Explaining Academic Success in Engineering Degree Programs: Do Female and Male Students Differ?

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Abstract

Background In Dutch engineering education, female students outperform male students. Using an interactionalist framework, this study explores factors that contribute to this gender-based difference.

Purpose This study aims to answer two questions: Do female and male students differ in background characteristics, engagement factors, and academic success? Are differences in the relationships among background characteristics, engagement factors, and academic success gender-specific?

Design/method Data on male and female engineering undergraduate students from five Dutch universities were subjected to linear structural modeling to compare potential gender differences in the relationships among the focal variables. Two structural models were considered.

Results Female students spent more time on independent study, reported more social integration, completed more credits, and were more likely to stay in engineering than were male students. Academic integration and intention to persist were important for completion of credits for both genders. Social integration was only important for men's academic success. Females seemed to benefit less from good preparation through active learning during secondary education, and the effect of a high grade point average on math was negative for females but positive for males.

Conclusions Interactionalist concepts can explain academic success, but the relationships among concepts vary by gender. Males' intentions to persist in engineering are an outcome of engagement processes during the first year, whereas females' intentions to persist in engineering are manifest at the start of the first year.

Keywords gender; engagement; persistence

Introduction

Female students in higher education programs today outperform male students, in both numbers and academic outcomes (Organisation for Economic Cooperation and Development

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[OECD], 2011; Shah & Burke, 1999; van den Berg & Hofman, 2005; Vogt, Hocevar, & Hagedorn, 2007). In science, technology, engineering, and mathematics (STEM) studies, where male students remain the majority, even as female students continue to face the challenges of being a minority group, they appear to be performing better than their male peers (National Center for Educational Statistics [NCES], 2000). In Australia, for example, female engineering students aged 18 to 20 years have a higher chance of degree program completion (between .60 and .70) than male students (between .50 and .60), and take 0.2 to 0.6 years less to finish an engineering degree program than males (Shah & Burke, 1999). Quantitative and qualitative developments in engineering degree programs in the Netherlands confirm such international trends (HBO-Raad, 2014; OECD, 2011; van den Berg & Hofman, 2005). Females in engineering degree programs are a growing minority, with a participation rate that increased from 13% to 15% between 1998 and 2005. In 2011, more than 18% of the first-year engineering students were female. Their performance: 77.3% of the females who started an engineering program in 2004 obtained a diploma in engineering after eight years, compared with 71.4% of those who started in 2000. Of the men who started in 2004, 68.7% obtained a diploma in engineering after eight years. This percentage is not an improvement compared with the 68.9% of those who started in 2000 (HBO-Raad, 2014). In 2007 to 2011, male engineering students were also more likely to leave after the first year of an engineering degree program (on average 34.0%) than female students (on average 28.4%).

Researchers have taken various standpoints to explain these academic outcomes and gender differences in engineering education (Fox, Sonnert, & Nikiforova, 2009; Min, Zhang, Long, Anderson, & Ohland, 2011). Studies focusing on individuals consider students' initial attitudes, abilities, behaviors, skills, and previous experiences as possible influences on student persistence and gender differences (e.g., Felder & Brent, 2005; Fox et al., 2009; Jones, Paretti, Hein, & Knott, 2010). Other studies (Amelink & Meszaros, 2011; Seymour & Hewitt, 1997) focus on the teaching environment, classroom interactions, and academic engagement as determinants of student performance and persistence. We propose instead an interactionalist approach (Astin, 1993; Tinto, 1993), which combines individual and institutional factors, to explain student success and retention in higher education. Together, these factors can determine students' completion of credits (i.e., credits earned) and decisions to stay in the program after one year (Braxton, Hirschy, & McClendon, 2004; Tinto, 1993). Figure 1 shows the predicted relationships in an interactionalist model between first-year students' characteristics, engagement factors during the first year, their intention to persist, and first-year academic success in terms of completion of credits and retention (i.e., the decision to stay and continue as a sophomore in engineering).

As shown in Figure 1, the model posits that students' engagement with a program is pivotal for their intention to persist, completion of credits, and the decision to stay in a program. Engagement develops through student interactions among peers and with faculty. In Tinto's (1993) theory, social and academic integration are central elements of engagement. Other aspects of engagement that are frequently linked with integration in interactionalist approaches are students' satisfaction and the time they invest in study activities. Intention to persist forms a vital link between engagement and academic success (e.g., Cabrera, Castañeda, Nora, & Hengstler, 1992). Intention to persist is distinguished, but not separate, from other engagement aspects in the figure. Background characteristics, such as level of preparation in secondary education, influence engagement and, directly or indirectly, students' decisions to stay.

Some relationships among the factors presented in Figure 1 may be gender-specific, though. For example, Griffith (2010) found that even though female students are relatively

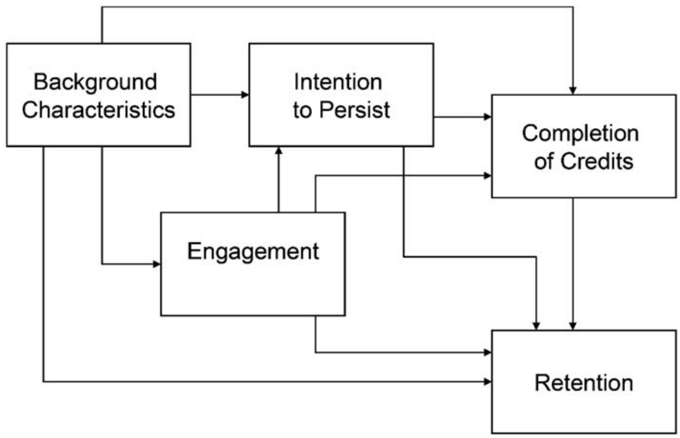

Figure 1 Conceptual model.

better prepared (i.e., that is, followed appropriate Advanced Placement courses to pursue an engineering major), they tend to switch to another major more often than do male students. In contrast, for male students the main driver of such switches is poor academic performance (Ohland et al., 2011). Female students become less persistent in their engineering degree programs (that is, they leave more frequently) when they experience lack of support, subtle discrimination, or experience exclusion by gender-specific treatment by teachers and male peers in engineering learning environments (Seymour & Hewitt, 1997). If, however, females receive encouragement through positive faculty interactions (feedback, respectful treatment) in the classroom and social activities (study groups), they are more likely to persist (Amelink & Meszaros, 2011; Hewitt & Seymour, 2006).

In engineering education in the Netherlands, innovations in the last decades attracted and retained more females in engineering programs (Hermanussen & Booy, 2002). Also, the recent changes in secondary education may have supported this trend (Tweede Fase Adviespunt, 2005). The academic climate in engineering programs is included in the interactionalist variables of academic and social integration (Tinto, 1993) that go into the model. The primary objective of this study was to determine whether the learning environment in engineering degree programs, in combination with some background factors, differently affects males' and females' intentions to persist, completion of credits, and retention.

Research Questions and Hypotheses

For this study, we took concepts from an interactionalist approach, such as Tinto's (1993) theory on student departure from college, to help explain the academic success of male and female engineering students. Because we recognized that the relationships among the concepts might differ according to gender (Braxton et al., 2004), we addressed two main research questions.

> **Research Question 1** What are the differences between first-year male and female engineering students with regard to their background characteristics, engagement, and academic success?

We expected female students' preparation for their post-secondary academic engineering program would not differ significantly from that of their male peers. First, they were in the same pipeline as male students during senior general secondary education or senior secondary vocational education and, thus, had a similar preparation in academic knowledge and skills and preparation through active learning (Hermanussen & Booy, 2002; Tweede Fase Adviespunt, 2005). Second, although male students generally perform better in subjects such as math, science, or chemistry at the end of secondary education, female students who choose engineering degree programs are atypical and perform better, and, therefore, we expected they would have an equal or even higher math ability compared with male students (Zhang, Carini, & Kuh, 2005). Also, we expected female students would have at least the same satisfaction level as male students when it comes to active learning and social integration, because they have been found to learn better in cooperative learning (NCES, 2000; Severiens & ten Dam, 1998). We expected they would also have at least the same levels of social and academic integration due to the focus on equal opportunity in higher engineering education in the Netherlands. Hermanussen and Booy (2002) argued that the changes in Dutch engineering education since the nineties, for example with regard to guidance, pedagogical approach, and content, increased the appeal of engineering education and retention rates for females through an improved academic climate and more positive student experiences in the learning environment. Furthermore, we expected female students would spend a larger amount of time on independent study than their male peers. We used this measure of time spent studying to measure student academic engagement. Research had suggested that female students are, on average, more independent learners than men (NCES, 2000), and therefore tend to study more on their own time outside class (Griffith, 2010). Finally, in line with recent research, we expected that female engineering students would outperform their male peers in the number of completed credits and their higher persistence rates. Hence, our first hypothesis:

> **H1** Female students (a) have the same level of preparation for engineering degree programs; (b) are just as satisfied with their academic knowledge, skills, and social and academic integration; (c) spend more time on independent study; and (d) perform better in terms of completion of credits and retention compared with their male counterparts.

Acceptance of H1a, b, and c would indicate that female students are at least equally fulfilling the conditions of preparation and engagement. Acceptance of H1d would indicate that females outperform males in engineering. Whether these factors are at work in the educational process, and do so in a gender-specific way, is the focus of the second question:

> **Research Question 2** Do gender-specific differences appear in the relationships among background characteristics, engagement factors, and academic success?

We had specific expectations with regard to five relationships. First, preparation through active learning is relatively more important for the success of female than male students; this expectation was in line with research that highlighted the importance of preparation during secondary education for success in higher education (Astin, 1997; Jansen & Suhre, 2010; NCES, 2000; Torenbeek, Jansen, & Hofman, 2010; Wolniak & Engberg, 2010). Second, this influence likely is partially caused by the extent of independent study (Geerdink, Bergen, & Dekkers, 2009; Griffith, 2010; Pascarella & Terenzini, 2005; Vogt et al., 2007). Third, academic integration, measured by good contacts with faculty, may be relatively more important for the completion of credits and persistence of female students (Amelink & Meszaros, 2011; Geerdink et al., 2009; Seymour & Hewitt, 1997; Vogt et al., 2007; Yorke, 2000). Fourth, since female students, being a minority in male-dominated engineering programs, seem to profit less from peer interaction in a male-dominated learning environment (Mastekaasa & Smeby, 2008; Zhang et al., 2005), the influence of social integration on completion of credits and persistence instead will be less for them than for male students. Finally, intention to persist is important for both genders (Astin 1993; Tinto, 1993). Hence our second hypothesis:

> **H2** When it comes to academic success, (a) preparation through active learning preparation is more significant for female than for male students, and (b) this effect is indirect through female students' level of independent study; (c) academic integration is more significant for female than for male students; but (d) social integration is more significant for male than for female students; and (e) intention to persist is equally important for the two groups.

These hypotheses are based on interactionalist and other studies that showed that active learning during secondary education results in good preparation and independent study behavior and, indirectly, influences academic integration. In the context of improved preparation and a warmed academic climate, these factors might be relevant, although they still may work differently for females and males. For example, social integration may continue to be an inhibiting factor for female academic success in male-dominated environments of engineering education. We did not hypothesize the possible influences of math GPA, type of secondary education, preparation in academic knowledge and skills, and satisfaction, because the literature is not conclusive about these factors. However, because they are relevant in the Dutch debate on academic success, we also examined the influence of these factors.

Method

Population and Sample

This study was made possible by a project in which five universities of applied sciences in the northeastern Netherlands are cooperating in monitoring freshmen who are enrolled in higher education for the first time, immediately after completing secondary education. The project started in 2003 and is still running. Three months after the start of the 2008–2009 academic year, we administered an online questionnaire to 1,157 first-year engineering students who were attending the five universities. These universities, with 68,000 students in 2008, fairly represented the population of more than 300,000 full-time students in Dutch universities of applied sciences with regard to prior education, gender, and age. We received completed responses from 353 engineering students (response rate = 30.5%). Regarding gender (290 male respondents [82%], 63 female respondents [18%]) and educational background (222 general secondary education [65%], 121 secondary vocational education [35%]), the sample was representative of engineering higher education students in the participating institutions and also nationally (83% males, 17% females; 59% general secondary education, 41% secondary vocational education; Kamphorst, Hofman, Jansen, & Terlouw, 2012). Later in this article we refer to the male respondents in this study as the male sample, and to the female respondents as the female sample.

In the context of this study, the engineering programs used forms of active learning. Different approaches, such as cooperative learning, project-based learning, or problem-based learning, may go under this name (Prince, 2004). The introduction of active learning methods to higher education aims to increase students' engagement, in terms of satisfaction with pedagogical methods, independent learning, and academic success (Astin, 1993; Griffith, 2010; Hermanussen & Booy, 2002; NCES, 2000; Prince, 2004).

Data Collection and Rationale for Variables

The online questionnaire consisted of four questions about background characteristics and seven questions about engagement in the first year. The academic success variables, i.e., completion of credits and retention, were collected from the students' university administrations.

Background characteristics The background questions included two one-item questions about prior education and math GPA in secondary education, and two multi-item questions about academic knowledge and skills and active learning during secondary education. Students' type of secondary education may influence their experience with and appreciation for pedagogical approach and course content, in terms of the knowledge and skills they gain in the first year, as well as their success in higher education overall. For example, van Bragt, Bakx, van der Sanden, and Croon (2007) reported that female students coming from general secondary education are more likely to be more successful in higher education. Math GPA was defined as the reported average score in math courses during the final year of secondary education. This variable offers a good predictor of both the decision to leave engineering degree programs at an early stage (Min et al., 2011; Moller-Wong & Eide, 1997) and completion of credits (van den Berg & Hofman, 2005).

We further distinguished between preparation through active learning and preparation in academic knowledge and skills (Hermanussen & Booy, 2002; Tweede Fase Adviespunt, 2005). The former is the degree to which students in their secondary education experienced forms of learning such as problem analysis, working in groups, cooperative learning, or reflecting on their learning process. The latter refers to the amount of time students spent during their secondary education on subjects that encouraged them to use subject area content, such as chemistry or math, and study skills in higher education. We believed good preparation through active learning and preparation in academic knowledge and skills would be relevant for success in the first year of engineering.

Students self-reported their degrees of preparation through active learning and academic knowledge and skills on two lists. The 14 items about preparation concerning academic knowledge and skills and active learning were rated on a five-point Likert scale, which ranged from 1 = "there was no time at all for this aspect during secondary education" to 5 = "there was very much time for this aspect during secondary education." A principal component analysis was conducted on the 14 preparation items. This analysis resulted in two factors with eigenvalues larger than 1. The first factor, "preparation through active learning," had substantial loadings on seven items and explained 26% of the variance. The second factor, "preparation in academic knowledge and skills," consisted of seven items and explained 19% of the variance. The factors, items, and factor loadings are presented in the rotated component matrix for the preparation scales (Appendix A). The reliabilities of the preparation scales were good, with Cronbach's alpha values of .84 and .76.

Engagement Engagement is a catchall term for the degree of students' involvement in a program (Astin, 1993). We measured time spent on study, satisfaction with active learning, satisfaction with academic knowledge and skills, integration, and intention to persist (Carroll, 1963; Chickering & Gamson, 1987; Pascarella & Terenzini, 2005). Time spent on study consists of scheduled contact hours, or the time students spend in classes in the presence of teachers, as well as independent study, or the time students spend on individual and group assignments, homework, and preparation for examinations, outside the presence of teachers. This dual measure of time spent on study is an important explanatory factor for academic success (Carroll, 1963), although several authors found more influence of independent study than of contact hours on completion of credits (Schmidt et al., 2010; Slavin, 1995; van den Berg & Hofman, 2005). Thus, the two questions about time spent on study were about the time invested in contact hours and independent study.

Respondents were also asked their opinion about active learning and academic knowledge and skills in the first year in 14 items and integration in seven items. For 14 items, respondents could indicate their satisfaction on a Likert scale that ranged from 1 = "very low" to 6 = "very high." We distinguished social integration, or contacts by students with other students, from academic integration, which refers to contacts of students with teachers (Tinto, 1993). We interpreted lower or higher levels of social and academic integration as indications of the presence or absence of a chilly academic climate in the students' first year of study. The specific items came from scales developed by Beekhoven, de Jong, and van Hout (2002). The Likert-like integration items could be rated from 1 = "very dissatisfied" to 5 = "very satisfied." We conducted principal component analysis with unweighted least squares and Varimax rotation on the 21 items concerning first-year experiences in terms of satisfaction and integration. Using as decision rules that eigenvalues had to be at least 1 and factor loadings had to be larger than .40 (items with factor loading less than or equal to .40 were discounted; Tabachnik & Fidell, 2007), four factors emerged, which jointly explained 58% of the total variance. Factor 1 explained 19% of the variance and showed substantial loadings on six items related to satisfaction with active learning. Factor 2 explained 16% of the variance, with substantial loadings on eight items formulated for satisfaction with academic knowledge and skills. Factor 3 explained 13% of the variance, with large enough loadings on four items to indicate the quality of contacts with peers. Factor 4 explained 10% of the variance, with loadings on three items related to academic integration. The rotated component matrix is presented in Appendix B. The reliabilities of the four scales were good, with Cronbach's alpha values between .87 and .73.

Finally, we included one question about intention to persist. Many interactionalist studies cite this factor or its equivalents as a significant predictor of academic success (Astin, 1993; Braxton et al., 2004; Cabrera et al., 1992). We defined "intention to persist" as a student's confirmation to choose the same program again if he or she were asked to do so. In our case intention to persist is related to the specific program a student is enrolled in, i.e., the engineering degree program. A straightforward "yes" means a student confirms his or her choice for the current program, and we regarded this as a proxy for a students' actual intention to stay in the same program.

A student's consideration to choose another program and/or institution *during* the first year, assuming that this is possible, indicates that he or she may be less motivated for the current program, is likely to complete fewer credits, and is unlikely to persist into the second year. In this study, 284 out of 342 respondents (83%) stated that they would choose the same specific engineering program. Of the 58 students (17%) who considered an alternative, one-third indicated they might choose another program within the same institution, one-third said they might choose a similar program at another institution, and one-third said they might do another program at another institution or leave the program to find a job.

Academic success We regarded completion of credits during the first year and retention, defined as continuation or persistence into the second year of the same program, as two indicators of academic success. Although strictly speaking, academic success involves more than completion of credits and retention (Pascarella & Terenzini, 2005), in prior interactionalist approaches, these two variables frequently served as indicators of success (Braxton et al., 2000; Tinto, 1993). After the end of the first year, after deadlines passed for students to fulfill the requirements for completion of the first year, the students' university administrations provided information on each student's number of credits and whether he or she stayed in the program.

Different from other colleges (e.g., those in North America), first-year bachelor's degree programs in the Netherlands do not have electives. The first-year engineering program consists of 20 courses, which carry a total of 60 credits, equal to an annual workload of 1,680 hours. A bachelor's degree in engineering is earned with 240 credits. Before any further analysis, we made these data anonymous.

Study Variables

We used 13 variables in this study, as shown in Table 1. The table shows that about two-thirds (63%) of the respondents entered their university after five years of senior general secondary education; this group averaged 17 years of age when they enrolled. The other one-third (37%) completed four years of junior secondary vocational education, followed by four years of senior secondary vocational education, and were about 20 years of age on entry. This group averaged a GPA of 6.91 (on a 10-point scale) for mathematics in the year before their entry into higher education engineering degree programs.

With regard to engagement, the students in our study spent an average of 20 hours in contact time and 13 hours on independent study each week. They largely expressed their satisfaction with active learning and academic knowledge and skills, with scores of 3.73 and 4.0 on the two scales, respectively. They were also satisfied with their levels of academic and social integration, with scores of 3.68 and 4.12, respectively, on the five-point scale. On average, students completed 47 credits in their first year, and 21% of the students left the program.

Analysis

To answer the first research question, concerning the differences between males and females with regard to background characteristics and engagement, we compared the mean scores provided by male and female students on all 13 variables and calculated Cohen's *d*. Effect sizes of 0.20 to 0.30 indicate small effects, about 0.5 indicate medium effects, and greater than 0.8 indicate large effects (Cohen, 1988). For the second research question, concerning causal relationships, we decided to use structural equation modeling (SEM). SEM helps researchers in developing a statistical causal model with multiple variables, analyzing hypothesized relationships, and determining whether these relationships are consistent with collected data. We used the software package LISREL 8.52 (Jöreskog & Sörbom, 1993). We first calculated the correlations and covariances. The covariance matrix served as input for the linear structural analysis. Then, following Bentler (1995) and Vogt et al. (2007), we developed two linear structural models separately, one for the male and one for the female sample. We defined paths in agreement with the hypothesized relationships. The initial structural models did not fit, but after a few adaptations, the two models fit the empirical data acceptably. We assessed the fit of the models using the following measures: chi square, standardized root-mean-square residuals, root-mean-square error of approximation, goodness-of-fit index, and standardized residuals (Jöreskog & Sörbom, 1993; Tabachnik & Fidell, 2007). A comparison of the fit indexes with their desired

Table 1 Study Variables

Variable	Description and response scales	Number of Items	Cronbach's alpha	*M*	*SD*
Background characteristics					
Secondary education	0 = general (senior general secondary education); 1 = vocational (senior secondary vocational education)	1	-	.63 .37	.48 .48
Math GPA[a]	1 = low; 10 = high	1	-	6.91	.97
Preparation through active learning	Degree of preparation through active learning during secondary education; 1 = low; 5 = high	6	.84	2.64	.68
Preparation of academic knowledge and skills	Degree of preparation of academic knowledge and skills during secondary education; 1 = low; 5 = high	8	.76	3.09	.55
Engagement process factors					
Contact hours	1 to 40 per week	1	-	19.75	8.87
Independent study hours	1 to 50 per week	1	-	12.67	7.62
Satisfaction with active learning	Satisfaction with education in the first year related to active learning skills; 1 = low; 6 = high	6	.87	3.77	.73
Satisfaction with academic knowledge and skills	Satisfaction with education in the first year related to academic knowledge and skills; 1 = low; 6 = high	8	.84	4.00	.57
Social integration	Satisfaction with contacts with other students in the program; 1 = low; 5 = high	4	.84	4.12	.60
Academic integration	Satisfaction with contacts with faculty and learning environment; 1 = low; 5 = high	3	.73	3.68	.76
Intention to persist	0 = no; 1 = yes	1	-	.17 .83	.38 .38
Academic success					
Credits[b]	1 to 69	1	-	47.03	15.3
Retention	0 = leave; 1 = stay	1	-	.21 .79	.41 .41

Notes. [a]In the Netherlands, marks are based on a 1-to-10 scale. A "6" is fair or (just below) average, best compared with B, B- or C in the American system. The equivalent of "7" (just above average) would be A- or B+, and "7.5" (good) or higher would be A-, A, or A+. Lower than "6" is poor, which means a student does not pass an exam. [b]One credit is equivalent to a study load of 28 hours.

cutoff values (Hu & Bentler, 1999; Jöreskog & Sörbom, 1993) indicated a good fit for both models (Table 2). Finally, we compared the relationships between the variables of the models for the male and the female samples. We reported *direct* effects, i.e., the significant ($p < .05$) structural path coefficients between pairs of variables, as well as *total* effects, i.e., the structural coefficients, which express the causal effect of independent or mediating variables on a dependent

Table 2 Fit Indexes for the Two Linear Structural Models

Fit indexes	Male model	Female model
Chi square (cutoff value $p > .05$)	46.84	35.97
p-value	.60	.97
Degrees of freedom	50	53
Root-mean-square error of approximation (cutoff value < .10).	.00	.00
Standardized root-mean-square residuals (cutoff value < .08)	.085	.075
Goodness-of-fit index (values between 0.9 and 1.0 indicate good fit)	.97	.91
Standardized residuals (cutoff values are between −2.58 and 2.58)	−1.55 to 2.33	−1.70 to 1.51

Note. The fit indexes indicated that the models for the male and the female sample fitted with the empirical data.

variable when controlled for other variables in the model. These path coefficients are standardized, similar to the standardized beta in regression analysis, and, thus, can have values between −1.0 and 1.0. It should be noted that the effect sizes indicated by these paths are different from the abovementioned Cohen's *d*. As a rule of thumb, we evaluated effects of approximately .10 as small effects; paths of .30 are medium effects; and paths of .50 or higher are large effects. In the presentation of the results in the following sections, we focus on the five hypothesized relationships (H2a–e) because they are crucial for attempts to attract and retain more female students in engineering.

Results

Means

With regard to our first research question, concerning the differences between males and females with regard to background characteristics and engagement, the results confirmed our hypothesis, which posited that female students would have the same or greater values as male students on the examined variables. In Table 3, however, there are three places where females differed from males.

Male students more frequently followed the senior secondary vocational education track into engineering. But the genders had the same math GPAs and had equal levels of preparation (effect size < 0.20). In terms of the engagement factors, the two groups had the same attendance in contact hours, satisfaction with active learning, satisfaction with academic knowledge and skills, level of academic integration, and intention to persist (effect size < 0.20). However, female students spent more time on independent study (medium effect size = 0.44), and had a higher level of social integration (small effect size = 0.22). Furthermore, female students were higher than their male counterparts in terms of credits and retention (medium effect sizes = 0.57 and 0.36).

Linear Structural Models

To address our second research question, concerning causal relationships, we first calculated the correlations and covariances among the 13 variables. The covariance matrixes were used as input for the linear structural analysis. The paths in Figures 2 (the model for the male

Table 3 Differences between Male and Female Students

Variables	Males	Females	*t*	*p*	Effect size[b]
Background characteristics					
Secondary vocational education (proportion)	.39	.27	1.847	.066	**0.26**
Math GPA	6.93	6.83	.748	.455	0.11[c]
Preparation through active learning skills	2.65	2.58	.720	.472	0.10[c]
Preparation of academic knowledge and skills	3.08	3.14	−.775	.439	0.12[c]
Engagement process factors					
Contact hours	19.90	19.08	.663	.508	0.10
Independent study hours	12.07	15.35	−3.243[a]	.002	**0.44**[e]
Satisfaction with active learning	3.78	3.71	.736	.462	0.10[d]
Satisfaction with academic knowledge and skills	3.99	4.06	−.876	.382	0.12[d]
Social integration	4.09	4.23	−1.550	.122	**0.22**[d]
Academic integration	3.66	3.74	−.831	.407	0.11[d]
Intention to persist (proportion 'yes')	0.83	0.84	−.129	.897	0.02
Academic success					
Credits completed	45.69	53.13	−4.959[a]	.000	**0.57**[f]
Retention	.77	.90	−3.006[a]	.017	**0.36**[f]

Notes: [a]Welch's *t*-test for unequal variances. [b]Effect sizes > 0.20 are in bold. Hypotheses: [c]H1a confirmed: females and males are equally well prepared; [d]H1b not confirmed: females and males are not equally satisfied; [e]H1c confirmed: females spend more time; [f]H1d confirmed: females perform better than males.

sample) and 3 (the model for the female sample) suggest that both background characteristics and engagement variables affected the completion of credits and retention. Several paths are present only in one or the other model.

A comparison of Figures 2 and 3 indicates six direct relationships that were similar across genders (in bold): preparation through active learning → time spent on independent study; preparation through active learning → satisfaction with active learning; preparation in academic knowledge and skills → satisfaction with academic knowledge and skills; social integration → academic integration; academic integration → number of completed credits; and completion number of credits → retention. In most respects, the comparison of Figures 2 and 3 confirms that these relationships varied with gender. The dotted lines show that 11 relationships were found only for males (Figure 2), whereas six relationships only applied for females (Figure 3). For example, math GPA and preparation through active learning negatively affected female students' number of completed credits and intention to persist in engineering, respectively; whereas math GPA had a direct positive effect on credits among male students, and active learning was not directly related to completion of credits. Tables 4 and 5 provide the total effects related to background characteristics (Table 4) and engagement variables (Table 5). In the presentation of the results in the following sections, we focus on the five hypothesized relationships (H2a–e) because they are crucial for attempts to attract and retain more female students in engineering.

Active learning and independent study In H2a we hypothesized that preparation would be more important for academic success of female than of male students. Contrary to this expectation, preparation through active learning had a negative influence on female students' completion of credits (total effect = −.26). For male students, a very small relationship between preparation through active learning and completion of credits was found. In contrast,

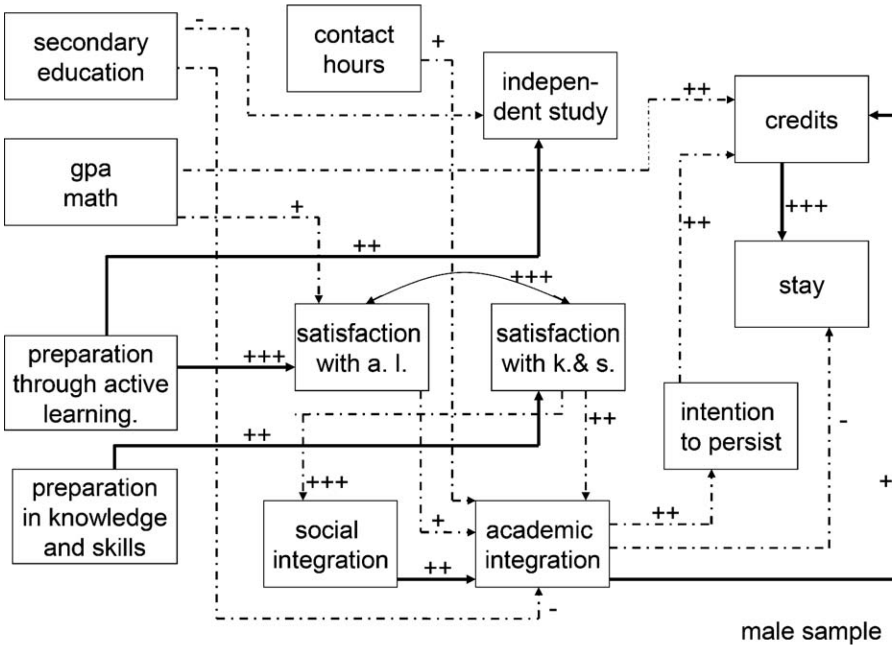

Figure 2 Significant paths for male students: – indicates a path with an effect size between –.10 and –.20; +, between .10 and .20; – –, between –.20 and –.30; ++, between .20 and .30; – – –, below –.30; +++, above .30. Curved ↔ = covariance between error terms. Paths in bold appear in both male and female models.

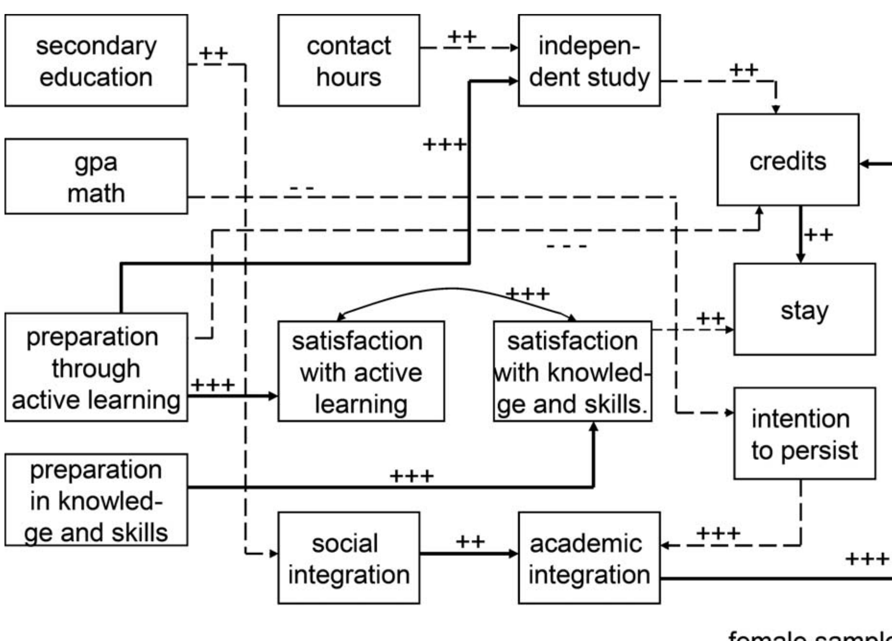

Figure 3 Significant paths for female students.

Table 4 Total Effects of Background Characteristics

	Secondary education		Math GPA		Preparation through active learning		Preparation of academic knowledge and skills	
	M	F	M	F	M	F	M	F
Engagement process factors								
Contact hours								
Independent study hours	–.18	–.06			.16	.31		
Satisfaction with active learning			.10		.36	.53		
Satisfaction with academic knowledge and skills							.27	.47
Social integration		.28					.09	
Academic integration	–.13	.06		–.16	.06		.08	
Intention to persist	–.03			–.27	.02		.02	
Academic success								
Credits	–.03	.01	.25	–.07	.02	–.26	.02	
Retention			.18	-.02		–.06		.13

preparation in academic knowledge and skills had a small positive effect on retention only for female students.

As hypothesized in H2b, we expected that this influence of preparation through active learning on academic success would be indirect, through students' participation in independent study. Table 4 shows that, more for female than male students, prior experience with active learning positively affected the time spent on independent study and satisfaction with active learning. Table 5 shows that independent study also affected the completion of credits by female students (effect = .26) but not the credits completed by male students. Thus, preparation through active learning positively indirectly influenced the female students' number of credits through independent learning (effect = .31 × .26 = .09). This positive effect partly compensates for the abovementioned negative direct effect of preparation through active learning.

Influence of academic integration We expected, as stated in H2c, that academic integration would be more significant for female than for male students. Table 5 shows that, for female students, academic integration affected the number of completed credits (effect = .44) and persistence (small effect = .10). For male students, we found smaller effects of academic integration on intention to persist in engineering (effect = .24), and on completion of credits (effect = .24).

Influence of social integration Our expectation, expressed in H2d, was that social integration would be more significant for academic success of male than for female students. Table 5 shows that the effect on female and male students' completed credits was similar (very small effects of .04 and .07). The effect on persistence was negligible for both groups (effect = .01). Figure 2 shows that the effect of social integration on completion of credits was indirect, through academic integration, for both groups. For female students, the social integration → academic integration effect was .22. Good contacts with peers apparently had a positive influence on the degree of academic integration. For male students, a higher degree of social integration also affected academic integration (effect = .29).

Table 5 Total Effects of Engagement Process Factors and Credits Completed

	Contact hours		Independent study hours		Satisfaction with active learning		Satisfaction with academic knowledge and skills		Social integration		Academic integration		Intention to persist		Completed credits	
	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F
Engagement process factors																
Contact hours																
Independent study hours		.25								−.22						
Satisfaction with active learning																
Satisfaction with academic knowledge and skills																
Social integration							.32									
Academic integration	.12				.18		.29		.29	.22				.58		
Intention to persist	.03	.07			.04		.07		.07		.24					
Academic success																
Completed credits	.03	.01		.26	.04		.07		.07	.04	.24	.44	.39	.25		
Retention				.06	.01		.01	.28	.01	.01	.04	.10	.21	.06	.73	.23

Note: Empty cell = no effect.

Influence of intention to persist We hypothesized, in H2e, that intention to persist would be equally important for both groups. Table 5 shows that the total effect of intention to persist in engineering among female students was .25 on completion of credits and .06 on retention. In contrast, male students showed larger effects of intention to persist on completion of credits and retention (effect = .39 and .21). There was another difference between female and male students relating to the position of intention to persist in the two models. Figure 2 shows that, for male students, intention to persist was preceded by social and academic integration and directly influenced academic success. The pattern for female students differed (Figure 3), because intention to persist *preceded* academic integration (effect = .58) and thus had an indirect instead of a direct influence on completion of credits and retention.

Intention to persist was important for both genders, though. An additional cross tabular analysis illustrated the significant relation of intention to persist with retention (chi square = 8, $df = 1$, $p = .003$). Twenty (35%) of the 58 students who said they might leave had in fact left the program after one year, twice as many than the 17% (49 of 284) who had the intention to persist but left the engineering program of their first choice after one year. In the model, females' intention to persist is not influenced by other variables from the study. An inference that could be made from this observation is that females' intention to persist has already been formed before or at the beginning of the first year.

Limitations

This study has several limitations. The self-reported data may be inaccurate, whether because respondents are subject to socially desirable response biases, respondents tend to perform better (the retention rate is comparatively high in the sample), or because respondents simply cannot recognize their degree of good preparation in their secondary education. A qualitative follow-up study could provide additional information about students' perceptions and the specific relationships found in the models. Furthermore, the results are from one country and one sample. Finally, a longitudinal design, with measurements during the final year of secondary education and then in the first year at university, might reveal the causal relationships more clearly than the cross-sectional design used in the present study.

Discussion

We started this article with the claim that, today, the development that females outperform males in higher education – and, more specifically, in engineering education – represents a shift from historical trends. According to interactionalist approaches (Astin, 1993; Tinto, 1993), individual factors, such as prior preparation and students' involvement in a program, together, influence student performance and persistence. This study aims to determine how these individual and environment-based key factors actually work in favor of females.

The results of the first research question suggest that females have the same math performance level as males and are equally well prepared with regard to active learning and academic knowledge and skills. In line with results from the literature (Hermanussen & Booy, 2002; NCES, 2000; Zhang et al., 2005), female engineering students had the same experiences as male students in terms of academic integration and satisfaction with active learning and academic knowledge and skills, and a slightly higher degree of social integration. That females spent even more time than males in independent learning is in agreement with previous studies (Griffith, 2010; NCES, 2000).

The focus of this study is the relationships among preparation, engagement, and academic success. The interactionalist model in Figure 1 has been useful for examining these relationships. In line with our hypotheses, Figures 2 and 3 show that for both genders, academic integration and intention to persist are relatively important determinants of completions of credits and retention. Furthermore, these models are similar regarding the influences of preparation through active learning and academic knowledge and skills on the two satisfaction variables and on time spent on independent study. The influence of social integration on academic integration also makes sense, because both forms of integration likely occur simultaneously and are related (Beekhoven et al., 2002). Furthermore, the influence of social integration on completion of credits and retention is the same for both genders.

Figures 2 and 3, and also Tables 4 and 5, show, however, that the patterns for females and males are quite distinct. The most striking differences pertain to the influence of active learning for females' academic success and the apparent different positioning of intention to persist in the two models. In contrast with our expectation, preparation through active learning has a negative effect on female students' completion of credits. Apparently, the influence of pedagogical innovations in secondary education was contrary to what was intended, namely, smoother transition into higher education. This result could arise because cooperative student projects in higher education, compared with those in secondary education, are organized more into small groups than into pairs. In these groups, female students remain a minority, and therefore may feel less confident than males. A faculty member at one of the engineering programs suggested this to us as a plausible explanation. Thus, being comparatively well prepared through active learning in secondary education is not a guarantee for completion of credits in engineering higher education. Another possibility, as suggested to us by a program manager, is that teachers in engineering (as well as in other disciplines in higher education) may be conservative and tend to over-organize the setting for active learning; doing so could have more discouraging and de-motivating effects on female students, who are more independent learners. However, the results of the present study should not be used as justification to eliminate active learning.

A second striking gender difference is the positioning of intention to persist in the two models. The male model suggests a causal chain from preparation and/or satisfaction, through integration, to intention to persist, to completion of credits and retention. In the female model, intention to persist is not affected by, but instead precedes, academic integration. This result aligns with findings that female students are more interested in a career in engineering and more likely to stay, once they have chosen engineering as their field of study (Jones et al., 2010; NCES, 2000; Vogt et al., 2007). Perhaps female students were more conscious of their choice for engineering and, therefore, more determined to stay in the program from the very beginning, whereas male students make up their minds during the first year. A qualitative, detailed approach or a longitudinal design with a larger sample of females, and inclusion of an "interest in an engineering career" variable, could add further support for this relatively early (among females) or late development (among males) of intention to persist.

Furthermore, we have identified low negative influences of math GPAs on females' intentions to persist, academic integration, and completion of credits. Could it be that females with a high math GPA are likely to be disappointed with the math level in the first year and do not feel challenged in this regard? In contrast, math GPA of males had a positive influence on completion of credits and retention. We also found that independent study affected the academic success only of females. It could be that independent study pays off more in completion of credits when it is above a certain minimum level, which is more often achieved by females than by males (see Table 3). However, explanations for these results remain hypothetical and need further research to be confirmed.

This study used concepts related to those in the National Survey of Student Engagement (NSSE; Harper & Quaye, 2009). The NSSE instrument is constructed around five benchmarks of effective educational practice. Although we did not explicitly use the NSSE instrument as a source, there are clear similarities with four of the five NSSE benchmarks (Harper & Quaye, 2009). The NSSE concepts of level of academic challenge and active and collaborative learning resemble our understanding of academic knowledge and skills and active learning. Likewise, the concepts of student–faculty interaction and enriching educational experiences have similarities with our operational definitions of academic integration and social integration. This study pays more attention than does the NSSE to preparation during secondary education and focuses on first-year experience. It could be interesting if this study and other Dutch or European approaches were compared more extensively with the NSSE.

Conclusion

Our first research question was, "What are the differences between male and female engineering students with regard to their background characteristics, engagement process factors, and academic success?" We expected females in the first year of an engineering degree program would have the same levels in preparation during secondary education through active learning and in academic knowledge and skills (H1a) and the same rates in engagement in terms of satisfaction with active learning, academic knowledge and skills, social integration, and academic integration (H1b); to spend more time on independent study (H1c); and to perform better in terms of completion of credits and retention (H1d). Three of the four hypotheses were largely confirmed. That is, females appeared to be equally well prepared with regard to math ability level, active learning, and academic knowledge and skills. Furthermore, females had the same levels of engagement with regard to time spent on contact hours, satisfaction with active learning and academic knowledge and skills, and academic integration. One part of H1b was not confirmed, because females even revealed a higher level of social integration. Female students also scored higher than male students on time spent studying on their own. Finally, once female students were eligible for and entered the first year of engineering, they performed better than males in terms of credits and reported being more likely to stay.

The second research question was, "Do gender-specific differences appear in the relationships among background characteristics, engagement factors, and academic success?" The conceptual model helped us express our expectations. On the basis of previous research, we expected to find gender-specific relationships. We rejected H2a, which stated that female students' preparation through active learning would have a positive influence on their academic success as measured by completion of credits and retention; rather, we found a negative influence on completion of credits (but not on retention), in contrast with prior research (Jansen & Suhre, 2010; NCES, 2000; Torenbeek, Jansen, & Hofman, 2010; Wolniak & Engberg, 2010).

In line with Amelink & Meszaros (2011) and Schmidt et al. (2010), we found support for H2b: Through time spent studying independently, preparation through active learning had a positive influence on females' completion of credits. This indirect effect, though, did not completely compensate for the negative effect of preparation through active learning on completion of credits. Compared with the effect on completion of credits, the effect of independent study on females' persistence in the engineering program was even smaller. In contrast, we found no effects of independent study on males' completion of credits or retention. Regarding the influence of academic integration on female students' success (Amelink & Meszaros, 2011; Geerdink et al., 2009; Hewitt & Seymour, 2006; Vogt et al., 2007; Yorke, 2000), our results supported H2c. Although academic integration affected completion of credits and retention among both male and female students, these effects were much stronger for females.

We expected that males might benefit more from social integration (H2d), but this hypothesis was not supported by the data. For both genders, social integration has a very modest effect on academic success; this result is not in line with Mastekaasa and Smeby (2008) and Zhang et al. (2005). Finally, we confirmed, consistent with the general interactionalist model, that the intention to persist was an important influence for males and females (H2e accepted). In other words, intention to persist is important in explaining completion of credits and retention of the two groups.

Practical Implications

This study adds to the evidence that interactionalist approaches help to explain differences in the academic success of engineering students. Females and males to some extent differ with regard to higher education experiences, intentions, and behavior. Their influences on academic success are different for the two genders. At the micro-level of teaching, two practical implications emerge as key for guaranteeing female academic success in engineering. The first is that maintaining an academic climate in which female students have interactions with faculty (academic integration), rather than interactions with peers, contributes to academic success. Second, educators should facilitate students' independent study behavior by offering extra classes in how to study, because independent study emerges as relatively important in our study. Encouraging independent study could be particularly significant for males, who on average spend less time studying on their own. At the same time, such a strategy could reinforce males' sense of academic integration.

At the meso- and macro-levels, it is important to create good links between general secondary as well as secondary vocational education and higher engineering education. Advisors in secondary and higher education need to recognize the factors that are important for students' future academic success in engineering. This need is most obvious in the influence of males' prior math GPAs and intention to persist on their completion of credits and retention. Advisors in engineering higher education can use this information when advising males who have a relatively low math GPA or who are hesitant about becoming an engineer (such hesitancy is not likely to result in an intention to persist) to encourage students to reconsider their choice of engineering or reinforce their choice of an engineering field of study. In contrast, for females, the influence of preparation in academic knowledge and skills matters most. Females with the appropriate knowledge and skills are more likely to stay, and therefore they should be advised to more actively consider engineering.

Regarding preparation through active learning, this study is somewhat ambiguous for educators at the secondary level and engineering educators. Preparation through active learning helps smooth students' transition from secondary into higher engineering education: it positively affects satisfaction with active learning. But it also negatively affects females' completion of credits and is not related to males' academic success through completion of credits or retention. Perhaps active learning simply takes different forms in secondary and higher engineering education. In that case, fine-tuning the forms of active learning at these two levels could make active learning an effective means for the success of both females and males in engineering.

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Appendix A

Factor Loadings for Principal Component Analysis with Varimax Rotation of Preparation Scales

Scales	Preparation through active learning	Preparation in academic knowledge and skills
Reflect on peers' ways of working	.817	
Reflect on ones learning process	.776	
Work in groups	.674	
Keep record of one's learning process	.663	
Work on larger assignments	.593	
Perform a problem analysis	.570	
Communication skills	.507	.423
Writing skills		.738
Information skills		.645
Knowledge of subject contents		.581
Study skills		.535
Presentation skills	.444	.520
Computer skills		.519
Independent study skills		.404

Appendix B

Factor Loadings for Principal Component Analysis with Varimax Rotation of Engagement Scales

Scales	Satisfaction with active learning	Satisfaction with academic knowledge and skills	Social integration	Academic integration
Reflect on peers' ways of working	.854			
Reflect on ones learning process	.806			
Perform a problem analysis	.725			
Keep record of ones learning process	.689			
Work in groups	.622			
Work on larger assignments	.613	.417		
Writing skills		.761		
Computer skills		.692		
Information skills		.674		
Presentation skills		.577		
Study skills		.566		
Communication skills	.468	.548		
Independent study		.479		
Transfer of subject contents		.427		
Making friends in this institution			.867	
Good contacts with other students			.834	
The type of students in this program			.807	
The contacts with peers in this program			.726	
Contacts with lecturers in this program				.819
The support of students in this program				.801
The way of working in this program during the first months				.684