

Using Personality Traits and a Spatial Ability Test to Identify Talented Aspiring Designers in User-Centred Design Methodologies

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Keywords: User-Centred Design, Holistic Persona, Scenario, Personality Traits, Big-Five Factors, Imagination, Spatial Ability.

Abstract: User-Centred Design (UCD) methodologies have been increasingly used during the past decade to develop software applications and products that are tailored to the needs of individuals and allow for human computer interactions on emotional and psychological levels. UCD designers and developers need to have special abilities and training to design products that meet the demands of users. This paper presents novel techniques to identify talented aspiring designers in UCD methodologies. Twenty-three undergraduate students, studying at a research-intensive metropolitan Australian university, participated in this study. Participants completed a spatial ability test, answered personality trait questionnaires and performed a design activity. Our results indicate that students who score high in the imagination personality factor and spatial ability tests are talented aspiring UCD designers. The implication of our study is that talented students who can design using UCD methodologies can be identified early in their studies and they can benefit by receiving advanced training. Likewise the less talented students can be given extra tutoring as abilities are not immutable and, interest and persistence is important in achieving expertise.

1 INTRODUCTION

User-Centred Design (UCD) methodologies, which consider the goals of the users as the primary requirement for developing software application (Norman 1986), have been actively developed and promoted by the Human-Computer Interaction (HCI) community (Seffah and Metzker 2004) and are increasingly used in software engineering practices and processes (Aoyama 2007, Grimes et al. 2008), particularly in the design and development of software applications and products (Vredenburg et al. 2002). The performance of designers in carrying out novel tasks depends on their abilities and training, as well as their motivations (Maslow et al. 1987). The relationship between performance in creative professions and personality has been studied by a number of researchers (Feist 1998, Furnham and Bachtiar 2008, Poropat 2009). It has been found that professionals who have been successful in domains such as architecture, engineering and programming are good in spatial ability (Mohler 2006). In a longitudinal study of mechanical engineering students, Field (2007) found that their performance in design subjects was more related

with their intuition and spatial ability and less related with their logical and mathematical ability. A specific link between design, spatial ability and personality has not been explored within software engineering and UCD methodologies.

Based on these previous findings and the identified gap, this paper presents a study that seeks to identify talented aspiring designers in UCD methodologies from among software engineering students by their performance in a spatial ability test and their answers to questionnaires which determine their personality traits. This study also contributes to our understanding of the personality traits and abilities required for being a talented designer using UCD methodologies.

The literature review in the next section introduces the concept of persona and previous work on intelligence, personality traits and spatial ability followed by research questions, methodology, results, discussion (including threats to experiment and measures to mitigate these), conclusion and plans for future research.

2 LITERATURE REVIEW

Personas, archetypical users, are tools used within UCD methodologies for software applications or product design and communication with stakeholders (Cooper 1999, Goodwin 2009, Miaskiewicz and Kozar 2011). Scenarios are the actions carried out by the personas interacting with the applications (Goodwin 2009). Personas support the design of the application by focusing on target users and facilitating communication with stakeholders regarding the scope and final outcomes (Goodwin 2009). Personas are authored using photographs, sketches, factual information gathered by market research, such as demographics, profession, hobbies and interests, etc. (Cooper 2004, Goodwin 2009). Long (2009) reported a higher level of empathy toward personas with photos of real people compared with illustrated personas. To improve the usability and accessibility of the application, and hence reduce cognitive load on the users, and for better communication with stakeholders, Anvari and Tran (2013) proposed Holistic Persona, a persona with five dimensions: Factual, Personality, Intelligence, Knowledge and Cognitive Process.

Intelligence is the ability to solve problems. Gardner (1993) listed seven intelligences: linguistic, logical-mathematical, spatial, musical, bodily-kinaesthetic, interpersonal and intrapersonal. Persons with innate ability or giftedness have high talent in one or more domains; with little tutoring, they can understand the abstract concepts, ask deep questions, reflect on various interpretations of the problems (Winner 2000) and can transfer their knowledge from similar domains (Anvari et al. 2013). Plucker et al. (2004, p 156) based on a number of peer reviewed journals defined creativity as “the interplay between ability and process by which an individual or group produces an outcome or product that is both novel and useful as defined within some social context”. Abilities are not fixed and, interest and persistence is important in achieving expertise (Lohman 2009).

Relationships between personality, creativity and academic performance were studied by a number of researchers. The Big-Five Factors (BFF) of personality is widely used to understand the structure of personality (Butt and Phillips 2008, Chittaranjan et al. 2011, Hu and Pu 2013, Nov et al. 2013, Oliveira et al. 2013, Poropat 2009, Wilson et al. 2010). Two models of the BFF of personality that are used by researchers are Trait Descriptive Adjective (TDA) by Goldberg (1993) and NEO

Personality Inventory, Revised (NEO PI-R) by Costa and McCrae (1992). Both models use similar terms to describe the five factors (Goldberg 1993). According to Goldberg (1993) the BFF are: (1) Extraversion, (2) Agreeableness, (3) Conscientiousness, (4) Emotional Stability and (5) Imagination or Intellect. Creative scientists were more likely to have personality traits of extraversion and openness to experience (Feist 1998, Furnham and Bachtiar 2008) and academics were more likely to be agreeable, conscientious and open to experience (Read et al. 2007). Silvia (2008) suggested that Plasticity (Extraversion and Imagination) is more strongly related to creativity than Stability (Agreeableness, Conscientiousness and Emotional Stability). McCrae (1987) in a study of 268 men found that openness to experience and divergent thinking, a psychometric investigation of the creativity, were correlated. Poropat (2009) in a meta-analysis of students' measures of academic performance measured by grade point average found that secondary and tertiary students' performances were related to conscientiousness and intelligence. In a longitudinal study of engineering students, Field (2007) observed that students who excelled in design subjects did not necessarily do well in other academic subjects; excellence in design requires different abilities.

The importance of spatial ability in science and engineering are studied by many researchers. Shea et al. (2001) in a longitudinal study of 563 students in late 1970s using Scholastic Assessment Test and spatial ability tests found that those who scored better in a spatial ability test had selected careers in Science, Technology, Engineering or Mathematics (STEM). Similarly Webb et al. (2007) in studying 1060 students during the 1990's found that spatial ability provided greater variance in predicting individuals' preferences for STEM. Wai et al. (2009) drawing a random sample from the population of 400,000 students, who were longitudinally studied for 11 years, found that among those who chose careers in science, technology or mathematics scored high in spatial ability during their adolescence. Charyton et al. (2011) in a study of engineering students found that their score in a Creative Engineering Design Assessment, a test for measurement of creativity in engineering, is related to their performance in Purdue Spatial Visualization Test of Rotation. Ault and John (2010) surveyed the literature across the USA with the result that students doing four year engineering courses generally scored about 75% in the Spatial Rotation of Visualisation test. Students with higher spatial

ability have been found to perform better in other fields. Anvari et al. (2013) found that students with high spatial ability had lower cognitive load while performing 3D computer graphics drawing and were better able to transfer knowledge from one domain to another similar domain.

3 RESEARCH QUESTION & METHODOLOGY

Based on the studies of Anvari et al. (2013), Charyton et al. (2011), Feist (1998), Field (2007), Furnham and Bachtiar (2008), Poropat (2009), Shea et al. (2001) we find that both personality traits and spatial ability are important in cognitively demanding tasks such as creativity and design within the software engineering field. Hence in this paper we address the research question:

Can we use a spatial ability test and self-assessment of personality traits to identify talented aspiring designers in UCD methodologies?

We conducted an empirical study to obtain data to allow us to answer the above research question as well as other research questions that were part of a larger study concerning the influence of the Holistic Persona on the designer and the relation between the designer's and persona's personality traits. In the study we investigated two factors of the personality, extraversion and emotional stability. Our findings for these other questions are reported elsewhere (Anvari et al. 2015).

Before the study commenced, we provided a brief introduction to UCD methodologies, an example of a persona, a conceptual design and a scenario; these materials were for educational purposes only. Participants were then asked to give consent if they wished to continue. The 75-minute study consisted of six parts: demographics questionnaires, self-assessed personality traits, assessing four Holistic Personas, a design task for one of the randomly assigned personas, post design questionnaires and a spatial ability test. The parts that are relevant to this paper are described briefly in the following subsections. The final subsection describes the evaluation and scoring of the participant's design.

3.1 Demographic Questions

Demographic questionnaires consisted of questions about the participant's gender, birth year,

occupation, interest in design, level of competence in the English language, country in which they spent their youth and the courses they are studying or have studied. The demographic data was used for analysis of the results.

3.2 Self-assessed Personality Trait

Participants rated their own personalities using Goldberg's 50 question Trait Descriptive Adjectives (TDA) on a 5-point Likert scale. The test is adopted from the literature (Goldberg 1993) and the International Personality Item Pool (IPIP 2013). The bi-polar answers to the self-assessment questions on a 5 point likert scale are added together after reverse scoring the negative questions (Goldberg 1993) to provide results in the range of 10-50. The resultant data is treated as interval-level data, converted to percentages and analysed using R statistical packages (Field et al. 2012).

3.3 Design Task

Participants performed a design session of 15 minutes duration with a Holistic Persona that was assigned randomly yet evenly from a set of four Holistic Personas that were authored to be very similar to one another in all dimensions except in the personality dimension. Two personality factors were varied as shown in Table 1 (appendix one shows an example of a Holistic Persona named Doris).

Table 1: Holistic personas and their personality traits.

Persona for design	Extraversion	Emotional Stability
Doris	Extravert	stable
Katie	Extravert	unstable
Minty	Introvert	stable
Eliza	Introvert	unstable

Participants wrote their conceptual design for a software application or product of their choice that would help the assigned Holistic Persona and a scenario about how the Holistic Persona would use the software application or product.

3.4 Spatial Ability Test

Participants performed a 20-item Purdue Visualization of Rotation Test. This activity was timed. The test consisted of 20 questions; each question showed an object in a position and the participant needed to mentally rotate the object to a new position; there were 5 choices representing how the object looks in the new position, one of which is

correct. One mark was given for the correct answer and there was no penalty for the wrong answer. Participants' total score at 10 minutes was selected as the measure of their performance in the spatial ability test (Bodner and Guay 1997).

3.5 Evaluation of the Design

Evaluation of the participants' design was based on the literature on the influence of personality traits on human uses of software applications or products. For example, Oliveira et al. (2013) found that extraverts used their mobile phone more often and extraverts and conscientious people were more satisfied with the level of service they received from their mobile phone service provider. Butt and Phillips (2008) found that extraverts not only receive more calls but spend more time changing the ring tone and wall paper on their mobile phones however the unconscientious, disagreeable and neurotic used SMS in preference to calling. Nov et al. (2013) found that the extraverts tend to be more responsive in a more popular website and emotionally stable people tend to be less influenced by a website's social anchoring.

Drawing on the literature and his industrial experience as a designer and software engineer, the lead author initially read all the design descriptions and noted down all provisions and features that the participants made to assist the Holistic Persona. He compiled Table 2 and listed the following criteria which are based on the Holistic Personas provided, as an analytic scoring rubric in assessing the participants' design. The two personality traits of the Holistic Persona that were present or absent, extraversion and emotional stability, were considered for assessing the design. The rubric was independently examined by another two experienced designers, Hien Minh Thi Tran and Deborah Richards.

(1) The conceptual design can be an application that is a diary, a calendar, a recommender or a specialised forum; or

(2) it can be an abstract design with sufficient description to visualise how the application works.

(3) A scenario for the Holistic Persona to interact with the application.

(4) The participant is expected to refer to the Holistic Persona by her name and the application reminds her about applying skin lotion while intending to walk in the sun, carrying eye glasses for certain appointments, and alerting her to her allergies while ordering food.

(5) The application is expected to concentrate on

food, exercise or weight as overweight is the main issue the Holistic Persona is facing.

(6) Expressions that reflect consideration given to the Holistic Persona while explaining the design and scenario.

(7) The software application can be installed on a generic device, a mobile phone or a personal computer. Inclusion of a device that reflected the personality of the persona attracted extra credit

The maximum score for the design work was 15 marks. Each participant's design was assessed by the lead author based on the rubric as explained in Table 2. The mark allocation was reviewed independently by two other experienced designers and adjusted accordingly to resolve any discrepancies.

4 ANALYSIS OF RESULTS

4.1 Participants

To maintain homogeneity and identify the population from which the sample is drawn, for this paper, we use the data from the undergraduate students at Macquarie University, a research-intensive metropolitan Australian University. The participants who were aged between 18 and 38, completed self-assessment of their personalities and took part in the design activity. There were 23 participants. The majority of them (91 %) were studying a second year Software Engineering subject within the IT Department. The Software Engineering subject is a core unit for students in the Software Technology major in the Bachelor of IT and Bachelor of Engineering students in the Software Engineering major. The unit prerequisites are very minor, so other students also take the unit to make up elective credit points. We observed that the students who chose to participate in this study were primarily from one of the two majors. They were invited to participate in this research during their tutorial session without receiving any course credit or financial benefit and thus students not majoring in this area were less interested in the study's activities and findings. They participated in this study to gain understanding of HCI design through exposure to the UCD methodologies and tools and they all indicated that they were interested in design; hence they are referred to as aspiring UCD designers.

Table 2: Analytic scoring rubric for assessing a design task.

No	Design Features	Descriptions	Marks assigned	Examples (Quote) (participants who gave their consent to quote)
1	Application	Recommending an existing application or product for food, exercise or as a reminder e.g. Forum, Diary or Recommender	5 marks in total 1 mark – mention an application targeting the identified problems. 2 marks – providing details on how the application works. 1 mark – providing for features such as GPS to detect location, online connectedness with other systems and applications.	<i>A Virtual Diary / Reminder Application. The virtual diary allows for entries based on various user designed topics or sub topics, weather that be health food ideas or new music that they enjoyed, or information relating to her social activities. The reminder application will utilize multiple parts of a phones system</i>
2	Abstract design	A new generic application that would serve the persona	1 mark – suggestive goal setting, automated reminder and advisory activities.	<i>... a software program that ... should be suggestive rather than informative, and give her clear instructions as to what to eat next. The program should also give her goals (realistic) as to improve her self esteem.</i>
3	Scenario	Holistic persona's interaction with the application	3 marks in total 1 mark – mention an interaction with the application for a query 3 marks – an interaction with the application to carry out a task	<i>... ping or notify her of various reminders and set goals for her to do each day and she can fill these out like a survey and the coach will say some words of encouragement ...</i>
4	Factual	Name Allergy Skin lotion Short sightedness	2 marks in total 0.5 mark – refer to Holistic Persona by name 0.5 mark – refer to her allergy 0.5 mark – refer to her skin disorder 0.5 mark – refer to her short-sightedness	<i>... to mention that she is allergic to food, ... away from her glasses ... device can be attached to Doris' sun-screen lotion container</i>
5	Weight Issue	Suggestions of food or exercise	2 marks in total 1 mark – acknowledging the problem by mentioning food or exercise. 2 marks – providing a feature for use to address the weight issue.	<i>... allow Minty to keep track of what she eats--both for allergies and taking care of weight. An app that will allow Minty to plan her meals a week at a time, keep track of her exercise, and tell her if she is eating too much based upon her exercise regime.</i>
6	Suitable to the Holistic Persona	Suggestive (Extravert) Informative (Emotionally Stable) Directive (Emotionally Unstable)	3 marks in total 1 mark for Ideas 1 mark for Connections 1 mark for Extensions These features help to assess the suitability of the application to the Holistic Persona (e.g. an extravert needs a mobile application).	<i>... would allow Eliza to find groups of people with similar interests, issues, and ideas to discuss and socialize with reduced pressure from her introverted personality</i>
7	Platform	PC / Mobile / Portable		<i>... assuming that such a social girl would have a relatively advanced phone ...</i>

Participant demographics are provided in Table 3. We can see that 87.0% of the sample population were male and the remainder were female. Only 4% in the sample population spoke and wrote in English for less than three years and 96 % of the sample population had lived in Australia or New Zealand or UK or the USA during their youth. Most of the sample population finished the study, including the

introductory session, within 70 minutes. The study was conducted on-line using Qualtrics (2014).

The 23 participants' scores for their conceptual design, spatial ability and personalities were analysed and the results are presented here. Table 4 presents the breakdown of the sample populations according to their performance in design. The sample population was divided into groups based on

Table 3: Demographics of participants in the study.

No	Participant demographic	Participant (%)
1	Male	87
2	Female	13
3	Native English speakers	87
4	Non native English speakers who have spoken and written in English >3 years	9
5	Non native English speakers who have spoken and written in English 1-3 years	4
6	Youth years spent in Australia, New Zealand, UK or USA	96
7	2 nd year Software Engineering Students	91

their scores in imagination personality factor and spatial ability. The groups were compared with one another based on the influence that the abilities have on their performance in design. The influence is described using effect size, the Pearson’s correlation coefficient, r , computed from the t-test (Field et al. 2012). Field et al. (2012) lists the description of effect size as small when $r = 0.1$, medium when $r = 0.3$ and large when $r = 0.5$. Table 5 shows partial correlation (r) of the five factors of personality with the participant’s performance in design. Our sample population indicates that there is a medium sized relationship between imagination personality factor and performance in design and it is significant ($r=0.45$, $p=0.056$) having a shared variability of 20%.

4.2 Dividing Performance into Four Quadrants

Since in our sample population, imagination personality factor is the only personality factor correlated with design performance, our further analysis concerning performance in design is restricted to the imagination personality factor and spatial ability. Figure 1 shows a scatter plot of the students’ performance in the spatial ability test at 10 minutes versus their imagination personality factor; the points are labelled with their performance in design. Figure 1 shows a group of students in the top right hand corner who have performed well in design. Using the area of the plot covered by this group as a guide, Figure 1 is divided into four quadrants. The first quadrant (Q1) is bounded by those students who scored 75% or greater in spatial ability (Ault and John 2010) and the imagination personality factor; in most Australian universities 75% or greater is used to award the grade of distinction. There are 8 participants in Q1.

The second quadrant (Q2) is bounded by those students whose score in spatial ability is less than

Table 4: Performance in design.

No	Performance in design (%)	Participant (%)
1	85 -100	31
2	75 - 84	30
3	65 - 74	4
4	50 - 64	22
5	Less than 50	13

Table 5: Partial correlation of the performance in design with personality factors study.

BFF	pcor (r)	r ²	t-value *	p (> t)	Effect size
Ext	0.08	0.01	0.32	0.75	small
Agr	0.07	0.01	0.31	0.76	small
Cn	-0.01	0.00	-0.02	0.98	nil
ES	-0.03	0.00	-0.13	0.90	nil
Img	0.45	0.20	2.05	0.056	medium

Legend: Ext - extraversion; Agr – agreeableness; Cn – conscientiousness; ES - emotional stability; Img – imagination; df – degrees of freedom; pcor – partial correlation; p - probability. *(df=17)

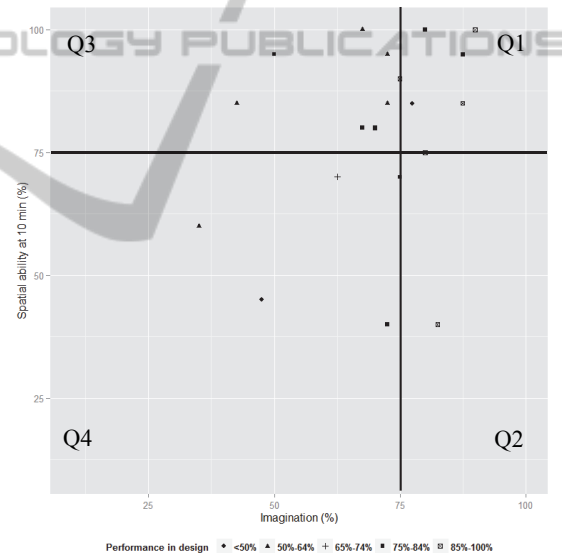


Figure 1: Students’ performance.

75% but their score in the imagination personality factor is equal to or above 75%. There are 2 participants in Q2. The third quadrant (Q3) represents those students whose score in spatial ability is equal to or above 75% but their score in the imagination personality factor is below 75%. There are 9 participants in Q3. The fourth quadrant (Q4) is bounded by those students whose scores in spatial ability and the imagination personality factor are below 75%. There are 4 participants in Q4. Figure 1 shows most students in the first quadrant (88% of the students in Q1) scored 80% or above for their performance in design.

4.3 Five Scenarios to Study Results in Four Quadrants

The students' data were analysed using five scenarios (see Table 6). In each scenario the performance in design was studied for two groups. The five scenarios are: (1) Effect of high imagination and spatial ability: performance of the group whose score in both imagination personality factor and spatial ability are high (Q1) compared with the rest of the sample population (Q2, Q3 & Q4); (2) Effect of imagination: difference in performance in design for the group of students whose score in the imagination personality factor is high (Q1 & Q2) versus other students (Q3 & Q4); (3) Effect of spatial ability - high imagination: difference in performance in design for the group of students who scored high in both imagination personality trait and spatial ability (Q1) versus the students who only scored high in imagination personality trait (Q2); (4) Effect of spatial ability: difference in performance in design for the group of students whose score in spatial ability is high (Q1 & Q3) versus group of other students (Q2 & Q4); (5) Effect of imagination - high spatial ability: difference in performance in design for the group of participants who scored high in both spatial ability and imagination personality factor (Q1) versus the

students who only scored high in spatial ability (Q3).

4.4 Comparison of the Results in Four Quadrants

Table 6 shows Mean (m), Standard Error (SE) and Median for each group of students. The two groups in each scenario are compared using Welch two sample single tail t-test and the effect size (r) between the two samples are described using the Pearson's correlation coefficient, r computed from the t-test (Field et al. 2012). The null hypothesis (H0) is that all groups are drawn from the same population, hence the difference in means of the different groups is zero, the alternate hypothesis (H1) is that the difference in mean is greater than zero.

Figure 2 shows five box plots of students' performance in UCD conceptual design for each of the five scenarios listed in Table 6:

Scenario 1 shows that the students who scored high in both spatial ability and imagination personality factor performed significantly higher in design (m=82.1, SE=6.8) compared with the other students' performance in design (m=64.9, SE=5.0). The Welch two sample single tail t-test indicates that the difference in the means of the two samples is significant at 5% (t=-2.0, df=14, p<0.05) and the Pearson's correlation coefficient shows the effect

Table 6: Analysis of students' performance in design under five scenarios.

No	Scenario	Quadrants (Q)	Mean (m) %	SE %	Median %	Welch two sample single tail t-test				Effect Size (r)
						t-test	df	p	Reject H0 at 5% confidence	
1	Effect of high imagination and high spatial ability	Q1 (SImg=>75% & SpAb=>75%)	82.1	6.8	88.5	-2.0	14	0.030	True	0.5 Large
		Q2, Q3 & Q4	64.9	5.0	70.0					
2	Effect of imagination	SImg =>75% Q1 & Q2	82.1	5.4	87.0	-2.6	21	0.009	True	0.5 Large
		SImg < 75% Q3 & Q4	62.3	5.4	63.0					
3	Effect of spatial ability - high imagination SImg=>75%	Q1 (SpAb=>75%)	82.1	6.8	88.5	0.01	5	0.494	False	0.0 nil
		Q2 (SpAb<75%)	82.0	NA	82.0					
4	Effect of spatial ability	SpAb=>75% Q1 & Q3	72.4	5.1	80.0	-0.6	9	0.295	False	0.2 small
		SpAb< 75% Q2 & Q4	66.8	8.5	73.5					
5	Effect of imagination - high spatial ability SpAb=>75%	Q1 (SImg=>75%)	82.1	6.8	88.5	2.0	15	0.035	True	0.5 Large
		Q3 (SImg<75%)	63.7	6.6	63.0					

Note: H0 - Hypothesis - True difference in mean is zero
H1 - Alternate Hypothesis - True difference in mean is greater than zero
Legend: Q – quadrant; df – degrees of freedom; p – probability; SE – standard error;
SImg – score in imagination personality factor; SpAb – score in spatial ability.

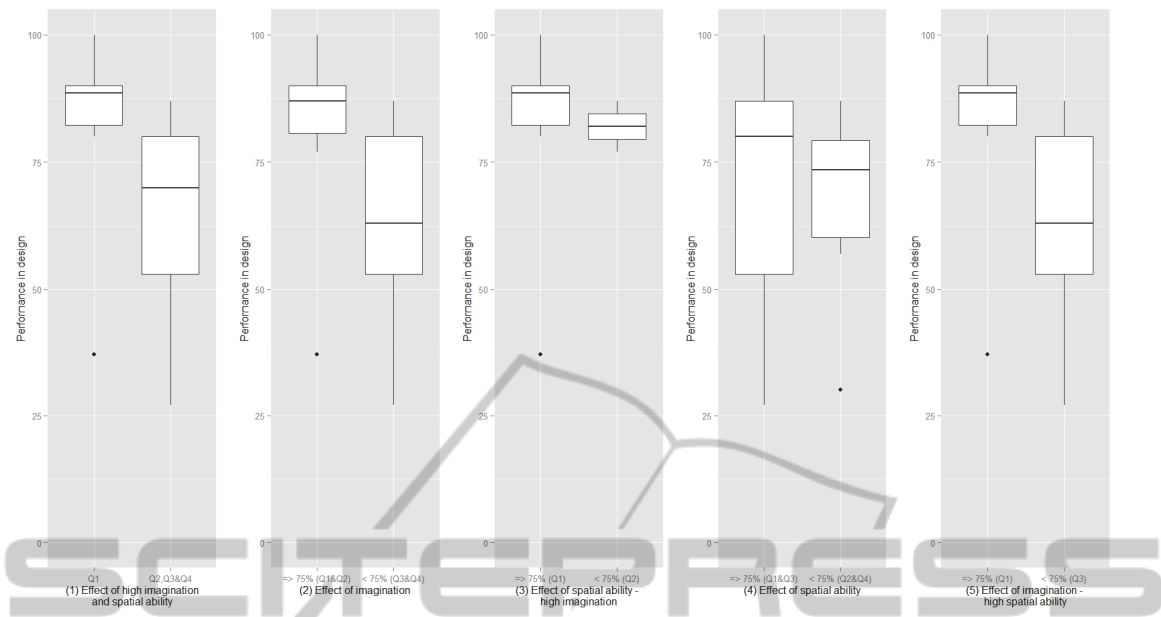


Figure 2: Box plots of the students' performance in design for five scenarios.

size is large. The post design survey questionnaire indicates that the students who scored high in both spatial ability and imagination personality factor were on average moderately engaged with the design task.

Scenario 2 (Table 6 and Figure 2) shows that the students who scored high in the imagination personality factor performed significantly better in design ($m=82.1$, $SE=5.4$) compared with the other students' performance ($m=62.3$, $SE=5.4$), ($t=-2.6$, $df=21$, $p<0.01$).

Scenario 3 (Table 6) shows that the students who scored high in both imagination personality factor and spatial ability ($m=82.1$, $SE=6.8$) did not perform significantly better than the students who only scored high in imagination personality factor ($m=82.0$). The Welch two sample single tail t-test indicates that the difference in the means of the two samples is not significant ($t=0.01$, $df=5$, $p>0.05$) and the Pearson's correlation coefficient shows the effect size is nil. Only two students fall into Q2, hence no inferences are made in regard to the effect of spatial ability and UCD design when the designers have high imagination.

Scenario 4 (Table 6) also shows that students who scored high in the spatial ability test did not perform significantly better than those whose spatial ability score was not high ($t=-0.6$, $df=9$, $p>0.05$).

Scenario 5 (Table 6), shows that the students who scored high in imagination personality factor and spatial ability performed significantly better in design ($m=82.1$, $SE=6.8$) compared with the

students who scored high in spatial ability but scored low in imagination personality factor ($m=63.7$, $SE=6.6$) ($t=2.0$, $df=15$, $p<0.05$).

From Table 5, imagination personality factor is related to performance in design ($r=0.45$, $p=0.056$) and, table 6 shows the combined effect of imagination personality factor and spatial ability significantly influence performance in design ($t=-2.0$, $df=14$, $p<0.05$). In the sample population, the correlation between performance in design and other personality factors such as agreeableness, extraversion and emotional stability is inconclusive. The relationships between these personality factors and performance in design will be explored further in future work.

4.5 Participant's Attitude towards Design

After the design activity, the participants answered questions about their experiences during their design and previous experiences in spatial ability and design. A summary of answers for participants who have scored 75% or more in design activity is presented in Table 7. In the sample of the participants who performed well in design activity, only 14% found the activity difficult and 36% did not engage with the Holistic Persona during their design activity.

Table 7: Participants' responses to post design questionnaire.

No	Question	Participants' Responses (%)		
		A	N	D
1	Design activity was easy	64	22	14
2	I was totally engaged with the Holistic Persona's personality	50	14	36
3	I have done Spatial Ability test	7		93
4	Selection for design session was one of my previous design work or I was familiar with it.	21		79

Legend: A=Agree, N=Neutral, D=Disagree.
Note: This table presents the response of the participants whose performance in design (table 4) was 75% or more

5 DISCUSSION

The participants were required to read the description of the Holistic Persona (for an example see Appendix), understand her requirements and prepare a design work within fifteen minutes. A few of the participants commented about the small amount of time allocated for the design activity. The range of designs including the level of detail and quality was varied. A qualitative analysis of results would be more suitable but it would also be prone to subjectivity and variability.

Though in this study, the number of students who participated is small, the results indicate that students that scored high in the imagination personality factor and spatial ability tests have learnt the techniques of UCD and applied them in their design work. In this paper we refer to them as talented aspiring designers in UCD methodologies. They can 'think on their feet'. The effect of spatial ability for UCD design requires further investigation because in our study only 20% of the participants who scored equal to or above 75% in imagination personality traits scored less than 75% in spatial ability.

The participants are categorised into quadrants depending on their score in imagination personality factor and spatial ability. The level of 75% or higher selected for quadrant Q1 is based on the Australian University standard for selecting distinguished candidates. However the results indicate that there is a positive relationship between spatial ability, imagination and performance in UCD design.

5.1 Threats to Validity of the Study and Measures to Overcome These

Threats to the validity of construct, conclusion, internal and external of the study were identified and measures taken to minimise their effects (Wohlin et al. 2012) as described below.

5.1.1 Construct Validity Threats

Construct validity governs generalising the concepts behind the experiment. Since the interaction between personality traits, spatial and UCD abilities are complex, the research question is exploratory. To mitigate this threat the experiment has to be repeated with samples drawn from a number of different populations. This study is not significantly affected by previous training as only 7% of the participants who performed well in design have previously done a spatial ability test and 21% produced a design that they were familiar with (table 7).

5.1.2 Conclusion Validity Threats

One of the threats to conclusion validity is low number of participants which affects the statistics used to evaluate the results. There are 23 participants in this study hence the conclusions are indicative only. In order to mitigate 'fishing for the results' threat (Wohlin et al. 2012, p. 104), the influence of participant's scores in spatial ability and personality factors on the results were removed by marking the design activity separately and without reference to other results from the study. Further, the marks for design activity were checked independently by Hien Minh Thi Tran, without knowledge of the participants' performances in spatial ability or their score in personality factors.

5.1.3 Internal Threats

The internal threats included partial completion of the study, maturation effect, boredom, fatigue, interruption and learning effect. The participants' answers were checked for soundness for each section of the study. Below is an outline of methodologies used to detect data that were not sound.

Learning effect: to mitigate the learning effect where students learn from the examples given during introduction to UCD, no mention of personalities of personas or users were made. The learning effect from one another is very low as all participants finished this study in one session.

Boredom or fatigue: the time to answer the personality rating questions was measured but not displayed. A short answer time compared to average answer time would indicate either boredom or fatigue. It was found that one participant's answer time was shorter than expected. His data was excluded as he did not present his design. Another participant in one of the text entries in a later part of the study indicated that he was bored. His data was checked and found to be sound for the parts needed in this paper.

Distraction during the spatial ability test: As the performance in spatial ability test is based on the first ten minutes of the test, any disruption such as slow system response can affect their result. The data for participants who performed well in the test but their performance in the first ten minutes were low were investigated. The time taken to answer each question for those participants who performed well in the test is checked. If the time taken to answer one question is larger than the rest, then the time is adjusted to the average time, disregarding extreme values, taken by others to answer the same question.

The analytic scoring rubric seeks to provide a numeric score for the qualitative design and hence in addition to quantitative assessment, it requires qualitative assessment (Biggs and Tang 2011). In order to prevent personal judgement affecting the assessments, the markings are rated independently by another experienced marker. In this paper little allowances were made for qualitative assessment.

Lack of incentive to design well: As no rewards are offered for the design work, some participants might not have incentive to perform as well as they could in the design. As the participants who completed the study were motivated to take part hence this was not considered to be a threat.

5.1.4 External Threats

External threats which relate to generalisation of the study are: (1) the results cannot be generalised due to limited sample size; (2) sample population in this study are undergraduate students hence the results would not extend to professionals.

We plan to mitigate external threats to generalise the results of this study by conducting horizontal and longitudinal studies. For horizontal studies we plan to repeat the study a number of times using participants from different population pools and include more professionals from various industries. These measures will increase the sample size and provide for mix of population. For vertical studies

we plan to observe the students score in their design subjects and their career choices and assess if there is a correlation between their performance in this study and their choices. However, we believe that personality traits are not easily changed and hence our results which rely on personality traits can be extended to professionals.

6 CONCLUSIONS AND FURTHER RESEARCH

This empirical study indicates that students, who score above 75% in the imagination personality factor, can think of design features that suit the Holistic Persona within a short period of time; they are identified as talented aspiring UCD designers. The novel techniques presented in this paper facilitates identification of talented aspiring designers in UCD methodologies early in their studies; they can benefit by receiving advanced training. Likewise the less talented students can be given extra tutoring. This study contributes to the understanding of personality traits and abilities required in being a talented designer using UCD methodologies. Identification of these traits has potential impact on team composition and designer selection.

This study highlights the importance of the imagination personality trait in performing well in UCD design. Professional software engineers may also have this personality trait and hence our results may be extendable to professionals; which we wish to investigate in future studies. Our study confirms previous research that imagination is important for design work (Feist 1998, Field 2007, Furnham and Bachtiar 2008, Poropat 2009, Read et al. 2007, Silvia 2008). To the best of our knowledge, this is the first empirical study that reports on a specific link between the performance of conceptual design, spatial ability and the imagination personality of the designers within software engineering and UCD methodologies. We plan to investigate other important characteristics for a UCD designer such as interpersonal intelligence, employ sophisticated tools to more accurately measure participants' abstract thinking capabilities and performance.

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- 1940's. Her parents are busy in their professional careers. Doris is studying at the University of Tasmania and is midway through her Bachelor of Arts. Since childhood, she has had interest in music and recently learnt to play guitar.
- Doris is an outgoing person and likes to meet people. She likes musical concert and attends all musical events in Hobart. After the concerts, she goes out with her friends to local restaurants. She has a large collection of records and enjoys sharing albums with her friends. Doris is an active member of university clubs. Doris has many friends and enjoys their company. She has been a long member of the 'Assisting Socially Disadvantaged Group', a volunteer group that help refugees and socially disadvantaged people in Tasmania.
- Doris is short sighted and has sensitive skin but she often forgets to take her glasses with her or apply sun-screen lotion when she goes out.
- Doris is vocal and enjoys debates. She listens to other people's point of view and learns from the experience. Doris' friends feel that Doris is calm, independent and confident. She makes plans for her future and is full of hope. She does not worry if she has to reject requests for help from her friends when she is already committed. She knows her limits. She always meets her commitments with high spirits.
- Doris is allergic to peanut but she often forgets to mention this fact while ordering her meals. Doris has read about relationships between height, weight and energy content of various foods.
- Doris has realised that she is overweight and wishes to reduce her weight.

APPENDIX

The following Holistic Persona, Doris, represents an archetypical user of the product or software application which you are designing or recommending to her.

Doris' grand-parents migrated to Tasmania during the early

