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Gender and Student Performance in STEM-Designated Information Systems Courses

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Abstract

This study tested gender-based differences in performance of students in science, engineering, technology, and math (STEM) Information Systems (IS) courses. Data collected from 94 STEM-designated information systems courses (STEM-IS) courses and 2,189 students over a 9-year period were analyzed using ANOVA. This study tested for differences in performances for all the sub-classifications and combinations of the sample such as gender-based differences by course type (technical vs. conceptual) and by course level (graduate vs. undergraduate). The results indicate that female students in STEM-IS courses performed better overall, as well as in all the sub-classifications by course type, undergraduate and graduate course levels, and technical and conceptual course types than the male students. The statistical analysis was followed up with a *post hoc* analysis of structured interviews of faculty and students in STEM-IS courses to corroborate the results obtained from ANOVA. The importance and implications of the results are discussed.

Keywords: STEM, Gender disparities, Student performance, Information systems (IS), IS programs, IS education

1. INTRODUCTION

Men outnumber women in four closely connected areas of study: science, technology, engineering, and mathematics (STEM) majors in academe and the workforce (Shi, 2018). The reasons for under-representation of women in STEM are often related to the gender stereotype issues (Allen-Hermanson, 2017; Smyth & Nosek, 2015), socio-cultural factors such as cultural beliefs, gender discrimination and the gender-based differences in perspectives (Tannen, 1994). Men and women's perceptions towards STEM-designated disciplines vastly differ in terms of their perceived abilities in their respective disciplines and so does their retention rate in these disciplines. Men believed that they had better abilities in computer science (Beyer et al., 2004) while women perceived computing disciplines as more difficult and felt less confident about their abilities (Beyer et al., 2004; Scragg & Smith, 1998; Tellhed et al., 2017). Women tended to drop out of those majors more than men (Cohoon, 2001, 2002; Miller & Wai, 2015; National Science Foundation, 2015). However, recent studies seem to indicate that the gender gap in STEM disciplines has decreased though the male dominance in STEM-designated disciplines continues (Miller & Wai, 2015).

STEM-designated academic programs are recognized by the Department of Homeland Security as those that focus on science, technology, engineering, and math (STEM) topics. STEM-designated programs are required to include at least 50% of its coursework in STEM fields: namely science, engineering, math, and technology (USCIS, 2024). In order to understand the current state of these gender disparities in STEM-designated programs, this study attempts to measure the gender-based performance and differences between male students and female students' performance in STEM-designated information systems courses (STEM-IS courses hereinafter).

2. GAP IN LITERATURE AND IMPORTANCE

Past research has addressed gender-based differences in attitudes toward and usage of technology in multiple studies in multiple contexts (Blau & Ferber, 1986; Blau & Kahn, 2007; Schumacher & Morahan-Martin, 2001; Seybert, 2005). At individual STEM courses level, math engagement among men and women genders was studied (Nosek & Smyth, 2011). The driving factors behind the gender disparity in choices of majors in education have been studied at length in past research (Siddiq & Scherer, 2019; Singh et al., 2007; Smyth & Nosek, 2015). Several studies identified the reasons for disparities as arising from gender-based perceptual factors, and social psychological factors but not necessarily due to their abilities (Charlesworth & Banaji, 2019; Wang et al., 2013; Wang & Degol, 2017). Past research measured the gender-based performance in undergraduate and high school students (O'Dea et al., 2018; Wang et al., 2023). However, the performance of genders – especially that of women, or gender-performance differences in technology intensive STEM-IS courses was not studied. This is a significant gap in literature that the current study attempts to address.

This study contributes to the literature by attempting to understand how female students actually perform in the STEM-IS courses compared to their male counterparts. This will enhance understanding of evolving gender issues in IS courses and help inform strategies to promote gender equity within the IS discipline—ultimately influencing workplace equity as students transition into their professional careers. Understanding female student learning and performance may help reduce gender-bias issues, skill gaps, and the attrition rate of female students drop-outs in STEM disciplines.

Given that the gender gap in STEM disciplines in terms of numbers has decreased (Miller & Wai, 2015), it is important to understand the current state, based on performance in the STEM-IS, as well as the extent and directionality of the gap. Further, this study attempts to understand the finer aspects of gender-based differences in STEM-IS courses based on course levels (graduate courses vs. undergraduate courses) and type of course (technically oriented courses vs. conceptual courses). Further, this study tries to understand the reasons behind gender-based differences in performance by conducting a *post hoc* analysis of interviews with students and faculty.

The research questions addressed in this study are summarized as follows: 1) Are there gender-based differences in students' performance in STEM-IS courses? 2) Do these gender-based differences extend to the sub-classifications such as course levels (graduate and undergraduate), and course types (conceptual courses and technical courses)? 3) What are the factors that could contribute to such gender-based differences in student performance in STEM-IS courses? The insights from the data and the interviews indicate that there are salient reasons why women outperform men in STEM-IS courses: Women seem to be more organized, multitask, and manage their time better.

For the purposes of this study, course level is defined as courses offered either at the graduate level or undergraduate level of education (Paravastu & Ramanujan, 2024). Course type is defined as whether the course is a technical course or a conceptual course (Paravastu & Ramanujan, 2024). Courses classified as technical courses in this study are also termed as "experiential courses" where the students are encouraged to learn through hands-on or direct experiences, learning by doing, reflection and developing skills, knowledge, and practices essential for a given area or discipline (Howell & Aryal, 2024). Conceptual courses on the other hand impart mostly the overall survey of codified knowledge of the discipline area (Roubanis et al., 2016). Conceptual courses are those courses in which the focus is more on the theoretical aspects and may or not involve significant amounts of labs or hands-on course work. Technical courses are those courses that require considerable hands-on practice of syntax, for example, programming or database courses.

The rest of the paper is organized as follows: A brief review of the gender issues in the Information Systems discipline, followed by the past research on gender, followed by hypothesis development. Data analysis and results are presented next, followed by a discussion of the results. Findings from *post hoc* analysis with structured interviews as a follow-up to the results obtained are presented next. This is followed by implications of the research, limitations, and conclusions.

3. LITERATURE REVIEW

The objective of this review is to establish from past research that in general there are differences in how women and men perceive and use technology and how these gender differences are rooted in and originate from social-psychological factors. These perceptual and social-psychological factors contribute to differences in how individuals of different genders make educational and career choices. They also influence how gender differences are perceived or reflected in performance, particularly in decisions related to majors and educational disciplines. This review provides a brief overview of recent research on gender disparities in STEM fields, followed by the development of relevant hypotheses.

3.1 Differences in Perceptions of Technology and STEM-Designated Disciplines Based on Gender

Seminal and extensive works on gender (Hofstede, 2001; Tannen, 1994) have established that gender differences exist in the way women and men think and behave in general, which might explain why there may be gender-based differences in perspectives towards technology and its use. Men use computers and the Internet more often than women and were better than women in the basic skills (Seybert, 2005).

This trend was demonstrated in slightly older studies as well, in the context of email (Gefen & Straub, 1997), virtual communities (Gefen & Ridings, 2005), and online threaded discussions (Gefen et al., 2009). In the context of technology-mediated communications such as online discussions, the use of technology and the modus of communications were different for women than men (Gefen et al., 2007a, 2007b, 2009). Even in the case of technology adoption and use, women were concerned about a system's ease of use whereas men were more influenced by the usefulness of the technology (Venkatesh & Morris, 2000; Venkatesh et al., 2000). Past research established that there are more men than women at the workplace in computing related disciplines (Corbett & Hill, 2015; Frenkel, 1990). Women reported a more negative attitude towards technology than men (Harris et al., 2009; Lee & Huang, 2014; Young, 2000) and had higher levels of anxiety using computers than men (Broos, 2005; Morahan-Martin & Schumacher, 2007).

Research suggests that women attach lesser importance to technological education and are low on self-efficacy and expectations about their success in technology related areas and, therefore, have to lower their expectations about succeeding in technology-related areas (Beyer, 2008). This was likely due to women reporting lower self-efficacy in technology usage in general. Self-efficacy, or belief about one's ability to succeed in the STEM disciplines, was an important factor in enrollment in STEM courses as well as success in those courses. Women reported lower self-efficacy in STEM-designated disciplines than men (Tellhed et al., 2017). Men felt more confident and comfortable using computers than women (Morahan-Martin & Schumacher, 2007). Males displayed more self-efficacy about their potential choice of STEM courses as well as succeeding in STEM courses (Correll, 2001, 2004; Eccles, 2009).

Even with advancements in technology, several studies indicate that male students tend to hold more positive attitudes towards information and communication technology use and report more self-efficacy and consequently better performance than female students, although the gap has narrowed (Cai et al., 2017; Siddiq & Scherer, 2019). Recent studies also confirm the underrepresentation of women in STEM-designated disciplines. A recent study in health information technologies found that women face barriers in technology use such as gender inequalities and/or perceived lack of technological skills (Moulaei et al., 2023). Potentially because of those reasons, more male students tend to enter technically oriented STEM education and careers than women (Charlesworth & Banaji, 2019; Wang & Degol, 2017).

Some explanations for the gender disparity particularly in the STEM courses are attributed to social-psychological aspects such as a misalignment between the gender specific goals for men and women and their major or career choices (Diekman et al., 2010). Feeling of belonging in computing disciplines was found to be less for women than for men (Lewis et al., 2017). Women often perceived STEM disciplines as isolated and as affording fewer opportunities than other disciplines to pursue their community goals such as social interaction, working with others, and/or emotionally supporting or helping others (Brown et al., 2015; Diekman & Clark, 2015; Diekman et al., 2015). The stereotypical perception that women in male dominated fields like STEM areas were less capable than men, both at the workplace (Grover et al., 2017) and in academics (McPherson et al., 2018), as well as women's perceptions and preferences about technology, were potential contributing factors for women moving away from the STEM disciplines.

3.2 Recent Trends

From a review of the literature it may be concluded that men have a more positive attitude towards technology and related disciplines than women, perceive themselves as more competent in technology use, and report more self-efficacy in technology use and in STEM-designated disciplines. These perceptual or attitudinal factors towards science and technology disciplines prevent women from majoring in STEM or choosing careers in STEM-designated disciplines. However, the perceptions may not always reflect the actual performance in those courses or careers. Past research found that, after controlling for cognitive performance, the underrepresentation of women in STEM disciplines is a result of potential gender bias and stereotypical associations with those disciplines as male disciplines (Liu, 2018; Nosek et al., 2009; Smyth & Nosek, 2015). Several meta-analytic studies reveal that the differences based on abilities of either gender were minimal (Else-Quest et al., 2010; Lindberg et al., 2010; Stoet & Geary, 2018).

Recent trends indicate that performance in STEM disciplines is no longer male-dominated. Nevertheless, the results about gender differences, their causes and gender-based performance in STEM majors are mixed at best and largely contradictory and inconclusive (Ceci & Williams, 2011; Ceci et al., 2009). Research indicates that the genders use their relative strengths to their advantage. Several studies found that women perform better in verbal communications and linguistic areas than in math (Chan, 2022; Miller & Halpern, 2014; Wang et al., 2013). Two important findings explain the gender patterns in STEM education: Firstly, individuals with strong mathematical as well as verbal abilities are less likely to choose the STEM majors because of the wider variety of career or academic options available (Wang et al., 2013). Secondly, females constituted a majority of individuals who were more skilled in both verbal and mathematical abilities (Wang et al., 2013).

These findings help explain the rationale behind the major and career choices where women diversify and choose disciplines closer to their gender centered interests, whereas men are likely to focus on STEM disciplines because of their relative strength in those areas (Wang et al., 2013; Wang & Degol, 2017). Men tend to prefer more financially rewarding, prestigious, or more intense majors and careers while women tend to prefer choices closer to their gender-native interests (Hyde, 2005) such as socially and altruistically rewarding jobs (Ma, 2009) even though such jobs choices are likely to be financially less rewarding (Davies & Guppy, 1997; Song & Glick, 2004) than careers in STEM disciplines. The literature seems to suggest that women tend to choose disciplines like education or nursing or other non-STEM disciplines because of reasons related to gender role preferences natural to females rather than to performance. It might be reasonable to infer from past research that the disparities in STEM choices have more to do with gender roles, values, and lifestyle preferences (Charlesworth & Banaji, 2019) rather than gender-based performance perceptions.

Based on the survey of literature, the gender differences and the underrepresentation of women in STEM-designated programs and disciplines seem to be based more on the stereotypical gender perceptions, attitudes, and expectations, rather than the actual performance. The hypotheses tested in this study are presented next.

4. HYPOTHESES DEVELOPMENT

This study tests the differences in performance of students enrolled in STEM-IS courses. Past research points to the need to understand whether there are differences in performance based on gender. This study takes a further step to better understand the factors that could potentially make a difference in student learning such as the nature of course content, student attributes such as gender, course level (graduate or undergraduate), and type of courses (technical/hands-on or conceptual courses).

A synthesis of the results from the past research indicates a few important aspects that are central for the hypotheses proposed in this study. The vast body of literature reviewed indicates that male students and female students may not be very different after all (Else-Quest et al., 2010; Lindberg et al., 2010; Stoet & Geary, 2018). In fact, there is research on how female students are equal to or better than male students in a variety of areas that opens a variety of opportunities that fit their preferences (Hyde, 2005; Ma, 2009; Wang et al., 2013). The past research also has laid out how several factors other than ability in STEM courses are different for male and female students, such as perceptions about STEM disciplines (Beyer, 2008; Diekman et al., 2010; Diekman & Clark, 2015), gender-based preferences (Diekman et al., 2010), self-efficacy, and beliefs about their competence and confidence levels in STEM courses or technology usage (Correll, 2001, 2004; Eccles, 2009; Morahan-Martin & Schumacher, 2007), and attitudes towards technology (Harris et al., 2009; Lee & Huang, 2014; Young, 2000). These results are potentially the possible reasons why we can expect differences in performance between male and female students. The linkages between perceptions, beliefs, self-efficacy, and other social psychological factors and actions and performance are well-established in research. Beliefs and perceptions, confidence, and self-efficacy levels influence the actions and the actual behavior or, in the context of this study, performance in a given STEM-IS course (Ajzen, 2005; Fishbein & Ajzen, 1975, 2010). Even though both genders have similar abilities, different gender-based external and social-psychological factors have a potential to impact the performance based on attitudes, self-efficacy beliefs, and confidence levels. Recent studies indicate that such differences in gender exist based on perceptions, self-efficacy as well as performance at least at the secondary education level (McPherson & Park, 2021). Therefore, it is reasonable to expect differences in performance based on gender. To explore and resolve the differences in gender-based performance in STEM-IS courses, drawing from the past results in research, this study hypothesizes that there are differences in performance of male and female students in information systems courses.

4.1 Hypothesis Based on Gender

H1) Gender: There will be a significant difference in male and female student performance in STEM-IS courses.

In the context of STEM-IS courses, recent research indicates that the differences in performances of students occurs because of a combination of factors such as: medium of instruction (face to face vs. online), gender, as well as level of education (whether graduate or undergraduate) (Paravastu & Ramanujan, 2024). The Paravastu and Ramanujan (2024) study found that students' performance in information systems courses differed based on medium of instruction during the pre-pandemic and post-pandemic (COVID19) period. The study's deeper analysis showed that students' performance in those pre-pandemic and post pandemic IS courses differed based on gender, level of courses – graduate or undergraduate, and the type of courses – conceptual or technical. Extending beyond differences in performance in medium of instruction, this study expects gender-based differences in student performance based on type of course (conceptual or technical) and level of course (graduate or undergraduate). Extrapolating those results beyond the context of the pandemic and applying the results from the past research to the context of the current study, this study hypothesizes that the gender-based differences in performances exist in course levels and course types as well.

The rationales for gender-based differences is as follows: Past research details the differences in the way gender-differences reflect in various aspects of technology: Women tend to learn technological skills from their cohorts–colleagues or friend–rather than through formal courses, while men tend to acquire their technology skills by practicing a hands-on approach to technology known as learning by doing (van Welsum & Montagnier, 2007). Past research found significant gender-based differences in level of proficiency in basic computer skill sets, with men being more skilled than women (Schumacher & Morahan-Martin, 2001; van Welsum & Montagnier, 2007). Men had a more positive attitude and higher self-efficacy towards technology and its usage than women (Broos, 2005; Jackson et al., 2001). Men and women differed even in the purpose of usage: men using the Internet for searching health related information, or for communication purposes rather than for playing online games or for downloading software (Jackson et al., 2001; van Welsum & Montagnier, 2007; Weiser, 2000). Women were more concerned with ease of use of the technology whereas men with the usefulness of the technology in their usage preferences (Venkatesh & Morris, 2000).

With several gender-based differences in perceptions, attitude, learning styles, and usage preferences towards technology, it is rational to expect that those gender-based differences extend to performance in technology-related STEM-IS courses as well. With the narrowing differences in the gender gap in the STEM courses, it will be interesting and important to understand the extent and directionality of those differences. Like the differences in performance found in Paravastu and Ramanujan (2024) in the context of medium of instruction, this study expects that the underlying gender-based differences in learning also apply to course levels and course types. This study also expects gender-based differences in course level together with course type as well.

4.2 Hypotheses Based on Course Type

H2a) There will be a significant difference in male and female students' performance in conceptual STEM-IS courses.

H2b) There will be a significant difference in male and female students' performance in technical STEM-IS courses.

4.3 Hypotheses Based on Course Level

H3a) There will be a significant difference in male and female students' performance in undergraduate level STEM-IS courses.

H3b) There will be a significant difference in male and female students' performance in graduate level STEM-IS courses.

It should be noted (refer to * in Table 1) that no hypotheses were proposed for gender-based differences by course level undergraduate conceptual STEM courses because the convenience sample did not contain any data related to undergraduate conceptual courses.

4.4 Hypotheses Based on Course Level and Course Type

H4a) There will be a significant difference in male and female students' performance in undergraduate level technical STEM-IS courses.

H4b) There will be a significant difference in male and female students' performance in graduate level technical STEM-IS courses.

It should be noted (refer to ** in Table 1) that no separate hypothesis was proposed for graduate or undergraduate or level conceptual courses as well because the convenience sample did not contain any data related to undergraduate level conceptual courses. All the data related to conceptual courses were from the graduate level courses which are covered by H2a.

A summary of hypotheses is presented in Table 1.

5. METHODOLOGY

5.1 Data Collection

Data used in this study were from a convenience sample of students enrolled in Information Systems courses in a midsized university in the Midwest United States. The data were collected over a period of 9 years from Fall 2014 through Summer 2023. The courses included both master's and baccalaureate level, technical and conceptual courses. All the courses were part of programs classified as STEM (Science, Technology, Engineering, and Math) programs. A total of 94 courses were included in the analysis. These courses were taught by a single instructor from Fall of 2014 through Summer 2023. Data for all students enrolled in these classes taught by this instructor were included in the analysis and no data were excluded, facilitating uniform and consistent grading and reporting. There were 2,189 students in all courses from Fall 2014 through Summer 2023. Of the students, 808 (36.91%) were female and 1381 (63.09%) were male. Most of the students were graduate students. While this study did not have access to data about student ethnicity, most of the graduate students were international students. Most of the undergraduate students were US citizens.

Summary of Hypotheses
1. Gender
H1: There will be a significant difference in male and female student performance in STEM-IS courses.
2. Gender-based differences by Course Type
Conceptual STEM-IS Courses
H2a: There will be a significant difference in male and female students' performance in conceptual STEM-IS courses.
Technical STEM-IS Courses
H2b: There will be a significant difference in male and female students' performance in technical STEM courses.
3. Gender-based differences by Course Level *:
Undergraduate level STEM-IS Courses
H3a: There will be a significant difference in male and female students' performance in undergraduate level STEM-IS courses.
Graduate level STEM-IS courses
H3b: There will be a significant difference in male and female students' performance in graduate level STEM-IS courses.
4. Gender-based differences by Course Level and Course Type**:
Undergraduate level technical STEM-IS courses
H4a: There will be a significant difference in male and female students' performance in undergraduate level technical STEM-IS courses.
Graduate level technical STEM courses
H4b: There will be a significant difference in male and female students' performance in graduate level technical STEM-IS courses.

Table 1. Summary of Hypotheses

The undergraduate level courses were: (1) Database Management and (2) Programming with C# courses. Both undergraduate courses were classified as technical or hands-on oriented courses. The graduate level courses were: (1) Management of Information Systems Security, (2) Project Management, (3) Software Engineering, (4) Legal Issues in Information Systems, (5) Advanced Applications Development Using C#, (6) Internet for the Enterprise (Web Development Using PHP and JavaScript), (7) Client-Side Programming Technologies and Frameworks for Web Development, (8) Mobile Applications Development Using Android and Kotlin, and (9) 5. Server-Side Internet Resources (Server-Side Programming With ASP.Net). The first four of these were classified as theory intensive or conceptual courses. The remaining five were all technical or hands-on oriented courses. In all, data from a total of seven technical courses consisting of 13 undergraduate and 63 graduate level sections, and four graduate level conceptual courses consisting of 21 sections were included in the analysis. There were no undergraduate level conceptual courses in analysis because of lack of availability of data for any conceptual level undergraduate level courses taught by this instructor. All seven technical courses involved considerable amounts of upper-level programming/scripting requiring the students to learn some form of syntax and to work hands-on labs involving application development. All the courses, conceptual and technical, had several grade components such as quizzes, homework, in-class labs (for technical courses), term papers (for conceptual courses), projects and exams in every section. Aggregate scores for all courses from all components were collected for all students. The student performance scores span for all semesters starting from Fall 2014 through Summer 2023. The details of the courses and number of students is shown in Table 2.

Data Characteristics

# of Courses	Courses					
	Conceptual		Technical		Total	
	#Courses	#Sections	#Courses	#Sections	#Courses	#Sections
Under-grad	0	0	2	13	2	13
Grad	4	21	5	63	9	84
Total	4	21	7	76	11	97

# of Students	Students								
	Conceptual			Technical			Total		
	Female	Male	Total	Female	Male	Total	Female	Male	Total
Under-grad	0	0	0	68	137	205	68	137	205
Grad	193	325	518	547	919	1466	740	1244	1984
Total	193	325	518	615	1056	1671	808	1381	2189

Courses Included		
	Conceptual	Technical
Under-grad	None (No hypotheses about Undergraduate conceptual courses are proposed in this study).	1. Database Management Systems 2. Advanced Applications Development Using C#
Grad	1. Management of Information Systems Security 2. Project Management 3. Software Engineering 4. Legal Issues in Information Systems	1. Advanced Applications Development Using C# 2. Internet for the Enterprise (Web Development Using PHP and JavaScript) 3. Client-Side Internet Resources (Client-Side Programming Technologies and Frameworks for Web Development) 4. Mobile Applications Development Using Android and Kotlin 5. Server-Side Internet Resources (Server-Side Programming With ASP.Net)

Table 2. Data Characteristics

5.2 Data Analysis and Results

This study hypothesized differences in mean performance of male students and female students in STEM-IS courses. Further, the study hypothesized that there will be gender-based differences in means of sub-classifications based on course type (gender-based differences in technical or conceptual courses), course level (gender-based differences in graduate or undergraduate levels) and further based on both course type and course levels (gender-based differences in graduate level conceptual, graduate level technical, and undergraduate technical courses). This study did not propose hypotheses for gender-based differences by course level – undergraduate conceptual STEM-IS courses because there was no data available in the convenience sample for undergraduate conceptual courses. No hypothesis was proposed for graduate level conceptual courses as well because there were no undergraduate level conceptual courses: graduate level conceptual courses are the same as H2a – all conceptual courses in the sample.

All the data were entered into SPSS. The data for all courses from Fall 2014 through Summer 2023 were split into two groups based on gender: male and female. A test of ANOVA was conducted on the two groups to find out if there was a significant difference in means between the two gender groups in all classes. ANOVA requires the following assumptions about the data: 1) The sample is drawn from a normally distributed population; 2) the variances of the populations represented by the samples are equal; and 3) the observations in each group are independent and random (Fein et al., 2022). The data were tested for any problems with the assumptions of ANOVA. QQ plots of the data were examined for violations of normality, and the data were normally distributed. The tests of homogeneity of variance conducted on the data did not reveal any problems with assumptions about variances. The observations being individual student data were indeed independent and random. The null hypothesis was that there was no difference in means between the performance of male students and that of female students. The alternate was that the means were significantly different across the groups. The results from the analysis are presented next.

All the hypotheses were supported. Across all the hypotheses, the performance of female students overall, as well as in the sub-classifications was better than that of the male students.

5.3 Hypothesis About Gender

H1: Gender. H1 was supported. There was a significant difference in the means of performance of male students and female students in STEM-IS courses. Female students (n= 808, mean = 82.1588, std. = 11.4672) performed better than male students (n = 1381, mean = 78.5969, std = 14.2123) in STEM courses (F = 36.748 with 1 df, $p < 0.001$). Measure of association Eta Squared ($\eta2$) was 0.01 for ratio of variance explained by gender in student performance in all STEM courses after controlling for other predictors indicating a small effect size.

5.4 Hypotheses About Course Type

H2a: Gender * conceptual STEM-IS courses. H2a was supported. There was a significant difference in the means of performance of male students and female students in conceptual STEM-IS courses. Female students (n = 193, mean = 82.9301, std. = 11.0477) performed better than male students (n = 325, mean = 80.75, std = 10.91) in STEM-IS courses (F = 4.786 with 1 df, p = 0.029). Measure of association Eta Squared ($\eta2$) was 0.009 for ratio of variance explained by gender in student performance in technical STEM-IS courses after controlling for other predictors indicating a small effect size.

H2b: Gender * technical STEM-IS courses. H2b was supported. There was a significant difference in the means of performance of male students and female students in technical STEM-IS courses. Female students (n = 615, mean = 81.9167, std. = 11.5939) performed better than male students (n = 1056, mean = 77.9339, std = 15.02) in STEM-IS courses (F = 32.078 with 1 df, $p < 0.001$). Measure of association Eta Squared ($\eta2$) was 0.02 for ratio of variance explained by gender in student performance in technical STEM-IS courses after controlling for other predictors indicating a small effect size.

5.5 Hypotheses About Course Level

H3a: Gender * undergraduate level STEM-IS courses. H3a was supported. There was a significant difference in the means of performance of male students and female students in undergraduate level STEM-IS courses. Female students (n = 68, mean = 82.3186, std. = 12.2133) performed better than male students (n = 137, mean = 74.8525, std = 17.30) in STEM-IS courses (F = 10.148 with 1 df, p = 0.002). Measure of association Eta Squared ($\eta2$) was 0.048 for ratio of variance explained by gender in student performance in graduate level STEM-IS courses after controlling for other predictors indicating a small effect size.

H3b: Gender * graduate level STEM-IS courses. H3b was supported. There was a significant difference in the means of performance of male students and female students in graduate level STEM-IS courses. Female students (n = 740, mean = 82.1441, std. = 11.4049) performed better than male students (n = 1244, mean = 79.0093, std = 13.7771) in STEM-IS courses (F = 27.215 with 1 df, $p < 0.001$). Measure of association Eta Squared ($\eta2$) was 0.02 for ratio of variance explained by gender in student performance in graduate level STEM-IS courses after controlling for other predictors indicating a small effect size.

5.6 Hypotheses About Course Type and Course Level

H4a: Gender * Undergraduate level technical STEM-IS Courses. H4a was supported. There was a significant difference in the means of performance of male students and female students in undergraduate level technical STEM-IS courses. Female students (n = 68, mean = 82.3186, std. = 12.2133) performed better than male students (n = 137, mean = 74.8525, std = 17.2953) in STEM courses (F = 10.148 with 1 df, p = 0.002). Measure of association Eta Squared ($\eta2$) was 0.05 for ratio of variance explained by gender in student performance in undergraduate level technical STEM-IS courses after controlling for other predictors indicating a small effect size.

H4b: Gender * graduate level technical STEM-IS courses. H4b was supported. There was a significant difference in the means of performance of male students and female students in graduate level technical STEM-IS courses. Female students (n = 547, mean = 81.8667, std. = 11.5253) performed better than male students (n = 919, mean = 78.3932, std = 14.6140) in STEM-IS courses (F = 22.55 with 1 df, $p < 0.001$). Measure of association Eta Squared ($\eta2$) was 0.02 for ratio of variance explained by gender in student performance in graduate level technical STEM-IS courses after controlling for other predictors indicating a small effect size.

A summary of the results for each hypothesis is presented in Table 3. The mean plots for each hypothesis are presented in the Appendix.

The results indicate that female students in STEM-IS courses performed better overall than the male students and for all the sub-classifications of the sample such as gender-based differences by course type (technical vs. conceptual) and by course level (graduate and in technical undergraduate courses). This could potentially point to the fact that the impressions that female students underperform in STEM-IS courses are just stereotypical anecdotes. The reality, at least in the current sample, is that the female students performed just as well or better than the male students in the STEM-IS courses. This study did not test for gender-based differences for undergraduate conceptual courses for lack of data regarding those courses in the convenience sample.

Results								
		Descriptives			ANOVA			Effect Size
		N	Mean	Std. Dev	df	F	Sig.	Point Est.
1. Gender								
H1: Gender	Female	808	82.1587	11.4672	1	36.748	<.001	0.017
	Male	1381	78.5970	14.2123				
2. Gender-based differences by Course Type:								
H2a: Conceptual STEM Courses	Female	193	82.9301	11.0477	1	4.786	0.029	0.009
	Male	325	80.7514	10.9064				
H2b: Technical STEM Courses	Female	615	81.9167	11.5939	1	32.078	<.001	0.019
	Male	1056	77.9339	15.0271				
3. Gender-based differences by Course Level								
H3a: Undergraduate level STEM courses	Female	68	82.3186	12.2133	1	10.148	0.002	0.048
	Male	137	74.8525	17.2952				
H3b: Graduate level STEM courses	Female	740	82.1441	11.4049	1	27.215	<.001	0.014
	Male	1244	79.0093	13.7771				
4. Gender-based differences by Course Level and Course Type								
H4a: Undergraduate level technical STEM	Female	68	82.3186	12.2133	1	10.148	0.002	0.048
	Male	137	74.8525	17.2952				
H4b: Graduate level technical STEM courses	Female	547	81.8667	11.5253	1	22.55	<.001	0.015
	Male	919	78.3932	14.6141				
Notes: No hypotheses were proposed for gender-based differences by course level – undergraduate conceptual STEM courses because the convenience sample did not have any data related to undergraduate conceptual courses. No hypothesis was proposed for graduate level conceptual courses as well because there were no undergraduate level conceptual courses, graduate level conceptual courses are the same as H2a – all conceptual courses in the sample.								

Table 3. Results

6. *POST HOC* ANALYSIS

Structured interviews were conducted with both current faculty and current and past students in STEM-IS courses to corroborate the results obtained. A total of 35 students enrolled in STEM-IS courses either currently or in the past and four faculty who currently teach or have taught STEM courses were interviewed for their impressions about the impact of gender and student performance in IS courses. Of the 35 students, 19 (54.29%) students were female and 16 (45.71%) were male. The student subjects were chosen at random for interviews. The faculty members interviewed volunteered to provide information. Questions on the interview were designed to elicit responses about the following common themes for both faculty and students: number of students in STEM-IS courses by gender, information about time management and student effort in STEM-IS courses, and student performance. These themes were chosen because time management and student effort are probably the most reflective and contributory to a student performance in any given course including STEM-IS courses. In addition, the students were asked why they chose to take the STEM-designated IS programs.

The faculty interviewed observe that typically they see more male students enrolled in STEM-IS courses. The faculty in general were neutral about gender performance in STEM-IS courses. However, when it comes to the question of time management at least two of the four faculty interviewed expressed that female students tend to manage their time better and were well organized. This is an important observation because in STEM-IS courses, which are often intense and involve several hours of study, time management is an important skill which can impact student performance. Presented below are excerpts from faculty interviews on time management.

"*I have no way to verify this, but female students seem to be more organized and seem to complete their work on time*."

"*I believe that female students manage their time better than males. After assessments, when I talk to students individually to learn how they have done and what could be improved on their side, many male students report that they ran out of time to study, or they did not give enough time to prepare for the test and then they were confused during the exam because they could not prepare well. I do not come across such comments from the female students. I believe female students tend to be better at multitasking and they manage their time well*."

On the theme of hard work in STEM courses, one faculty reported that the female students tend to work harder to overcome their perception that they may not be as good as the male students. This is in line with several results from past studies about the confidence levels and self-efficacy aspects of female students (Beyer et al., 2004; Beyer et al., 2003; Singh et al., 2007). An excerpt from the interview reads: "*Female students tend to work harder. This is because female students try to overcome the perception that they are not naturally good at the STEM courses*." The results from the structured interviews are presented in Table 5.

Interviews with students uncovered several interesting details that corroborate and strengthen the results obtained in this study. An overall summary of all the interviews can be distilled as follows: (a) Almost all of the students, males and females, enrolled in a STEM-IS major because of their deep interest in problem solving skills, cognitive stimuli provided in the STEM disciplines, as well as a promising prospect of a future career advancement after completion of the program. (b) Male students often had prior experience and wanted to extend and enrich their career and growth prospects. (c) A majority of male and female students had a perception that male students performed better in STEM-IS courses. (d) There was a broad consensus among the students as well as faculty that the female students came across as better in time-management and as being organized. (e) Almost all responses indicated that they expect to find a greater number of male students in STEM-IS courses than female students.

However, when it came to number of hours spent in study, female students reported that they spent more time studying in general and spent more time on the STEM-IS courses than male students. Female students spent an average of 9 hours on their coursework per week, and 4 hours were dedicated to the STEM-

IS courses. Male students spent an average of 4 hours for study, and 2 hours for STEM-IS coursework.

Results of Structured Interviews - Students						
	Number of respondents		Average hours spent for Studies		Average study hours spent for STEM courses	
	Number	Percent				
Female	19	54.29	14.97		5.75	
Males	16	45.71	12.53		5.14	
All	35	100.00	13.82		5.47	
Which gender do you think are you likely to find more in STEM classes?						
	More females		More males		Neutral/Equal Numbers	
	Number	Percent	Number	Percent	Number	Percent
Female respondents	1	5.26	10	52.63	8	42.11
Male respondents	0	0.00	10	62.50	6	37.50
All	1	2.86	20	57.14	14	40.00
Time Management						
	Females are better at Time Management		Males are better at Time Management		Both are equally good/no opinion	
	Number	Percent	Number	Percent	Number	Percent
Female respondents	7	36.84	5	26.32	7	36.84
Male respondents	6	37.50	3	18.75	7	43.75
All	13	37.14	8	22.86	14	40.00
Who among male or female students are likely to work harder in STEM courses?						
	Females work harder		Males work harder		Both/Neutral	
	Number	Percent	Number	Percent	Number	Percent
Female respondents	1	5.26	6	31.58	12	63.16
Male respondents	4	25.00	3	18.75	9	56.25
All	5	14.29	9	25.71	21	60.00
Who among male or female students are likely to perform better in STEM courses?						
	Female students perform better		Male students perform better		Both/Neutral	
	Number	Percent	Number	Percent	Number	Percent
Female respondents	0	0.00	6	31.58	13	68.42
Male respondents	2	12.50	5	31.25	9	56.25
All	2	5.71	11	31.43	22	62.86

Table 4. Results of Structured Interviews (Students)

Both genders interviewed knew that STEM-IS has been a male dominated discipline, and the trend has been changing to accommodate more and more female students in IS discipline as well as in the workforce. Twenty of the 35 students (57.14%) mentioned they are likely to find more males than females as their STEM-IS classmates. A break-down of the above number is as follows: only 1 out of 19 female respondents (5.26%) felt there are likely to be more female students in STEM-IS courses, while 10 out of the 16 male respondents (62.50%) indicated it is likely there will be more male students than females in STEM-IS courses. 40% of the respondents of both genders felt that the numbers of male and female students in STEM-IS courses are likely equal. The responses reinforce the perception of dominant male presence in STEM-IS majors. Almost all the 35 respondents acknowledged the rapid change in the trend of gender representation in STEM-IS courses and the narrowing gender gap in STEM courses.

Most of the students interviewed felt that females manage time better. Thirteen out of 35 students (37.14%) felt that the females managed their time better and were better at multitasking, whereas only 8 students out of 35 (22.86%) felt that males were better at time management and multitasking. Fourteen students out of the 35 (40%) were neutral about either gender being better at time management, or did not have an opinion. When the neutral responses were excluded from the analysis, the number becomes even more interesting: 61.9% of the respondents of both genders felt that the female students are better in time management than their male counterparts. Time management, coupled with more hours spent on studying could be an important reason females showed a better performance in STEM-IS courses than the male students.

A few excerpts from the interviews about time management are as follows:

"*I think that female students are better at managing their time. Female students have experience multi-tasking and they manage time better than most male students. Most women handle their home, work, and personal lives*."

"*I feel like male students manage their time better based on my experience. For example, I have seen female students (not everyone but mostly) start their tasks/assignments as soon as they as assigned whereas male students often start their tasks as the deadline approaches and finish them within the time frame*."

"*Female students manage time better than males. [More males] spend their time doing some extracurricular activities such as playing games, attend parties than females*."

"*Women are efficient multitaskers. They manage their time well to balance both personal and professional life*."

"*Female students manage their time better, as they are more organized and disciplined than male students. Because women are good at planning, scheduling, and multi-tasking in general*."

"*I think female students are better at time management because they take tasks seriously*."

The interviewers asked the students about their perceptions of which gender works harder and which gender performs better in the STEM-IS courses. A majority of 21 out of 35 students (60%) felt that both genders work equally hard on the courses and 22 out of 35 students (62.86%) felt that both genders perform equally well in STEM-IS courses indicating a neutrality of opinion. However, when the neutral responses were excluded from the analysis, 64.27% indicated that the males work harder and 84.62% indicated that they felt males perform better than females in the STEM-IS courses. One of the students interviewed mentioned: "*Male students perform better because they spend more time with tech and like to experiment more rather than take an existing solution*." Both genders had a perception that males are smarter in technology related areas and therefore spend less time and effort in those courses. This aligns from findings in research about the STEM stereotypes and perceptions that the male students perform better than female students in the computing disciplines (Frieze & Quesenberry, 2019).

Overall, the interviews lend support to the statistical results that female students perform better in the STEM-IS courses. The interviews in addition enlighten the reasons for better performance by female-students such as being better organized, being better at time management, being determined to succeed in the STEM-IS courses, and willing to put in the additional time and effort into those courses given that they enrolled in those courses out of passion for the IS courses. The interviews also indicate awareness about the decreasing gender-gap at least in the STEM-IS courses context tested in this study.

7. DISCUSSION

The important conclusions from the results of data analyses and the *post hoc* interviews are summarized as follows.

The past research indicated that most of the time gender-stereotype perceptions position the STEM disciplines as male-dominated disciplines. Male students are perceived as better and smarter with technology, experiment more with it, are more confident, and hold stereotypical perceptions that female students are not naturally good at STEM-designated disciplines (Beyer et al., 2005; Beyer et al., 2004; Beyer et al., 2003; Cohoon, 2002; Singh et al., 2007). Such perceptions and gender stereotypes have contributed to the notion that those factors represent the actual abilities of women or men in STEM-designated disciplines. These notions are identified as contributory reasons for underrepresentation of women in STEM-designated disciplines in general and technology heavy IS disciplines in particular. The results from study attempt to dispel these notions.

Considering the results of this study where women outperformed men overall as well as at the sub-classifications of graduate and undergraduate levels, and in the conceptual and technical courses, the following conclusions can be made in respect of women in the STEM-IS courses.

Women match or outperform men in terms of their abilities. However, the perceptions about women's reported lower self-efficacy in the STEM disciplines, perceptions about themselves as inferior to men in technology usage and STEM-designated programs seem to act an important motivator for female students to work hard and to succeed in what is perceived as a male dominated discipline (Bjorkman et al., 1998). It is likely that female students put in more effort in IS courses to overcome their apprehensions and succeed in the STEM-IS courses that they enrolled themselves in. The *post hoc* interviews conducted in this study also seem to indicate the same. Several the students as well as the faculty seemed to suggest in the *post hoc* interviews that women seem to outperform their male counterparts academically.

The results from the data analysis and interviews also reveal that the female students choose to enter the STEM-IS disciplines on their own volition and a deep determination to succeed. Therefore, it is likely that female students spend more time on their studies, are more organized, and manage their time better than the male students. The interviews seem to allude to females being better in time management and multitasking. This is an important factor behind the female students performing better than the male students in STEM-IS courses considering that the STEM-IS disciplines require a significant effort to be successful.

Counterintuitively, it seems that women's under-estimation of their self-efficacy and perceptions about their technology-usage or abilities in STEM-designated disciplines works to their advantage; the women students seem to sustain more effort and focus, keep their distractions to a minimum and seem more determined than men to be successful. Therefore, females perform better than the male students, come across as better managers of their time, and put in the required effort.

Other non-STEM related research also indicates that women have multifaceted abilities in other areas such as communication (Chan, 2022; Miller & Halpern, 2014; Wang et al., 2013). The breadth of abilities in multiple areas including STEM as well as non-STEM-designated disciplines affords women a wider choice of career areas and major choices. The results reaffirm results from prior research that women happen to choose the areas that are close to their personal and situational preferences. To encourage more women in STEM-IS majors and careers, it is critical to highlight that women match or outperform men in these disciplines. This study is one step in that direction.

8. LIMITATIONS AND DIRECTIONS FOR FUTURE RESEARCH

This study is a correlational study and does not claim causality of the results. The sample was a convenience sample of graduate and undergraduate students from a university in the midwestern United States. The courses were taught by a single instructor across all the STEM-IS courses, with a large sample size of 2,189 students, both graduate and undergraduate. The generalizations of findings may be problematic, unless tested across multiple universities and across courses taught by multiple instructors. The data spanning 9 years from information systems courses consistently taught and evaluated by a single instructor removes the disparities in assessment and adds to the reliability of the data, which is the strength of the study. The study also goes one step further in validating the results by conducting *post hoc* interviews with several faculty members and students to verify the results obtained from the data sample.

Although gender is a non-binary construct (van Anders, 2015), this study was limited to gender as a binary. Analysis of gender as a non-binary construct, as interesting as that may be, was not feasible with this convenience sample since the gender were coded as male or female.

Future research could replicate and test for gender-based performance differences with different samples from across multiple geographical regions and from across universities over multiple courses, taught by multiple instructors. This could provide a better understanding of the current state of gender in STEM-designated courses. Such research could potentially provide deeper understanding of other related research topics like the "leaky pipeline" issues, and the gender biases, perceptions, and stereotypes in STEM-IS courses.

9. IMPLICATIONS AND CONCLUSION

This study measured gender-based differences in performance of 2,189 male and female students in STEM-IS courses offered at both graduate and undergraduate levels from data spanning 9 years from 94 courses. Further, this study examined the gender-based differences in performance based on course type and course levels. The results revealed that, in the sample examined, female students' mean performance overall, as well as in technical and conceptual courses, graduate and undergraduate level courses, significantly exceeded that of male students. These findings have important implications. The results of the study align with the trends reported in the current research (e.g., Frieze & Quesenberry, 2019; O'Dea et al., 2018) and extend the body of knowledge in gender gaps in STEM-IS courses. This study reaffirms the findings of earlier studies (Beyer et al., 2004; Beyer et al., 2003) that, in terms of overall performance as well as a spectrum of sub-classifications, female students perform better than male students. This study extends and updates the finding that female students match or outperform male students.

There is a large body of research that provides insights into the reasons for women's underrepresentation in STEM disciplines and information systems disciplines (Beyer, 2008; Cohoon, 2001; Frieze & Quesenberry, 2019; Weinberger, 2004). This study builds on that literature by contributing new empirical evidence through the measurement of student performance in STEM-IS courses. This could contribute to improving the representation of women in STEM disciplines and reducing the gender gap. The results help identify and highlight the strengths of female students in STEM-IS courses – especially their abilities for problem-solving and time management, which can be a huge advantage in STEM-IS courses. One of the most significant implications of this study is that the insights gained could be used to encourage more female students to pursue STEM-designated disciplines in both educational settings and the workplace.

The *post hoc* interviews and results from this study supported the findings in the literature that the gender gap is reducing. There are also strong indications of increasing awareness about this reduction. The following practical implications could be drawn from the results of this study. Instructors of STEM-IS courses should make conscious efforts toward creating an inclusive learning environment that fosters a welcoming learning experience ensuring success for all students, regardless of gender. Students, irrespective of gender, should realize that study habits, determination to succeed, willingness to learn, and setting priorities and goals are the keys to success.

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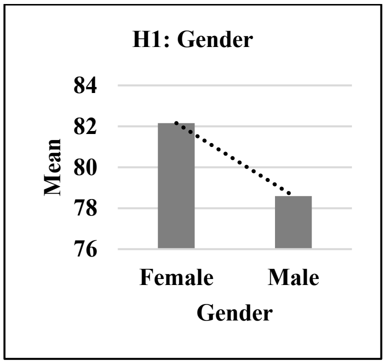
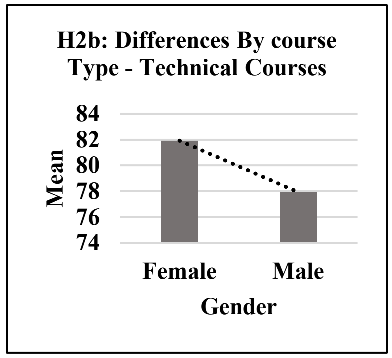
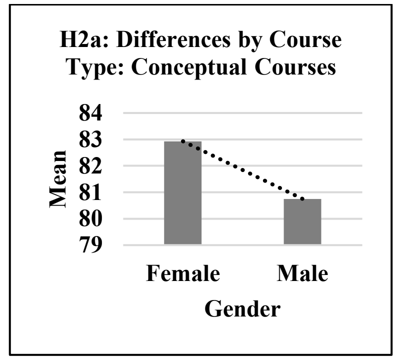
APPENDIX

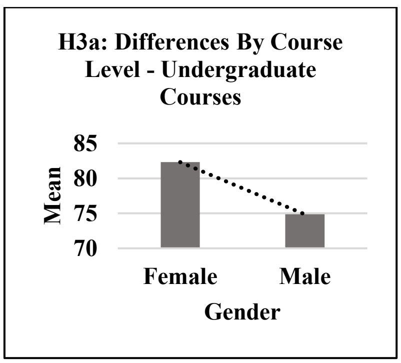
Mean Plots

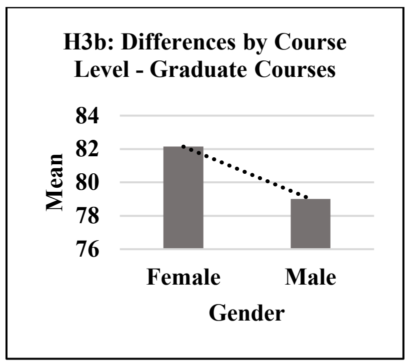
Mean Plots

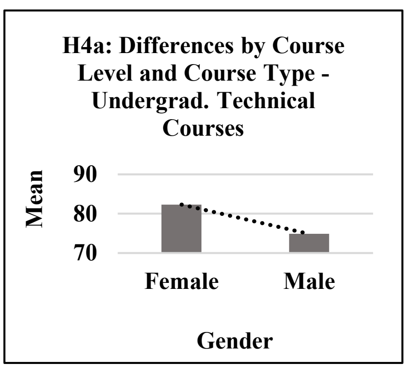


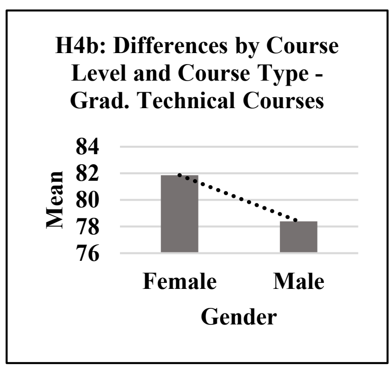












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