Effectiveness of Persona with Personality Traits on Conceptual Design

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Abstract — **Conceptual design is an important skill in Software Engineering. Teaching conceptual design that can deliver a useful product is challenging, particularly when access to real users is limited. This study explores the effects of the use of Holistic Personas (i.e. a persona enriched with personality traits) on students' performance in creating conceptual designs. Our results indicate that the students were able to identify the personality traits of personas and their ratings of the personalities match closely with the intended personalities. A majority of the participants stated that their designs were tailored to meet the needs of the given personas' personality traits. Results suggest that the Holistic Personas can help students to take into account personality traits in the conceptual design process. Further studies are warranted to assess the value of incorporating Holistic Personas in conceptual design training for imparting skills of producing in-depth design by taking personalities into account.**

Index Terms — **User-Centered Design, persona, personality, conceptual design, software engineering education.**

I. INTRODUCTION

Software Engineering is an applied discipline that incorporates theoretical concepts and practical approaches from a wide variety of disciplines such as Computer Science, Mathematics, Engineering, Business and Psychology. That is why Software Engineering students are expected to learn a wide range of theoretical concepts and a good mix of practical approaches to identifying, understanding and solving challenging and complex problems by developing and delivering appropriate software-based solutions. Software Engineering educators are expected to provide students with hands-on learning activities that challenge them to solve authentic (i.e., real or very close to real world) problems by applying the relevant Software Engineering concepts and principles. As a consequence, there is an increasing realization and focus on problem based and experienced based teaching and learning in Software Engineering education of different phases of Software Engineering such as Requirement Engineering, Design, Implementation, and Testing.

Conceptual design is considered an important and influential phase of early lifecycle stages of developing a software application. Conceptual design plays an important role in determining the structural and behavioral aspects of a system [1, 2, p. 57]. That is why the Software Engineering community has been increasingly advocating the importance of imparting appropriate design knowledge and skills in Software Engineering students. Identifying and understanding a real-world problem and specifying requirements are considered pre-requisite inputs to conceptual design. In industry, Software Engineers usually interact with customers and/or end users to elicit system requirements for conceptual design activities, or involve key stakeholders in the design according to User-Centered Design or Participatory Design Principles. However, real stakeholders are often not available in the educational context [3]. While role-plays or other methods can seek to simulate this process, there is the further problem of validation that the users' requirements have been fulfilled in a software design. An alternative to elicitation of requirements from end users and validation of proposed design is the use of personas.

Having gained tremendous popularity in Human-Computer Interaction (HCI), personas have also started showing their usefulness for requirements elicitation and design in Software Engineering practice and education. Personas are fictional characters that represent the needs of typical users of the software applications [4, pp. 11; 13]; personas are usually composed of scenarios that describe the interactions that a persona can have with an application to achieve a goal [4, pp 308-312]. Personas support the design of applications by focusing on target users and facilitating communication with stakeholders [4, pp. 231-234, 5, 6].

Currently, however, personas do not take into account that even people with the same needs and profile (such as family and employment status) will represent a range of different personalities that may impact on their utility and usage of a particular software product. We believe that if personas do not adequately resemble real stakeholders, then they will not provide a suitable alternative for students to practice and validate alternative conceptual designs of software products. Anvari and Tran [7] have proposed Holistic Persona, that has more detail and structure than other types of personas and are designed to more closely resemble the end users. The appendix I shows an example of a Holistic Persona used in the research reported in this paper. We suggest that the use of Holistic

Persona in conceptual design education and training can enable students to learn to differentiate personality traits of a persona and to use the perceived differences to produce tailored conceptual designs. Thus, we investigate whether personas with personality traits might help students to produce conceptual designs tailored to the specific user needs.

This paper reports a study that has investigated whether students, who, as far as we know, were not trained in the use of personality, were able to perceive different personality traits of a persona and whether these perceived differences could be used by the students to produce tailored conceptual designs. We postulate that providing personas to students, who have received training to take into account the personality traits of a persona, will enable them to conceive designs that are more suited to the targeted users' needs. Empirical evaluation to determine if students can recognize the personality traits of personas and the effect of the personality traits on the conceptual designs produced by students is a novel contribution of this paper.

II. BACKGROUND AND RELATED WORK

Software Engineering education is expected to cover different areas that provide the foundational bases of this discipline such as Computer Science (e.g., Data Structures, Algorithms, and Programming Languages), Engineering Knowledge (e.g., Architecture, Project Management, and Effort Estimation) and the Economic and Social context (e.g., Economics, Marketing, and Psychology) [8, 9]. In a number of institutions, Software Engineering education places greater emphasis on Computer Science and Engineering knowledge and less on social and economic aspects [10]. Software Engineering has evolved over time with methodologies and best practices that are influenced by system-driven philosophies. For example, User-Centered Design (UCD) methodologies, which consider the goals of the users as the primary requirement for developing software applications [2], have been actively developed and promoted by the HCI community [11] and are increasingly used in Software Engineering practices and processes [12, 13]. Personas and scenarios are tools within UCD methodologies.

Several researchers are exploring the use of Personas in different areas of computing. Guo, Shamdasani and Randall [14] outline their experience with authoring personas to explore user needs and behavior and use these personas in design and development of e-commerce applications. Cleland-Huang, Babar and Mirakhorli [15] have reported a study on teaching student design using Architecturally Savvy Personas (ASP). Chen, Nivala and Chen [16] found that designers who design with a persona are more empathetic. Chang, Lim and Stolterman [17] found that personas might take various forms: personas, mash-up personas, incomplete personas and unspoken personas, the last being personas that exist but are not documented. While previous work have shown the value of personas, personas have failed to become a mainstream approach in design because they tend to over generalize or stereotype users and do not take into account that even though

a user may have the same needs, due to their individual differences the solution to address those needs can vary.

To address the problem of overgeneralization, Anvari and Tran [7] analyzed the specific software requirements in five case studies from various Australian industries. As a result of their analysis, Anvari and Tran [7] proposed the notion of Holistic Persona, a persona with five dimensions: factual, personalities, intelligences, knowledge and cognitive processes, that seek to take into account individual differences in users and the impact of these differences on conceptual design of software to meet those users' needs.

Individual differences can be understood in the context of the lexical hypothesis, as defined by Goldberg [18], that states 'the most important individual differences in human transactions will come to be encoded as single terms in some or all of the World's languages'. The Big-Five Factors (BFF) of personality, which is based on the lexical hypothesis, is widely used in research to measure personality [19-21]. The five factors of personality are [22]: (1) Extraversion, (2) Agreeableness, (3) Conscientiousness, (4) Emotional Stability (Costa and McCrae [23] and John and Srivastava [19], refer to this factor negatively as Neuroticism) and (5) Imagination or Intellect (Costa and McCrae [23] refer to this factor as Openness to Experience and John and Srivastava [19] refer to it as Openness/Intellect).

Researchers tend to use one of three instruments to measure the BFF of personality [19]. The instruments are Trait Descriptive Adjective (TDA) by Goldberg [18, 24], Big Factor Inventory (BFI) by John and Srivastava [19] and NEO Personality Inventory, Revised (NEO-PI-R) by Costa and McCrae [23]. The BFF models use similar terms to describe the five factors [19, 22]. For our study we consider the terms used by Goldberg's TDA, NEO-PI-R and BFI to be similar [22]; we use the term 'Imagination' for the factor Intellect/Imagination or Openness to experience. The Ten-Item Personality Inventory (TIPI) is a short version of TDA, freely available and widely used [25]. TIPI is validated in English [25], German [26], Spanish [27] and Dutch [28].

The value of teaching students how to create personality relevant conceptual designs is motivated by research involving students that shows that personality affects the way users interact with software applications. Hamburger and Ben-Artzi [29], in a study which consisted of a sample of 72 students at Bar-Ilan University found that the use of the internet among extraverted men was positively associated with the use of leisure services and among the emotionally unstable men was negatively associated with the use of work or study related services. For women, extraversion was negatively related and emotional instability positively related to the use of the internet for chat, discussion group and people-address seeking [29]. Landers and Lounsbury [30], in the sample of 117 undergraduate students from a large university in Tennessee, found that those who were introverted and had a lower score on conscientiousness and agreeableness used Internet more often.

Other studies not involving students have also shown the relevance of personality on software design and user behavior. Vazire and Gosling [31] predicted the personality of the author

of websites with reasonable accuracy. Oliveira, Cherubini and Oliver [21] found that extraverts used their mobile phone more often and that extraverts and conscientious people were more satisfied with the level of service they received from their mobile phone service provider. Nov, Arazy, López and Brusilovsky [20] found that extraverted people tend to be more responsive on a more popular website and emotionally stable people tend to be less influenced by a website's social anchoring. Use of an e-learning application, according to a study by Orvis, Brusso, Wasserman and Fisher [32] is affected by personality: extraverts and imaginative people would do better in a less controlled environment. They prefer to select their topics of study and pace of learning.

A growing body of literature supports the importance of taking users' personality into consideration when designing software applications. Behrenbruch, et al. [33] used personality to evaluate the adaptation of an application operating on a mobile phone platform and authored personas with personality for future development of applications. Svendsen, Johnsen, Almås-Sørensen and Vittersø [34] found that extraversion is positively related to behavioral intention, perceived usefulness and perceived ease of use.

We seek to build on this body of work through empirical evaluation with Software Engineering students of the benefits of incorporating personality into persona.

III. RESEARCH QUESTIONS

We propose that personas with personality traits can provide students with a context that is similar to developing and validating a conceptual design based on user requirements. Towards testing that proposition, our aim in this study is to provide guidance to students in the conceptual design phase by raising their awareness of personality differences in users and using those perceived differences to tailor their designs to create products that better meet the intended users' needs. The following research questions are considered in this study:

Research Question 1 (RQ1): Can students tailor their designs according to the personality traits of personas?

To answer RQ1, we sought to explore whether participants considered personality in their design. If participants either explicitly stated that they had done so or if their design notes referred to the personality of the persona, then the participants were deemed to have considered personality in their design.

Research Question 2 (RQ2): Can students, who as far as we know have not received training in personality and its effect on application utilization, produce in-depth conceptual designs?

To answer RQ2, the design was considered an in-depth design when the statements made in the design notes can be supported by the literature on personality.

To answer RQ1 and RQ2 we need to assess the participants' perception of the personas' personality. Hence we need to evaluate:

Research Question 3 (RQ3): Do students correctly identify the intended personality traits of a persona?

IV. METHODOLOGY

In order to answer the research questions, we designed an empirical study that was conducted with two different student cohorts (undergraduate students in an IT Department at an Australian University and postgraduate students in a Danish University). The data were collected by getting the participants to perform seven tasks:

1. Fill demographics questionnaire,
2. Complete a self-assessment of personality traits,
3. Receive a brief introduction to UCD methodologies for educational purposes, which included an example of a persona, a conceptual design and a scenario.
4. Then the participants carried out :
   4.1. assessment of each of the four personas, and
   4.2. four design activities with each of the four personas.
5. The design activities were followed by:
   5.1. redesign activities and
   5.2. answering design questionnaire
6. Answer post design questionnaires about their overall design experiences,
7. Perform a spatial ability test.

For the research questions investigated in this paper, we only consider the data provided for demographics, assessment of the four personas, the design tasks and replies to post design questionnaire. Task 4.1 sought to answer RQ3, while tasks 4.2, 5.1, 5.2 and 6 sought to answer RQ1 and RQ2. These tasks formed four phases of the study as described in the following subsections.

The teaching and learning goals of the study included introducing students to UCD (task 3 included a short quiz), teaching about personas with personality in conceptual design (task 4.1), practicing creating conceptual designs (tasks 4.2 and 5.1) and validating their designs by reflecting on their designs in the context of the provided personas (tasks 5.2 and 6).

A. Persona Assessment

To keep the length of the study manageable, four personas were authored to be very similar to each other in all aspects and differ only in their personality traits. Two personality factors extraversion and emotional stability were varied, as shown in TABLE I, with other factors planned to be investigated in the future. An example of a persona, Minty (Meta in the Danish study), is given in Appendix I. The participants were provided with all four personas for their rating and design task. The order in which the four personas were presented to each participant was randomized.

During persona assessment, participants performed the following activities:

1. Participants evaluated each of the four personas' personalities answering ten personality assessment questions on a 7-point scale ranging from 1 (disagree strongly) to 7 (agree strongly). The personality assessment questions were adopted from the Ten-Item Personality Inventory (TIPI) [25].

TABLE I. PERSONAS AND THEIR PERSONALITY TRAITS

Australian Persona	Danish Persona	Extraversion	Emotional Stability
Doris	Helena	Extravert	Emotionally stable
Katie	Katherina	Extravert	Emotionally unstable
Minty	Meta	Introvert	Emotionally stable
Eliza	Agneta	Introvert	Emotionally unstable

2. Participants rated whether the persona is a real person on a 7-point scale ranging from 1 (disagree strongly) to 7 (agree strongly).

B. Design activity

The participants performed a design activity with each of the four personas. All four personas had the same issues, a health issue (overweight) and other minor issues. The participants were expected to provide a conceptual design or recommend an application that would help each of the personas to overcome their issues and a scenario to demonstrate how the persona would use the designed or recommended application. The total time that the participants were expected to spend on assessing each of the personas and performing the design activity was 15 minutes.

C. Re-design activity and design questionnaires

The participants were given opportunity to modify each of their original designs. The participants answered questionnaires about their design experience, their perceptions of each of the personas and if they added any features in the design to help the persona. The questions from the design and post design questionnaires are listed in the discussion section.

D. Post design questionnaires

The participants answered post design questionnaires about their overall design experience with the four personas and their preferences for a persona.

V. THREATS TO VALIDITY OF THE STUDY AND MEASURES TO OVERCOME THESE

Two types of threats, internal and external, were identified during the design of the study and measures were taken to minimize their potential effects.

A. Internal threats

The internal threats included partial completion of the study, maturation effect, boredom, fatigue, and learning effect, where a participant learned from the examples given during introduction to UCD. For each known threat, we took appropriate measures to mitigate its effects. To mitigate the learning effect, we did not make any mention of personalities of personas or users during introduction to UCD. The participants' answers were checked for soundness for each section of the study. We used the following criteria for assessing the soundness of data:

1. If the same rating is selected for all questions for one or more of the personas and the time to answer the question is short (less than one standard deviation from the average time) then the data is considered as unsound data. However a longer answer time does not indicate soundness of data as the participant could have taken a break during the answer time. For these situations the answers to all questions are checked for soundness.
2. The time to answer the personality rating questions is measured but not displayed. A short answer time compared to average answer time can indicate either boredom or fatigue. The data is checked for soundness.
3. If a participant indicates that s/he has been bored or fatigued during rating of the personas, in any of the entries in later parts of the study, the data is checked for soundness.
4. If a participant partially completes the study, her/his data is used in persona statistics only if she/he completes ratings of all personas.

B. External threats

The following threats to generalization were considered:
1. The results cannot be generalized due to limited sample size from selected population.
2. When the study is undertaken by groups in different countries, their understanding of personality and hence their assessment of personas might be different. The cultural differences would affect the validity of the results.

VI. PROCEDURE

Two studies were conducted: one in Australia and another in Denmark. The two studies were identical with the only difference being different names given to the personas and places to make the context more familiar to the Australian and Danish students. This paper includes data from those participants who gave consent to analyze their data. The Australian participants were undergraduate students studying a second year Game Design subject in the Computing Department at Macquarie University. The Danish participants were postgraduate students studying Software Architecture course offered by IT University of Copenhagen. The students did not receive any course credit or financial benefit for participation. TABLE II presents the demographic information of the participants.

TABLE II shows that there were 42 males (91%) and 4 females (9%) in the study; 17 participants (37%) were native English speakers, while 27 participants (59%) had spoken and written in English for more than three years and 2 participants (4%) wrote and spoke English for 1-3 years. The data for those who had spoken and written English for less than 3 years was examined carefully and it was found that participants demonstrated a reasonable level of competence in understanding the required concepts. Most of the sample population finished the study within 70 minutes. The study was conducted on-line using Qualtrics, a web-based tool for building surveys.

TABLE II. NUMBER OF PARTICIPANTS IN THE STUDY AND THEIR DEMOGRAPHICS

Participants	Country	
	Australia	*Denmark*
Professional	0	7
Postgraduate	1	16
Undergraduate	22	0
Male	22	20
Female	1	3
English is first language	17	0
Spoken and written in English >3 years	4	23
Spoken and written in English for 1- 3 years	2	0
Sub total	23	23
Total	46	

Note: Those who classified themselves as professional were post gradute students in Denmark. Their professions were: Skilled IT, Developer (two), Front end developer, System developer, Programmer and IT architect

TABLE III. ANALYSIS OF VARIANCE FOR TWO SAMPLES OF DATA

Persona	Attribute	F value (df = 1)	Pr (>F)	H0
Doris	Ext	0.27	0.61	True
Doris	ES	0.11	0.75	True
Doris	Real Person	0.03	0.866	True
Katie	Ext	0.08	0.78	True
Katie	ES	0.50	0.49	True
Katie	Real Person	1.37	0.25	True
Minty	Ext	1.19	0.28	True
Minty	ES	0.28	0.60	True
Minty	Real Person	0.68	0.42	True
Eliza	Ext	3.02	0.09	True
Eliza	ES	0.39	0.54	True
Eliza	Real Person	0.17	0.68	True

Legend: Ext - extraversion; ES - emotional stability; df – degrees of freedom. H0 – Null Hypothesis (True difference between the means is zero at 95% confidence)

VII. MEASURE TO ENSURE VALIDITY OF THE STUDY

We used Analysis of Variance to ensure that the persona assessments by students in two countries are consistent. ANOVA for the four personas for the three factors, two personality traits of extraversion and emotional stability and the question, believing the persona is a real person were conducted (TABLE III). The result demonstrates that at 95% confidence level the true difference between the means of the

TABLE IV. MEAN VALUES OF PERSONAS' PERSONALITY FACTORS

Persona	Ex %	Ag %	Cn %	ES %	Im %	Persona represents a real person %
Doris	76 **	68	70*	72 **	71 *	57 **
Katie	72*	38*	37	29 **	56	63 **
Minty	32 *	69	64	70	61	63 **
Eliza	16 **	48*	42	32 *	40	55 **

Note: ** p < .01 ; * p< 0.05;
Legend: Ex - extraversion; Ag – agreeableness;
Cn – conscientiousness; ES - emotional stability; Im – imagination.
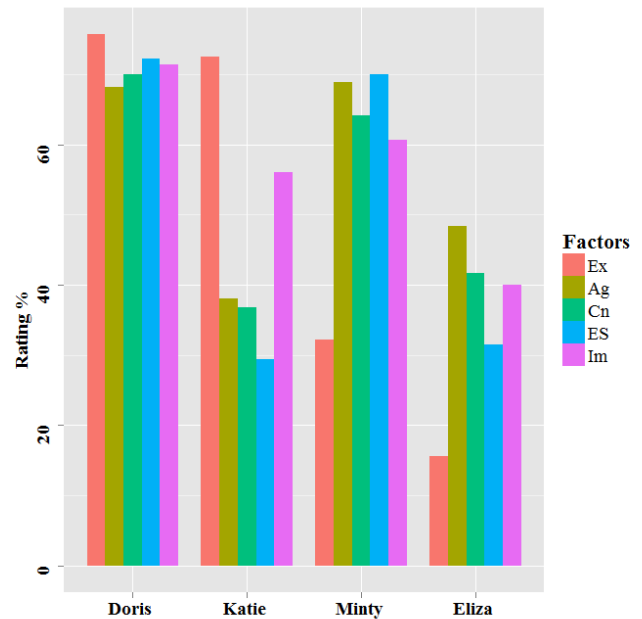
Legend: Ex - extraversion; Ag – agreeableness; Cn – conscientiousness; ES - emotional stability; Im – imagination.

Figure 1. Mean values of personas' personality factors rated by the sample population.

two groups is zero for all four personas for the three factors. Hence the data supplied by two groups can be considered to be homogenous.

The answers given by some participants were excluded from parts of this study.

1. The average time to rate each of the four personas and conduct a design activity is 398 sec with the standard deviation of 207 sec, after removing extreme data. The participants who took less time than the average time minus one standard deviation were investigated for soundness of their entries. Four participants were found to have a shorter answer time, but only one participant's data was excluded as he had provided same rating to all the questions to two personas and did not participate in the design activity. He also stated that he was bored. Other participants' data found valid after all the checks.

2. Two participants' data were excluded from the personas' rating statistics as they chose exactly the same answers for three of the four personas. One of the participants did not take part in the design activity.

VIII. RESULTS AND DISCUSSIONS

The bi-polar answers to the persona's assessment questions on a 7-point Likert scale were added together after reverse scoring the negative questions [25] and recoding to provide results in the range of 0-12. The resultant data is treated as interval-level data, converted to percentages and analyzed using R statistical packages [35]. The mean values (in percentages) of the rating given to each persona by the sample population are presented in TABLE IV and Fig. 1. Due to inter relationship between the five factors [36], even though the other personality traits agreeableness, consciousness and imagination are authored similarly, the participants rated these factors differently.

The dominant point to notice from TABLE IV and Fig. 1 is that Minty has been rated similarly to Doris in all factors except extraversion. Eliza is rated similarly to Katie in all factors except extraversion. Also TABLE IV shows that Doris and Minty are rated 72% and 70% respectively for emotionally stability and Katie and Eliza are rated 29% and 32% respectively for emotionally stability. These results confirm the intended personality traits of the personas as listed in TABLE I. The box plot of the participants ratings of the personality factors for two factors of extraversion and emotional stability are shown in Figures 2 and 3. Figure 2 shows that the participants rated Doris and Katie as extraverts whereas Minty and Eliza are rated as introverts. Figure 3 shows that the participants rated Doris and Minty as being high on emotional stability factor but Katie and Eliza are rated as being low. Again, this reinforces the intended personal traits of the personas were correctly identified by the participants.
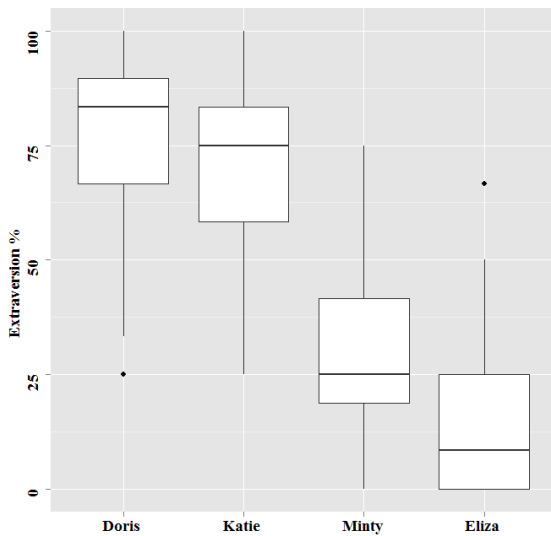

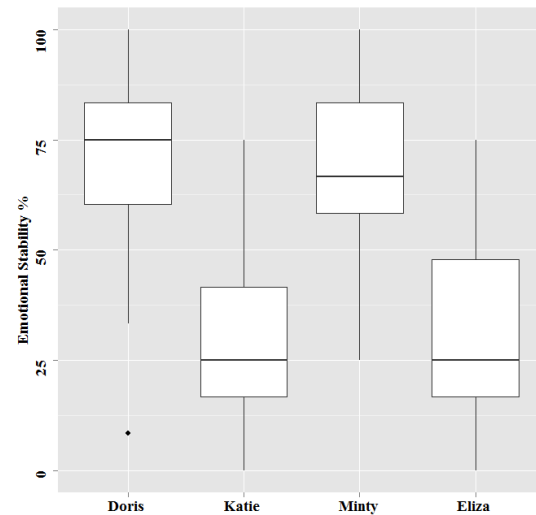Figure 2. Rating personas' personality Extraversion

Figure 3. ratings personas' personality Emotional stability factor

TABLE V. AVERAGE DIFFERENCES BETWEEN THE FOUR PERSONAS FOR EACH OF THE FIVE FACTORS OF PERSONALITY.

No	Personas differentiated		Ex %	Ag %	Cn %	ES %	Im %
1	Doris	Katie	4	30	30	**33**	15
2	Doris	Minty	**44**	-1	6	2	10
3	Doris	Eliza	**60**	20	28	**40**	31
4	Katie	Minty	**40**	-31	-27	**-41**	-5
5	Katie	Eliza	**56**	-10	-5	-3	16
6	Minty	Eliza	16	21	22	**38**	21

Note: the bold items were the factors that were purposely manipulated in the persona.

Legend: Ex - extraversion; Ag – agreeableness; Cn – conscientiousness; ES - emotional stability; Im – imagination.

TABLE V shows the average of the differences between the ratings the participants gave to the personalities of each of the personas. Doris and Minty are rated similarly for all personality traits except extraversion where Doris is more extraverted than Minty (44% higher), as intended. Katie was intended to be only lower on emotional stability (33% lower) compared to Doris, but the participants rated her lower also for personality factors of extraversion (4% lower), agreeableness (30% lower), conscientiousness (30% lower) and imagination (15% lower) despite the fact that Doris and Katie's academic achievements, musical abilities, cognitive abilities and knowledge were kept constant. Similarly comparing Doris with Eliza, Eliza scored lower not only in the two factors of extraversion (60% lower) and emotional stability (40% lower) which were as intended but also scored lower in agreeableness (20% lower), conscientiousness (28% lower) and imagination (31% lower).

The inter-factor correlations, as given by Ehrhart, et al. [36], show that emotional stability and extraversion affect the ratings of agreeableness, conscientiousness and imagination. TABLE VI presents inter-correlations between each factor of emotional stability and extraversion, and the other three factors of agreeableness, conscientiousness and imagination that are found in the literature.

TABLE VI. INTER CORRELATION BETWEEN PERSONALITY
FACTORS FOUND IN LITERATURE.

Ex & Ag	Ex & Cn	Ex & Im	ES & Ag	ES & Cn	ES & Im
0.05	0.04	0.15	0.27	0.18	0.22
Legend: Ex - extraversion; Ag – agreeableness; Cn – conscientiousness; ES - emotional stability; Im – imagination. Source: Ehrhart, et al. [36] Table 1					

From TABLE V and TABLE VI, variations in our results are as expected and are in line with the variations quoted in the literature. The findings in the literature review concern studies with real people whereas the personas used in our research are authored by us. The participants considered that the personas resemble a real person (TABLE IV, Doris 57%, Katie 63%, Minty 63% and Eliza 55%). In answering to RQ3, our results indicate that participants clearly saw the authored personas' personalities as intended and were able to correctly identify them.

A. Persona likeability

After the design sessions, the participants answered post design questionnaires about their overall experience during the four design activities with the four personas. In one question the participants were asked to select either one of the four personas for their future design activity or indicate they did not remember the name. They were given an opportunity to comment on their choice. From answers given to the above questions, their explanations for their selection and their design notes, TABLE VII was compiled which shows that 74 % of these participants preferred to design for a persona that is emotionally stable, 33 % of them selected Doris/Helena and 41 % of them selected Minty/Meta. Only 11% of the participants preferred to design for the emotionally unstable personas (Katie/Katherina and Eliza/Agneta). The rest selected the

TABLE VII. PREFERRED PERSONA FOR A FUTURE DESIGN
ACTIVITY.

Persona		Percentage of participants select (%)
Doris	Helena	33
Katie	Katherina	4
Minty	Meta	41
Eliza	Agneta	7
Did not remember the name		9
Did not have a preference		4
Prefer a new persona		2

TABLE VIII. EFFECT OF PERSONALITY TRAITS OF THE
PREFERRED PERSONA DURING THE DESIGN SESSION

No	Statements about persona	Participants' Responses (%)		
		A	N	D
1	I was totally engaged with her personality while I was designing for her	69	23	8
2	Her personality positively influenced my design	74	16	10
LEGEND: A=Agree, N=Neutral, D=Disagree				

TABLE IX. CONCEPTUAL DESIGN TAILORED ACCORDING
TO PERSONALITY TRAITS OF PERSONA

No	Consideration of personalities of the personas during conceptual design	Conceptual Design %
1	Did not consider personalities of personas	26
2	Considered personalities of the personas	48
3	Considered personalities of the personas and produced in-depth conceptual designs	26

option that they could not remember the name of their preferred personas (15%) but in the notes 4% indicated that they did not have a preference and 2% indicated that they preferred to design for a new persona.

B. Design according to the personality traits of a persona

To assess the awareness of the participants about the personalities of personas, the following statements were made during the design modification activity for each persona and the participants were asked to rate each of these statements on a 7-point scale ranging from 1 (disagree strongly) to 7 (agree strongly): (1) I was totally engaged with [the persona]'s personality while I was designing for [the persona], (2) The personality of [the persona] positively influenced my design for [the persona]. The participants' responses for the persona that they selected as their preferred persona during the post design questionnaire (TABLE VII) are presented in TABLE VIII.

Analysis of answers to the above questions (TABLE VIII) indicates that 69% of the participants felt that they were totally engaged with the personality of the persona and 74% of the participants reported that the personality of the persona positively influenced their design. In answer to RQ1, the above statistics indicate that the participants were aware of the personality traits of the persona during their design activity and hence they believed that they tailored their design according to the personality traits of the persona.

C. Qualitative Analysis of design

Analysis of the designs took into consideration that few of the students had professional experience and many would have been challenged to rate the persona and prepare a design work within fifteen minutes. As a result, the range of designs including the level of details and quality were very varied. To make assessment as objective as possible a rubric has been used by the research team. The marking rubric and qualitative analysis of the designs are presented in [38]. TABLE IX shows that 74% of the participants considered personalities of personas during conceptual design. Among them 26% of the participants produced conceptual design that can be considered in-depth. A design is considered in-depth when participants' design or explanations are in line with literature or the designer has incorporated knowledge of personality in their design that takes into account the needs of Holistic Persona beyond normal expectation. For example, a popular website or a mobile application for an extraverted personality [20, 21], an informative application for an emotionally stable personality and a directive application for a person who is not emotionally stable. TABLE X shows a sample of quotes from the

participants. These quotes indicate that the participants were aware of the personalities of the personas. For example the participant Id 3152's design is considered an in-depth design as his comments are in line with Hamburger and Ben-Artzi [29] and Landers and Lounsbury [30]'s findings; emotionally unstable women seek information online anonymously. Some participants considered personalities of the personas but did not provide an in-depth conceptual design for an application. For example the participant Id 3154 (TABLE X) did not provide a conceptual design for an application for Agneta. Some participants became aware of personality during the study. For example the participant Id 2132 (TABLE X) gained awareness of the different personalities of personas during the study however he did not provide an in-depth conceptual designs. Another participant suggested a 'Fitness weight loss application' for the first persona, Minty. He suggested the same application for the second persona, Eliza, but added punishment and reward features. For the third persona, Doris, he removed the punishment feature.

In answer to RQ2, from TABLE IX, the number of students who produced in-depth conceptual designs is not high enough for us to draw a conclusive answer. We conjecture that had the participants received training in personality and its effect on usability, the number of in-depth designs presented would have been higher than the current value of 26%. More research needs to be done on the effect of training in personality traits within Software Engineering education for design of more usable products.

TABLE X. PARTICIPANTS' COMMENTS ABOUT PERSONALITY OF THE PERSONA.

Id	persona	Affected personality	Participants' comments
2113	Katie	Extravert / Emotionally unstable	*"Group improvement software designed to allow a group of individuals to try and improve in different areas (skills, exercise regularly, etc) and comparing their progress. Katie is a social animal, and so she would need societal peer pressure on her to improve herself in the ways she may wish to..."*
2120			*"The personalities helped me consider the different ways such a system could be interpreted by people o f different emotional/mental states."*
2125	Minty	Introvert / Emotionally stable	*"... she is similar personality to me, so i can relate to her and design a better program for her ..."*
2127	Eliza	Introvert / Emotionally unstable	*"A single program or product will not help Eliza as she lacks self confidence nor is she sociable enough to seek help from others due to this underlying lack of self confidence."*
2127			*"Knowing how each personality planned out each day and the how likely it was that a external program or product would be utalised did influence each design to fit into each personas' hypothetical day so that it would have the greatest impact ..."*
2129	Katie	Extravert / Emotionally unstable	*"As Katie is quite disorganised and doesn't follow through with her plans, I would design a planner/ organiser/motivational app for her. The app would have tools such as a diary and reminder chimes, 0have motivational pictures and quotes, and help her to break down tasks so that her goals will be more achievable for her ..."*
2132			*"It makes you think about people and personality traits you might not have thought about."*
	Minty	Introvert / Emotionally stable	*"a diary/timetabling style application, so she can keep track o f her busy uni lifestyle and when she can have time to herself. minty wants to go to a restaurant with her close friends, but when she o pens the app she is reminded that she has to tutor a socially disadvantaged person that evening. She is a little disappointed that she cant go to dinner but she brightens up when she meets her commitments."*
2134	Doris	Extravert / Emotionally stable	*"She seemed to be the best person to get concise specifications about what she wants the software to do."*
2135	Minty	Introvert / Emotionally stable	*"Rather have a persona that relates to me so I can further understand what they would want."*
3140	Katerina	Extravert / Emotionally unstable	*"I don't have any recommendations for Katerina. I think she needs a personal coach."*
3145			*"Generally I tried to add features based on their perceived personality. If I felt pity for them, I tried to add features that could make them "better". If I sympathized with them, I added features that supported their present personality"*
3148	Agneta	Introvert / Emotionally unstable	*"My idea is a piece of software that would help Agneta building trust in others. This could be with the help of psychical exercises, mentally through conversations or other activities through a mobile app. The app notices that Agneta is nearby others that are introverts, and that she has not planned anything for the afternoon, the app suggests that they go meet at the nearby cafe."*
3150	Meta	Introvert / Emotionally stable	*"she are more easier to construct a work-out application for, because she are more determined. Its hard to construct a mentally convincing application for people that do [not] have any self confidence or determinism in they everyday life."*
3152	Meta	Introvert / Emotionally stable	*"She might use a software to record her own songs and play them as motivation for working out. She might like it because she likes music and just learnt to play guitar, and she wants to lose weight. It could be a mobile app that keeps the records in a cloud service. Meta plays some song on her guitar and record them. After that, Meta goes for a run and start listening her most recent artistic achievements."*
3152	Agneta	Introvert / Emotionally unstable	*"I would recommend her a software to express ideas in an anonymous way so everyone can share thoughts without being directly criticized. Sometimes people like her wants to share what they think but they don't want to be identified..."*
3154	Agneta	Introvert / Emotionally unstable	*"Se needs a personal coch app. Maybe it should involve real people - so it's not a computer program which helps her, but volunteers in a way..."*
3164	Katerina	Extravert / Emotionally unstable	*"Katerina's personality forced me to think a way of how the application could engage and motivate person to perform some kind of physical activity and follow their diet plans..."*

D. Plans to mitigate external threat to generalise this study

The study has been conducted twice in two separate cultures: undergraduate students from Macquarie University in Australia and postgraduate students from IT University of Copenhagen in Denmark (TABLE II). We plan to mitigate external threats to generalize the results of this study by further repeating the study a number of times using participants from different population pools.

IX. CONCLUSIONS

The results of our empirical study demonstrate that the participants in the study can identify personality traits of the personas and the personas with personality traits affect designers at the conceptual design phase. The collected design notes and answers to the post design survey questionnaire indicate that 74% of the participants tailored their conceptual designs according to personalities of the personas however only 26% of the participants produced conceptual design which considered the effects of personality in line with literature. As personality affects the way users interact with software applications or products [20, 21, 31, 33, 34, 37], it is expected that the target users would find software applications tailored to their personality to be more user friendly.

Since the students in our study were able to correctly recognize the personalities of the persona and indicated that they considered the personalities of the Holistic Personas in their conceptual design, we hope that in future studies we are able to show that this results in more in-depth conceptual designs. The practical implications for educators would be that teaching Software Engineering students to take account of personality in their design work, would result in greater number of students being able to create in-depth conceptual designs and would address requirements and validation issues around lack of access to real end users.

We plan to evaluate other dimensions of the Holistic Persona in design in future studies. We will also explore other factors that might improve the quality of personas to propose a formal framework to aid in authoring Holistic Personas.

I. APPENDIX : AN EXAMPLE OF A PERSONA WITH PERSONALITY TRAITS

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

Minty's grand-parents migrated to Tasmania during the early 1940's. Her parents are busy in their professional careers. Minty 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.

Minty seldom goes out and meets people, but she responds positively to people who approach her. She has few good friends that have known each other for many years. They often visit her and occasionally she goes out with them to local restaurants. She likes musical concert and attends important musical events in Hobart. She has a large collection of records and enjoys listening to the albums. Minty is not a member of any clubs or societies. However when the team leader of the 'Assisting Socially Disadvantaged Group' approached her for help, Minty offered to tutor students in her home.

Minty 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.

Minty is quiet and seldom expresses her views unless she feels strongly about an issue and has investigated it well. She listens to other people's point of view and learns from the experience. Her friends feel that she 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 others when she does not feel like helping. However she always meets her commitments with high spirits.

Minty is allergic to peanut but she often forgets to mention this fact while ordering her meals. Minty has read about relationships between height, weight and energy content of various foods.

Minty has realized that she is overweight and wishes to reduce her weight.

Please spend about 10 minutes on the following tasks:

- Recommend a software application or product
- Briefly describe your design ideas or recommendation.
- Write a scenario in which Minty uses your software application or product

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