales. The ACL scales that we studied are listed in Tables 3 and 4 in Section VII).

We surveyed one hundred and fourteen (114) information technology professionals in three oil and gas companies in the Southwest. Subjects were systems analysts, designers, programmer analysts, and project managers with, on average, over eight years of experience. We identified the managers of these subjects and conducted semi-structured interviews with nineteen managers in three firms. The managers were asked to identify those employees who they felt were "exceptional" in terms of job performance. They were also asked to describe their concept of *exceptional* and to discuss factors that they believe to be significant. As a result, the managers identified forty of the subjects as being "exceptional".

We also administered the ACL to 119 undergraduate IS and CS majors. 80 of these students were juniors or seniors (JS). The upper class students were given a questionnaire requesting additional information, including cumulative GPA. Seventy one of these students supplied their grade point average. The junior and senior students were then classified as "exceptional" if their cumulative GPA was greater than or equal to 3.5 (Table 2).

ANALYSIS

For the two samples, students and professionals, we factor-analyzed (separately) the computed scales from the ACL (minus those excluded for relevance and privacy reasons) using principal components extraction and promax rotation (a form of oblique rotation used when independence of the factors cannot be assumed). The resulting factor scores were recorded for each subject. We then matched the empirically determined factors to the "Big 5" personality dimensions [Piedmont *et al.* 1991]. Although we had partial results for Emotional Stability, we did not include these results.

Table 2. Summary of Subjects

Juniors & Seniors (JS) 80 Freshmen. & Sophomores (FS) 39	**JS Students (Exceptional if GPA > 3.5)**	**IT Professionals**
N	71	143
Exceptional	18 (25%)	40 (28%)
Non - Exceptional	53 (75%)	103 (72%)

To begin addressing the hypotheses, we used independent sample t-tests to determine if the means of the personality dimension scores were equivalent for the groups of interest. For hypothesis 1, we compared exceptional versus non-exceptional students. To address hypothesis 1a, we compared the personality dimension scores of both exceptional and non-exceptional IS and CS students. For hypothesis 2, we compared exceptional IT developers to non-exceptional

IT developers. For hypothesis 3, we compared the personality scores of exceptional IT developers to those of exceptional upper-division IT students. These tests, however, examine the personality dimension scores independently.

To address the hypotheses further, we used logistic regression analysis to determine whether the personality dimensions, taken together, could classify subjects. The personality dimensions were the independent variables of the logistic regressions and the classification variable of interest was the dependent variable. Thus, for hypotheses 1 and 2, the category variable Exceptional was the dependent variable. We assigned a value of 1 for exceptional subjects and a value of 0 for others. Because we investigated the effects of screening on GPA, the upper class students were classified in only two groups, exceptional (if GPA was greater than or equal to a threshold value) and not exceptional (if it was less than the threshold value).

For hypothesis 1a, we used logistic regression to examine the relationship between the personality dimensions (as independent variables) and student major (IS versus CS) as the dependent variable. To address hypothesis 3, we used logistic regression to test whether personality dimensions (independent variables) distinguished between professionals and students (dependent variable), where all subjects were "exceptional", as defined for the subgroup.

VII. RESULTS

When the scores for the IT developers and the IT students were factor analyzed (separately), five factors emerged, consistent with the Five Factor Model. Results of the factor analysis for the four dimensions included in this study are shown in Tables 3 and 4. Only scores with absolute values greater than .399 are reported.

The signs of the scale items scores were consistent across Tables 3 and 4 on pages 145 and 146, respectively. The Contingency Coefficient, a measure of association for nominal data, was .856, with a p-value of .000. Goodman & Kruskal's (GK) tau reflects the proportional reduction in error when values of the independent variable are used to predict values of the dependent variable. The GK tau was .89 with a p-value of .000. Thus, we cannot reject the hypothesis that the assignment of the ACL scales is consistent between students and IT professionals.

H1 – EXCEPTIONAL STUDENTS ARE MORE CONSCIENTIOUS THAN NON-EXCEPTIONAL STUDENTS

There was support for this hypothesis. When we compared the means for the exceptional versus non-exceptional students, the exceptional students were significantly more Conscientious (Table 5). Of the other personality dimensions studied, only extraversion was significantly different for exceptional and non-exceptional students. For this dimension, we reported p-values for a two-tailed test since a direction was not hypothesized.

Table 5. Comparison of Means: IT Students
(Exceptional vs. Non-exceptional on GPA)

Mean (standard deviation)	Exceptional	Non-Exceptional	t	Significance (one-tailed)
Extraversion	-0.527 (.978)	0.194 (1.103)	2.347	**0.015***
Conscientiousness	0.625 (1.139)	-0.149 (.943)	-2.281	**0.018***
Agreeableness	-0.270 (1.010)	-0.093 (.987)	0.571	0.288
Openness	0.038 (.806)	-0.100 (1.069)	-0.504	0.310

Assume unequal variances.
* Significant for $\alpha < .05$

Table 3. Factor Components & Component Correlations -- IT Developers

	Extra-version	Conscien-tiousness	Agreeable-ness	Openness
	1	2	3	4
Exhibition	.900			
Dominance	.871			
Aggression	.848			
SelfControl	-.826			
Abasement	-.757			
SelfConfidence	.729			
Autonomous	.696		-.429	
Deference	-.668		.442	
Order		.938		
Endurance		.924		
Change	.416	-.703		
Logical, analytical, independent, unsociable (LO-HI)		.688		
Achievement	.555	.593		
Intuitive, impersonal (HO_HI)		-.556	-.462	
Military Leadership		.553		
Extroverted, friendly, self-effacing (LO_LI)			.889	
Affiliation			.880	
Nurturance			.813	
Personal Adjustment			.704	
Intraception			.473	.458
Creative personality				.669
Ideal self				.679
Succorance				-.669
Playful, outgoing, non-conforming (HO_LI)				
Counseling readiness				

Extraction Method: Principal Axis Factoring.
Rotation Method: Promax with Kaiser Normalization.

Component Correlation Mtrix	Extraversion	Conscientiousness	Agreeableness	Openness
Extraversion	1	-.006	-.127	.251
Conscientiousness		1	.226	.185
Agreeableness			1	.156
Openness				1

Table 4. Factor Components & Component Correlations -- IT Students

	Extraversion	Agreeableness	Conscientiousness	Openness
	1	2	3	4
Exhibition	.894			
Aggression	.879			
Dominance	.842			
Self Control	-.727			
Autonomous	.723			
Abasement	-.656			
SelfConfidence	.655			
Deference	-.652			
Achievement	.554		.417	
Extroverted, friendly, self-effacing (LO_LI)		.847		
Affiliation		.828		
Personal Adjustment		.790		
Nurturance		.748		
Intraception		.533		
Order			.780	
Logical, analytical, independent, unsociable (LO-HI)			.726	
Change			-.654	
Endurance			.641	
Playful, outgoing, non-conforming (HO_LI)		.445	-.567	
Military Leadership			.505	
Succorance				-.801
Ideal Self				.748
Creative personality				.451
Intuitive, impersonal (HO_HI)				

Extraction Method: Principal Axis Factoring.
Rotation Method: Promax with Kaiser Normalization.

Component Correlation Mtrix	Extraversion	Agreeableness	Conscientiousness	Openness
Extraversion	1	.017	-.051	.137
Conscientiousness		1	.163	.239
Agreeableness			1	.250
Openness				1

We also estimated logistic regression models, with the dependent variable classifying subjects as either exceptional or non-exceptional. For Hypothesis 1, analysis of the data from the junior and senior level IT students is shown in Table 6.

Table 6. Logistic Regression IT students

0→ non-exceptional
1→ exceptional (GPA >= 3.5)

Dimension	B	S.E.	Wald	df	Significance (one-tailed)	Exp(B)
Extraversion	-.958	.415	5.341	1	**.011***	.384
Conscientious	1.049	.428	6.007	1	**.007***	2.854
Agreeable	-.314	.378	.693	1	.203	.730
Openness	.270	.458	.348	1	.278	1.310
Constant	-2.045	.465	19.316	1	.000	.129

*Significant for $\alpha < .05$

The coefficient for conscientiousness was positive and significant, suggesting that exceptional students are more Conscientious than non-exceptional students. The coefficient for extraversion was also significant, again suggesting that exceptional and non-exceptional students differ with respect to extraversion. The signs of the coefficients for extraversion were negative, suggesting that exceptional students are not just *less* extraverted than non-exceptional students, they are introverted.

H1A – IS STUDENTS ARE MORE EXTRAVERTED THAN CS STUDENTS.

There was support for this hypothesis. As shown in Table 7, the Extraversion dimension scores for IS majors were significantly higher than the scores for the CS majors. Also note the reversed signs on the means for Extraversion, indicating that IS majors tend to be extraverted and CS majors tend to be more Introverted. The logistic regression results (Table 8) also suggest that IS students are more extraverted than CS students. The coefficient for Extraversion was both positive and significant.

Table 7. Comparison of Means -- IT Students
(IS Juniors and Seniors versus CS Juniors and Seniors)

Mean (standard deviation)	IS (n=38)	CS (n=41)	t	Significance (one-tailed)
Extraversion	0.255 (1.004)	-0.203 (1.174)	1.867	**.033***
Conscientiousness	0.129 (.984)	0.104 (.997)	.114	.455
Agreeableness	-0.070 (.968)	-0.116 (1.030)	.202	.420
Openness	-0.100 (.988)	-0.037 (.999)	-2.82	.390

Assume unequal variances.
*Significant for $\alpha < .05$

Table 8. Logistic Regression --IT Students versus CS

0→ CS juniors and seniors
1→ IS juniors and seniors

Dimension	B	S.E.	Wald	df	Significance (one-tailed)	Exp(B)
Extraversion	.434	.224	3.750	1	.027*	1.543
Conscientious	.109	.250	.188	1	.332	1.115
Agreeable	.078	.244	.102	1	.375	1.081
Open	-.218	.264	.679	1	.205	.804
Constant	-.105	.235	.201	1	.327	.900

*Significant for $\alpha < .05$

H2 – EXCEPTIONAL IT DEVELOPERS ARE MORE EXTRAVERTED, CONSCIENTIOUS, AND AGREEABLE THAN NON-EXCEPTIONAL IT DEVELOPERS.

There was partial support for this hypothesis. As shown in Table 9, when we compared the means for exceptional versus non-exceptional IT developers, Extraversion and Conscientiousness were significantly higher for exceptional IT developers. We found no significant difference with respect to Agreeableness. Also note that the signs were reversed on both Extraversion and Conscientiousness for the non-exceptional IT developers.

Table 9. Comparison of Means -- IT Developers
Exceptional Versus Non-Exceptional Developers

Mean (standard deviation)	Exceptional	Non-Exceptional	t	Significance (one-tailed)
Extraversion	0.391 (1.064)	-0.152 (.936)	-2.828	.003*
Conscientiousness	0.211 (1.090)	-0.082 (.956)	-1.493	.070**
Agreeableness	-0.071 (1.087)	0.028 (.968)	0.502	.309
Openness	0.039 (.806)	-0.015 (1.069)	-0.325	.373

Assume unequal variances.
* Significant for $\alpha < .05$
** Significant for $\alpha < .10$

The logistic regression model was estimated to compare exceptional to non-exceptional IT developers and provides further support for these results (Table 10).

Table 10. Logistic Regression IT professionals

0→ non-exceptional
1→ exceptional (GPA >= 3.5)

Dimension	B	S.E.	Wald	df	Significance (one-tailed)	Exp(B)
Extraversion	.641	.221	8.414	1	**.002***	1.898
Conscientious	.429	.229	3.514	1	**.032***	1.536
Agreeable	-.064	.209	.094	1	.380	.938
Open	-.140	.211	.441	1	.254	.869
Constant	-1.053	.204	26.637	1	.000	.349

*Significant for α < .05

Only the coefficients for the extraversion and conscientious dimensions were significant. These coefficients were both positive, indicating that exceptional it developers appear to be more extraverted and conscientious than non-exceptional it developers. The coefficient for agreeableness was not significant

H3 – THE PERSONALITY CHARACTERISTICS OF EXCEPTIONAL IT STUDENTS ARE SIMILAR TO THOSE OF EXCEPTIONAL IT PROFESSIONALS.

There was no significant support for this hypothesis. As shown in Table 11, when we compared means for the exceptional IT developers versus exceptional IT students, the exceptional IT developers were significantly more Extraverted. Note the reversed sign for exceptional IT students, indicating that the IT students with a high GPA are, on average, Introverted. No significant difference was observed between the other dimensions when comparing the means of the two groups.

Table 11. Comparison of Means: Exceptional Subjects

	IT Professionals	Students (GPA > 3.5)	t Significance (two-tailed)
Extraversion	0.391 (1.064)	-0.527 (.978)	-2.877 **(.010)***
Conscientiousness	0.211 (1.090)	0.625 (1.139)	1.150 (.264)
Agreeableness	-0.071 (1.087)	-0.270 (1.010)	-0.604 (.552)
Openness	0.039 (.806)	0.038 (.806)	-0.004 (.987)

Assume unequal variances.
*Significant for α < .05

For the exceptional subjects (Table 12), the logistic regression results also did not support Hypothesis 3. The sign of the coefficient for Extraversion was significant and negative, suggesting that exceptional IT professionals are more extraverted than exceptional students. The coefficient for Conscientiousness was significant in this model and the sign of the estimated coefficient was positive. This suggests that exceptional IT professionals, while conscientious, may actually be *less* conscientious than the exceptional students. We thus rejected hypothesis 3, that the two groups are similar with respect to personality characteristics.

Table 12 Logistic Regression --Exceptional Subjects

0→ Exceptional Professional Developers
1→ Exceptional IT students (GPA > 3.5)

Dimension	B	S.E.	Wald	df	Significance (two-tailed)	Exp(B)
Extraversion	-1.263	.463	7.433	1	**.006***	.283
Conscientious	.800	.440	3.308	1	**.070****	2.225
Agreeable	-.638	.418	2.333	1	.126	.528
Open	.368	.483	.583	1	.446	1.445
Constant	-1.685	.482	12.208	1	.000	.185

*Significant for $\alpha < .05$
**Significant for $\alpha < .10$

When we analyzed GPA cut-off values of 3.0 and 3.3, we obtained nearly identical results to those for the 3.5 GPA threshold reported here. As a control, we also used logistic regression to test whether personality characteristics, as independent variables, could classify subjects as IT professionals or IT students (the dichotomous dependent variable), for all subjects. None of the personality dimensions were significant in distinguishing between the students and professionals when both exceptional and non-exceptional subjects were included.

VI. CONCLUSIONS AND IMPLICATIONS

RECRUITING AND PLACEMENT

The results of this study suggest that Extraversion and Conscientiousness may be significant factors in identifying exceptional IT application developers. This result is comparable with the work of Smits, McLean, and Tanner [1993], who found that as an IT professional progresses through his or her career, "people" skills become increasingly important for success.

Extraversion and Conscientiousness were also significant factors in identifying exceptional IT students, as indicated by GPA. However, the coefficient for Extraversion for the high-GPA students was negative, indicating that the exceptional IT students are Introverted, rather than Extraverted. If the assertion that one's personality remains stable over time is correct, the result suggests that initial screening or filtering by GPA, a common practice in recruiting for entry-level positions, may actually be counter-productive.

GPA is a self-directed and individual-centered measurement, reflecting a combination of individual goals, effort, and intelligence. The finding that GPA alone is not a good predictor for success in the IT profession is not new. These results, however, extend the caveat against "GPA only" to a warning against "GPA first". Essentially, the use of GPA as an initial screening factor in a multi-stage hiring process for IT professionals may actually result in the exclusion of those candidates who are most likely to become exceptional IT application developers.

An initial screen on *any* easily accessible relevant variable reduces the cost of recruiting. In a world of surplus talent, enough exceptional candidates will still be forthcoming. As described above, however, exceptional IT developers are a scarce resource. Further research is indicated to understand better the market for IT professionals with respect to these issues. Would my firm ultimately recruit more exceptional IT developers if we didn't screen initially on GPA alone?

Entry-level application software developers should possess technical skills and aptitudes, and the native intelligence to understand and accomplish the work. Traits such as extraversion and conscientiousness, however, should not be ignored, particularly in initial screenings.

We suggest that recruiters may benefit from screening mechanisms that identify those entry-level candidates who managed to balance grades and other activities. We propose the identification of those types of activities that provide evidence of extraversion – jobs, internships, sports, club memberships, and involvement in service organizations. For example, one significant "signal" of extraversion may be leadership in such activities.[1] Further research is needed, however, to determine the significance of extraversion and to identify measures or surrogates for this personality trait that are available at the initial screening stage.

The development of a portfolio of criteria to aid in selecting personnel is also significant for retaining, placing, and developing IT professionals. The Human Resource function of matching individuals to assignments is facilitated by an identification of the professional requirements along multiple dimensions, and the availability of a set of criteria to measure these dimensions.

ISSUES FOR ACADEMIA

The warnings presented here against initial screening based solely on GPA can be further generalized to the academic world. Are the qualities of those who complete an IS or CS degree program a match for the qualities needed by industry? What if the higher education system, with its dependence on grades and GPA for academic "survival", is actually weeding out individuals who might be exceptional IT professionals?

This study finds that exceptional IT developers are different from exceptional (as determined by GPA) IT upper-level students, largely with respect to Extraversion, and, to some extent, with respect to Conscientiousness. The exceptional developers are extraverts, while the exceptional students are introverts. Both groups exhibit conscientiousness, with the exceptional students displaying significantly higher levels.

As noted, the IS majors in our study appeared to be significantly more Extraverted than CS majors. Perhaps those same personality factors that impact development expertise also affect the program of study a student selects (e.g. IS versus CS). Further research, for example, may show that CS majors are better system developers than IS majors. Such a result could have a significant impact on job placement and task assignment.

An understanding of the mechanisms through which personality factors affect an individual's success in an academic field can also inform the modification and evolution of curricula for IT-related majors. The dynamic nature of the IT environment places a high value on flexibility and foresight in education. Some dimensions of this changing environment introduced industry goals (such as the ability to work in heterogeneous groups, or the ability to communicate technical concepts in layman's terms) that were not necessarily compatible with the personalities of the individuals already in place. This difference may perhaps be a factor in the genesis, evolution, and ultimate success of the field of IS in a world of Computer Scientists and Software Engineers.

STUDENT SUBJECTS

These results also have implications for the use of student subjects as surrogates for IT professionals. The sample of professionals in our study did not differ, with respect to personality, from the student sample when considered as a whole. Significant differences were found, however, when looking at cases within the samples. Thus, when student samples are used as surrogates for professionals, care must be taken when using student-related measures (e.g., test scores, GPA) as proxies for measures of performance in the professional world. Groups of working IT professionals include, for the most part, only survivors. Student samples, however, also include those who survived the academic process but will not survive in the profession. The results of this study suggest that additional research on this issue may be warranted.

The IT novices in this study were a convenience sample of IT students at one university, and the IT professionals were employed at three oil and gas companies. This selection process may introduce a bias from sample homogeneity. Furthermore, a more accurate understanding

[1] An interesting observation is that the ACL scale, *Military Leadership*, typically loads on the Conscientiousness personality dimension, and not on Extraversion. (Tables 3 and 4.)

could be achieved by studying entry-level IT professionals (e.g. in their first year or two of employment), rather than students.

Finally, the IT professionals in this study were application developers. Additional research is needed to explore further the dimensions of expertise in system development, and to determine what combination of traits and variables can be used to improve the selection process for novice system personnel.

In summary, a better understanding of the factors that lead to IT-developer excellence could greatly assist in IT-related curriculum development, in the creation of initial screening mechanisms for job candidate selection, and ultimately in creating methods for fostering the development and retention of exceptional IT personnel. We suggest that both professional organizations and academic institutions could benefit from more attention to the person as a whole, providing guidance in career selection and job placement based on a combination of aptitude and personality. We recommend further research to identify a broader set of economical initial screening measures (including such items as personality tests or leadership history, in addition to GPA) that can help narrow the selection process without excluding potentially good candidates. Such measures would also help in determining the best placement of individuals in academic and professional settings and would help to prevent potential exceptional individuals from becoming mere survivors, or worse.

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ABOUT THE AUTHORS

Jan Guynes Clark is Associate Professor of Information Systems at The University of Texas at San Antonio. Her research interests include information security, telecommunications in a global environment, and IS strategies. Her publications appear in leading journals such as *Communications of the ACM, The Data Base for Advances in Information Systems, IEEE Transactions on Engineering Management*, and *Information & Management*

Diane B. Walz is Professor of Information Systems at The University of Texas at San Antonio. Her industry experience includes work as a systems analyst and with corporate databases. Her research interests include the personality and characteristics of IT professionals, the use of metadata in the auditing functions of security and control, group software development, and financial forecasting. She publishes in *Communications of the ACM, The Data Base for Advances in Information Systems, IEEE Transactions on Engineering Management, Decision Science, and Information Technology & People.*

Judy L. Wynekoop (http://ruby.fgcu.edu/courses/jwynekoop) is Professor of Information Systems at Florida Gulf Coast University and Co-Director of the Center for Assisted Living Innovation. Her previous experience includes work in industry as a systems auditor and loss control analyst, and in government as a criminal investigator. She holds a PhD from the College of Business at Georgia State University. Her current research interests include distance education, team processes and their applications to teaching, learning, and systems development, and technology to support developmentally disabled adults. Her research appears in *The Data Base for Advances in Information Systems, IEEE Transactions on Engineering Management, Information Systems Journal,* and *Information Technology & People.*

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