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In this issue:

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A Validation Study of Student Differentiation Between Computing Disciplines

Michael Battig
mbattig@smcvt.edu
Computer Science & Information Systems
Saint Michael's College
Colchester, VT 05439, USA

Muhammad Shariq
mshariq@auaf.edu.af
Information Technology & Computer Science
American University of Afghanistan
Kabul, Afghanistan

Abstract

Using a previously published study of how students differentiate between computing disciplines, this study attempts to validate the original research and add additional hypotheses regarding the type of institution that the student resides. Using the identical survey instrument from the original study, students in smaller colleges and in different cultural contexts are studied. Both the original and the validation study consider computing and non-computing majors. Although the original research was largely validated through some strikingly similar results, some significant differences were observed depending on the size and orientation of the institution. Furthermore, we noted some differences in college students outside of the US.

Keywords: information systems, information technology, computer science, software engineering, computer engineering, student perceptions, information systems education

1. INTRODUCTION

The January 2010 issue of ACM SIGSOFT Software Engineering Notes devoted the monthly Software Engineering Education column to the topic of how well students differentiate between computing disciplines (Ardis & Henderson, 2010). The column urged readers to obtain and read a study presented at SIGCSE 2009 (Courte & Bishop-Clark, 2009) that surveyed undergraduate students (both computing and non-computing majors) to determine their understanding of the five major computing disciplines: Computer Science (CS), Information Technology (IT), Information Systems (IS), Computer Engineering (CE), and Software Engineering (SE).

Both articles acknowledged that "there is very little difference between majors and non-majors in these responses." Furthermore, Ardis & Henderson noted that "of the five disciplines Software Engineering appears to be the least understood." These observations piqued our curiosity and led us to engage in several tasks.

We wanted to validate this study through our own administration of the same survey. We contacted the authors of the 2009 SIGCSE study and requested a copy of and permission to utilize their survey instrument. The request was immediately granted and the survey instrument provided to us electronically.

In addition to validating the original study, we were particularly interested in hypotheses related to the understanding of IS and IT in various contexts. Therefore, our sample populations vary slightly from the original studies in that our student subjects reside in different academic and cultural contexts.

The import of this research lies in our continuing efforts to clarify the nature of our discipline so as to attract bright individuals. We do this because "perception problems carry over to computing professionals and educators who, to some degree, have difficulty defining, describing and explaining these disciplines. This, in turn, carries over to prospective students and their parents" (Ardis & Henderson, 2010). Furthermore, "computer applications are found in almost every academic discipline, and the creation of useful, innovative computer applications in any discipline requires both knowledge of that discipline and knowledge of computing" (Walker and Kelemen, 2010).

Therefore, we as educators must continue to explore the verbiage and effective communication necessary to convey to the world outside of our discipline exactly what it is we do and why. This survey is a significant part of examining and improving that endeavor of communicating the essence of our discipline in the world of ideas.

2. SURVEY & HYPOTHESES

An overview of the original survey from Courte & Bishop-Clark, which we used without editing in any way to preserve the integrity of our study, is presented in Appendix A. We encourage readers to read this overview in order to become familiar with the verbiage used to differentiate between the disciplines in the study.

In addition to validating the general results concerning differentiation between majors and non-majors, we were keenly interested in discovering if results at our institutions would match the original findings. Our institutions fit into the small to medium college classification, whereas the original study was conducted at larger universities. Thus, we wanted to test the hypothesis that students at smaller institutions would more accurately differentiate between computing disciplines. We also wanted to add an international dimension to our study. Therefore, we administered the survey to students at the American University of Afghanistan. Our hypothesis was that students at AUAF would less accurately differentiate between computing disciplines than their American counterparts. We also hypothesized that computing majors at both institutions would more accurately differentiate between computing disciplines than the non-computing majors.

3. RESULTS

During the spring semester of 2010, students were given the survey in Business (non-major) and IT, IS, and CS courses at our institutions. Many of the original study surveys were completed electronically during class time. All of our surveys were on paper.

The original study had 375 students responding. The majority (67%) were male. They also had a slight majority who were majors (53%). Our study had 196 usable respondents completing the survey. Some were discarded as unusable (e.g., if the student indicated "don't know" for every answer). The majority of our American respondents were male (68%) and the majority of the Afghan respondents (77%) were male. We had far fewer majors in our survey (28%) than the original.

The survey asks each respondent three questions about each sub-discipline (the order is mixed so as to conceal the *correct* response). Thus each survey contains 15 questions in order to cover all five sub-disciplines. The questions are reproduced in each subsection below. Respondents may indicate one of six answers: CE, CS, IS, IT, SE, or Don't Know. We will contrast the top answers to each question from the original study with our study.

Computer Engineering

Table 1 shows the results for the CE questions. The original study and this validation study produced strikingly similar results for the sub-discipline of Computer Engineering. Each cell contains three lines of data – the first indicating *total students*, the second indicating *majors* and the third indicating *non-majors*. For example, the second question, Builds hardware devices such as iPods, 82% of majors picked CE in the original study, compared to 92% of majors in the US and 56% in Afghanistan. The **boldface numbers** indicate that the percentage is the top response and the correct one. The most frequently answered sub-discipline is listed in the lower portion of cells where the percentage is not bolded. For example, majors in the US picked CE 15% of the time for Question 3 in Table 1 where their top (wrong) answer was CS. The actual percentage that picked CS (and other wrong answers) is shown in Appendix B.

Questions 1 and 2 for CE proved to be validated in our study. Students are generally aware of the fact that Computer Engineers design and build hardware. The results are somewhat exaggerated in that our US population had much stronger results for the majors and the Afghan population had weaker results. The third question is more interesting in that all three populations missed the mark. The top answers for all three populations turned out to be Computer Science, showing that students are universally confused about the fact that Computer Engineers more than Computer Scientists do a fair amount of hardware/software integration.

Table 1 – Computer Engineering Questions and Results (in each cell, the first line indicates total students, the second line indicates the majors, and the third line indicates non-majors)

	Original	US	Afghan
Designs hardware to implement communications systems	**62%** **72%** **51%**	**53%** **82%** **39%**	**38%** 25% **41%**
Builds hardware devices such as iPods	**71%** **82%** **59%**	**72%** **92%** **61%**	**46%** **56%** **44%**
Integrates computer hardware and software	25% 28% 21% **CS**	9% 15% 6% **CS**	14% 13% 14% **CS**

Computer Science

Table 2 shows the results for the CS questions. Once again, the prior study was validated with striking consistency. There are some small variations within the Afghan survey data which will be discussed later. What is striking about these results is how consistently students fail to differentiate between CS and SE. As Ardis and Henderson (2010) have stated, this can "be viewed as a perception problem for all students regarding software engineering."

Table 2 – Computer Science Questions (total students, majors, and non-majors)

	Original	US	Afghan
Uses new theories to create cutting edge software	33% 40% 26% **SE**	18% 21% 17% **SE**	14% 13% 14% **SE**
Focuses on the theoretical aspects of technology	**51%** **56%** **46%**	**57%** **62%** **55%**	25% **31%** 23% **IS**
Utilizes theory to research and design software solutions	36% 40% 31% **SE**	25% 41% 17% **SE**	14% 13% 14% **SE**

We do not believe that these results can be totally attributed to perception confusion between CS and SE. The reader will notice that both questions 1 and 3 in Table 2 feature the word "software" prominently. One wonders how the results would have differed by substituting the phrase "computing system" for "software" in these questions, which would shift the emphasis to *theory*.

Software Engineering

Table 3 shows the results for the SE questions. We have placed the SE and CS sections together since they really tell the same story as the results show. Students are not able to identify the statements in this survey as pertaining to SE. The only exception to this being that US students in our study were able to correctly choose SE related to "testing large scale systems." Again, one wonders how the wording of the survey questions might impact the outcomes. Clearly the word "software" substituted for "technological" or "systems" could change the results even though the emphasis of this line of questioning is on "large scale." In most cases it appears that students make their selection based on certain key words. We can't help but notice that the word "system" occurs in questions 1 and 2 in Table 3, which apparently leads students to choose IS as their answer.

Table 3 – Software Engineering Questions (total students, majors, and non-majors)

	Original	US	Afghan
Focuses on large-scale systems development	12% 17% 6% **IS**	13% 18% 10% **IS**	4% 6% 3% **IS**
Designs testing procedures for large-scale systems	23% 27% 18% **IS**	**22%** **36%** 14%	18% 19% 17% **IS**
Manages large scale technological projects	10% 13% 6% **IS**	7% 18% 1% **CE**	13% 13% 13% **IT**

Information Systems

Table 4 shows the results for the IS questions. Notice that the US students in our survey outperformed the original survey students by about 10 points in each category. The Afghan students on the other hand were more torn between IS and IT when it came to identifying the "business" orientation of IS. We will discuss potential reasons for this below.

Table 4 – Information Systems Questions (total students, majors, and non-majors)

	Original	US	Afghan
Is business oriented	**51%** **59%** **42%**	**59%** **69%** **53%**	29% **31%** 28% **IT**
Combines knowledge of business and technology	**40%** **48%** 31%	**51%** **59%** **47%**	26% 25% 27% **IT**
Selects computer systems to improve business processes	**43%** **49%** **37%**	**47%** **54%** **44%**	**28%** **38%** **25%**

Information Technology

Table 5 shows the results for the IT questions. The results show that the US students in our survey performed comparably to the original in questions 1 and 3, but were more prone to see question 2 as pertaining to CS. The Afghan student responses were mixed between IT, IS and CE (the CE responses pertaining particularly to question 3).

Table 5 – Information Technology Questions (total students, majors, and non-majors)

	Original	US	Afghan
Troubleshoots and designs practical technical applications	**32%** **36%** **27%**	**35%** **38%** **32%**	**23%** **44%** 17%
Applies technology to solve practical problems	**35%** **40%** **30%**	24% 15% **29%** **CS**	**31%** **38%** **30%**
Applies technical knowledge for product support	**55%** **67%** **41%**	**53%** **72%** **43%**	15% **31%** 11%

4. CONCLUSIONS

Our first hypothesis was that students at smaller liberal arts based institutions would more accurately differentiate between computing disciplines. The rationale for this hypothesis is that our smaller institutions emphasize the liberal arts and as such tend to discuss the points of commonality and difference between disciplines (not just limited to *computing* disciplines). As noted by Walker and Kelemen (2010), "Overall, a liberal arts program emphasizes general knowledge, multiple perspectives, alternative ways of thinking, and connections among disciplines." This hypothesis proved to be true among the US computing majors who out performed the students from the original study in 12 out of 15 questions. The non-majors, however, only outperformed the subjects in the original study in 8 out of 15 questions.

Our second hypothesis was that students at AUAF would underperform the American students. Our rationale being that the computing educational infrastructure in Afghanistan is very new. This hypothesis appears to be substantiated by the data in that both majors and non-majors in our study only outperformed the original study in 1 out of 15 questions. We should mention here that our study in Afghanistan only included 16 majors of the 80 total surveys from AUAF. Additionally, out of these 16 majors, 8 were freshman, 6 were sophomores and only 2 were juniors. AUAF is a still in its infancy with no student in the senior year of a computing major.

We would be remiss if we did not point out a particular bias of the Afghan students in this study. The majors at AUAF are in a program that is a hybrid of IS, IT and CS. Many of the students work full or part-time as IT/IS employees with local firms in Kabul. However, they have communicated to the administration on several occasions that they wish to have the department called "computer science" since they perceive that the most prestigious institutions in the US have computer science programs. This desire to be called computer science may significantly influence the students' ability to differentiate between the computing disciplines.

Our third hypothesis was that majors would more accurately differentiate between computing disciplines than non-majors. Kurkovsky (2007) discussed and suggested a need to clear misconceptions among the non-majors about CS. Our study confirms not only the initial finding of misconceptions about CS among non-majors but about all computing disciplines in general. In the original study, the majors outperformed the non-majors in all 15 questions. The US majors in our study outperformed the non-majors in 14 out of 15 questions (the one exception being the 2nd IT question). The Afghan majors in our study outperformed the non-majors in 9 out of 15 questions. Thus, in the US population, we can confidently assert that our original hypothesis was correct, especially given that in many instances the difference was in excess of 20 percentage points. However, the outcomes in the Afghan population were more mixed. What impact (at AUAF) does having the majority of computing major students (88%) in their initial years of studies? This may be an area of further research.

5. REFERENCES

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Kurkovsky, S. (2007), Making Computing Attractive For Non-Majors: A Course Design, 22(3), 90-97.

Walker, H. M., & Kelemen, C. (2010). Computer Science and the Liberal Arts: A Philosophical Examination, **ACM Transactions on Computing Education (TOCE),** 10(1).

Appendix A

Overview of the original survey by Courte & Bishop-Clark (2009):

Respondents were presented with phrases descriptive of each discipline and asked to select one discipline that they thought best matched the phrase (options included Computer Engineering, Computer Science, Information Science, Information Technology, Software Engineering, and Don't know). There were 15 phrases with 3 for each discipline, randomly mixed. The phrases were created by surveying colleagues and other practitioners for keywords thought to represent the discipline. Keywords that had a greater consensus were then used to construct the survey phrases.

For **Computer Engineering**, the keyword was *hardware*:
- Designs *hardware* to implement communications systems
- Builds *hardware* devices such as iPods
- Integrates computer *hardware* and software

For **Computer Science**, the keyword was *theory*
- Uses new *theories* to create cutting edge software
- Focuses on the *theoretical* aspects of technology
- Utilizes theory to research and design software solutions

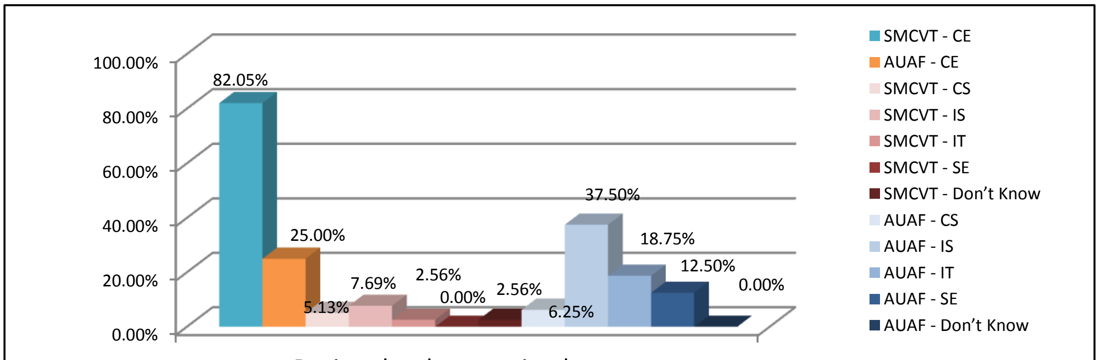
For **Information Science**, the keyword was *business*:
- Is *business* oriented
- Combines knowledge of *business* and technology
- Selects computer systems to improve *business* processes

For **Information Technology**, the keywords were *practical* and *applied*:
- Troubleshoots and designs *practical* technical *applications*
- *Applies* technology to solve *practical* problems
- *Applies* technical knowledge for product support

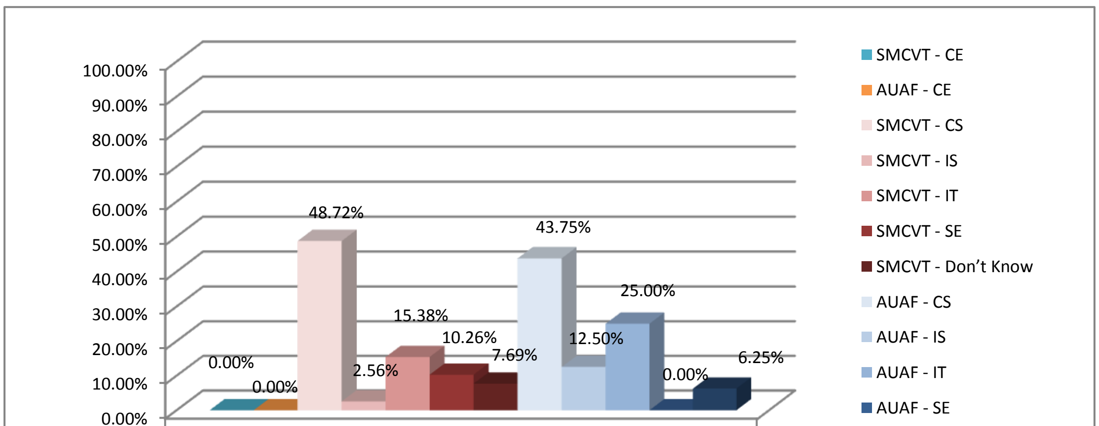
For **Software Engineering**, the keywords were *large-scale systems* and *projects*:
- Focuses on *large-scale systems* development
- Designs testing procedures for *large-scale systems*
- Manages *large scale* technological *projects*

Respondents were also asked to provide basic demographic information, such as gender, age, state and type of employment, student status, major, and type of university.

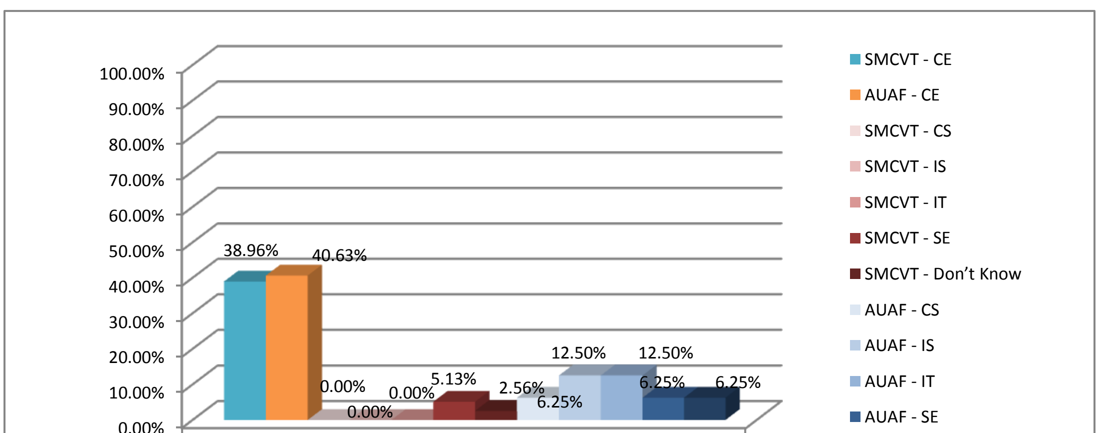
Appendix B - Computer Engineering



Designs hardware to implement communications systems

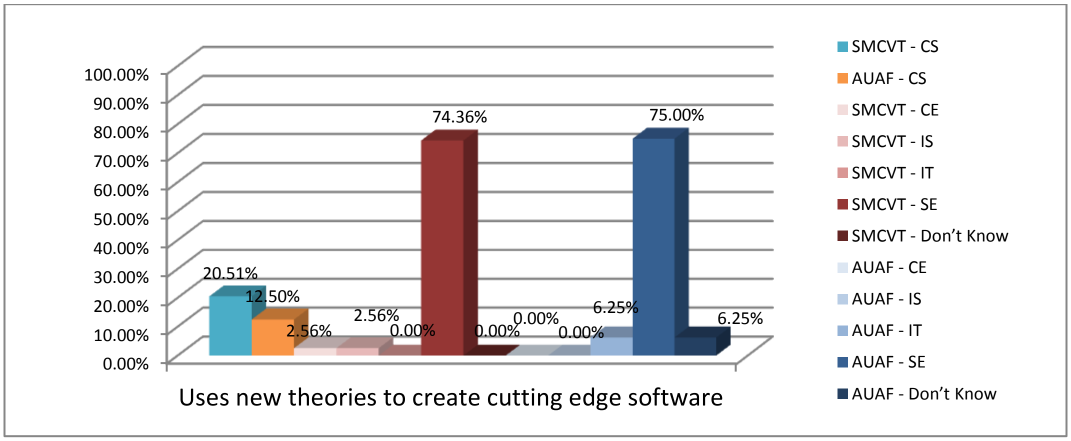


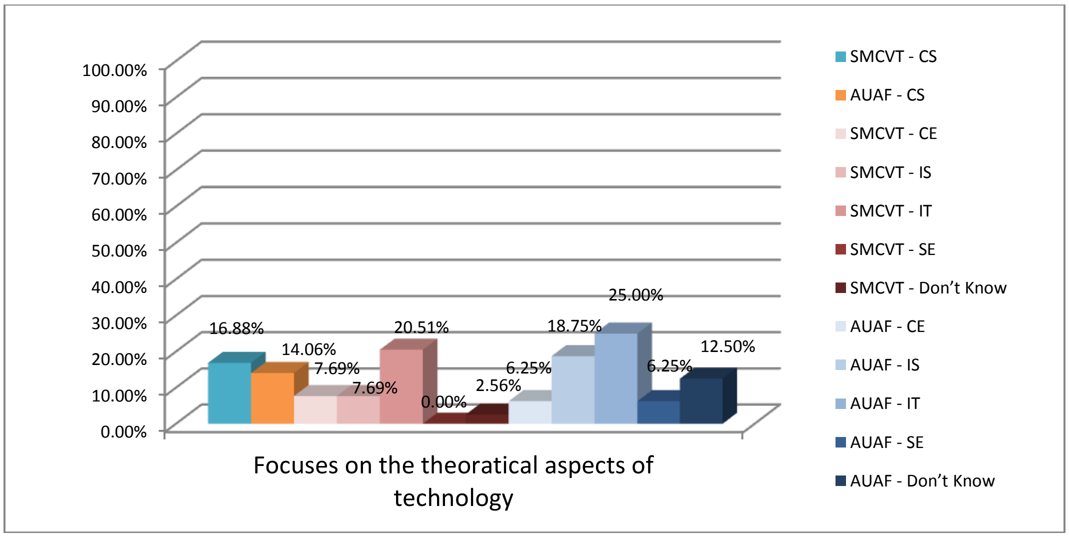
Integrates computer hardware and software

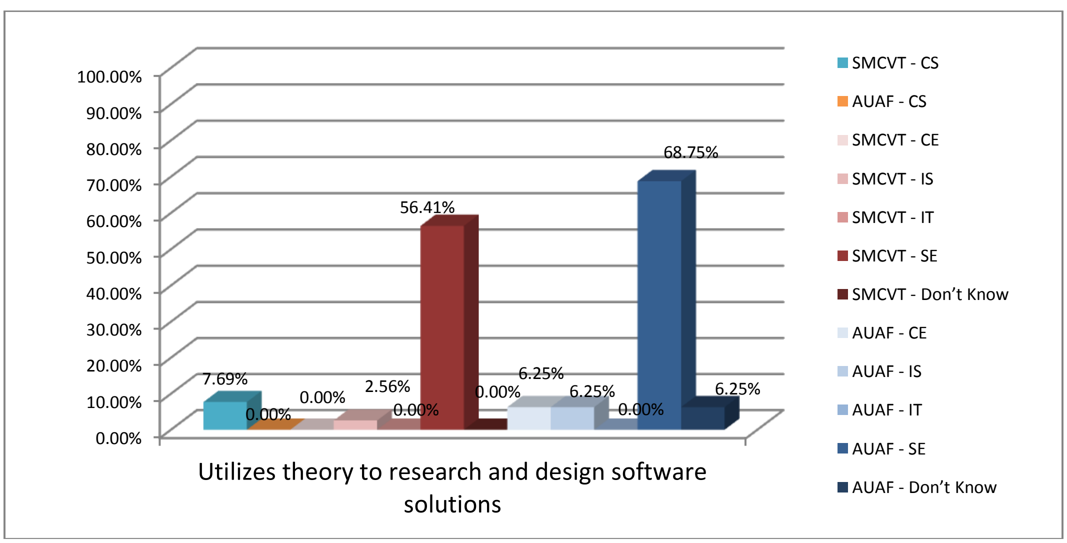


Builds hardware devices such as iPods

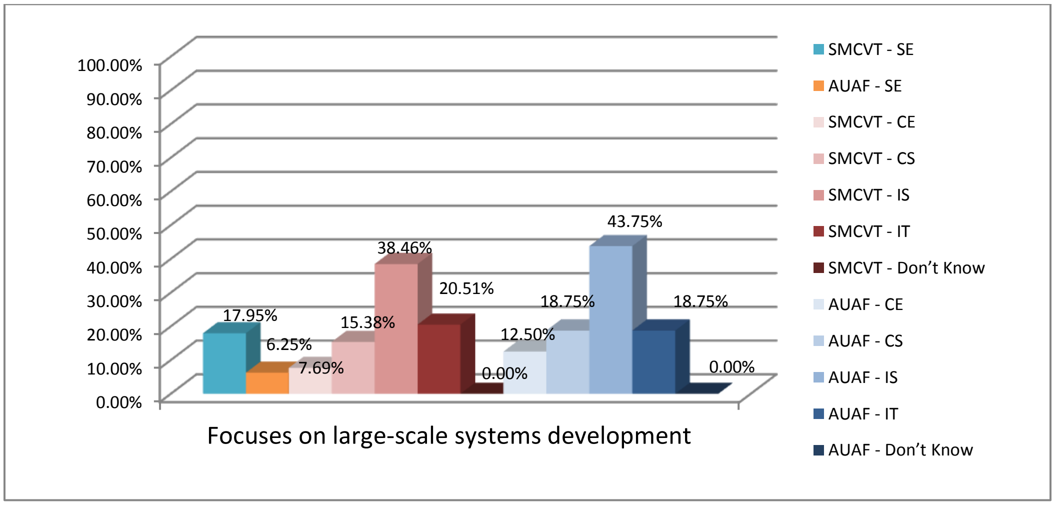
Computer Science

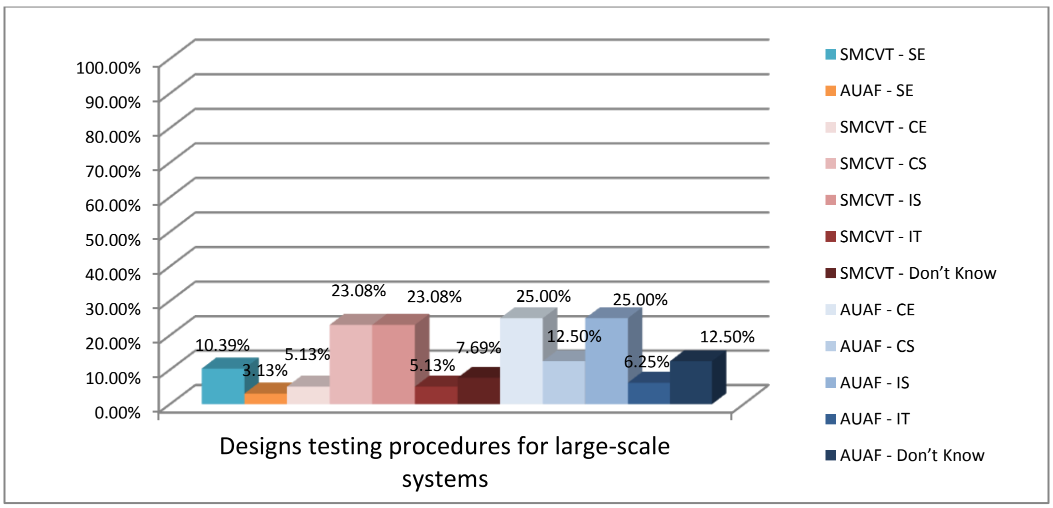


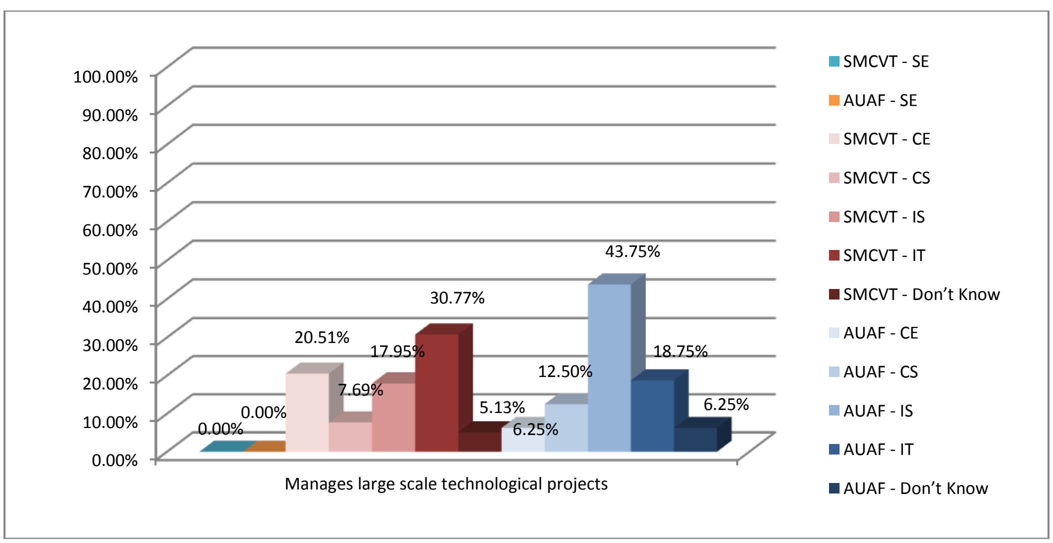




Software Engineering







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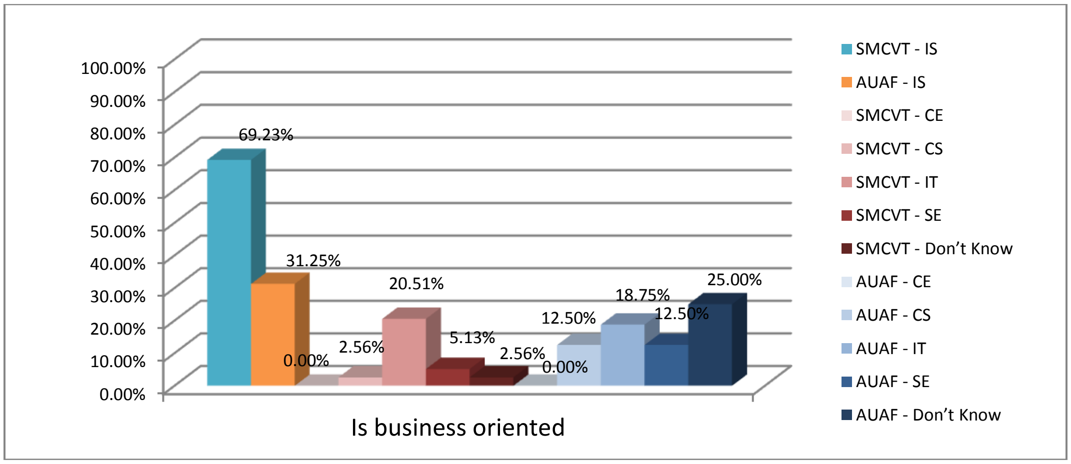

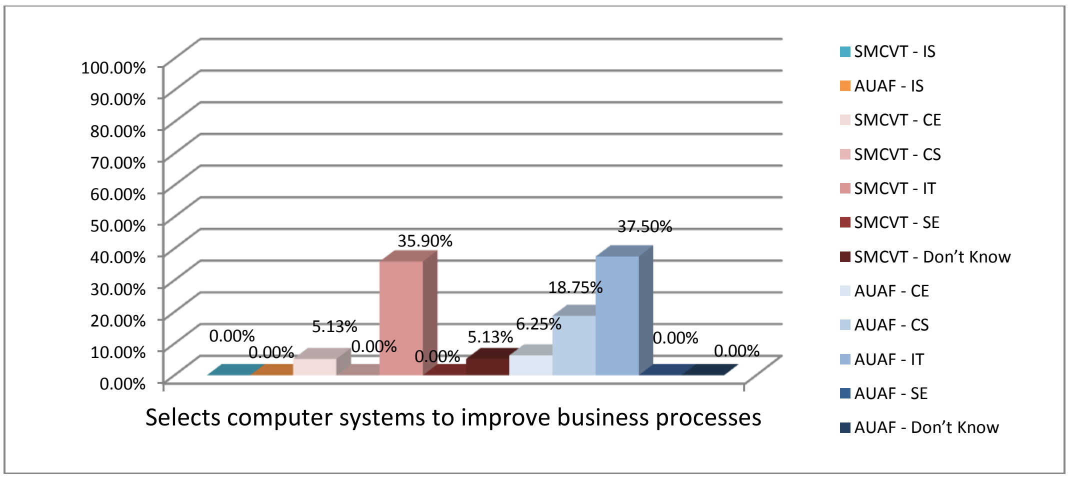

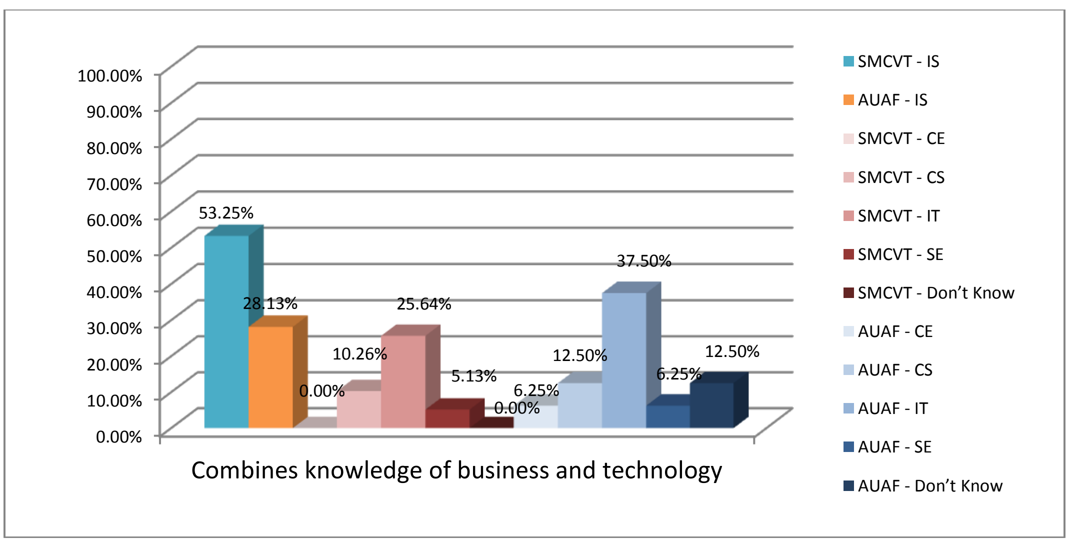

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