GRADUATE STUDENT-ADVISOR RELATIONSHIP AND THE DEVELOPMENT OF EXCELLENCE IN STEM IN TOP STEM GRADUATE STUDENTS

By

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To my supportive family and friends

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CHAPTER I

INTRODUCTION

A strong and healthy Science-Technology-Engineering-Mathematics (STEM) workforce is essential in a world becoming increasingly more dominated by a knowledge based economy. Therefore, a nation's future prosperity will largely depend on how well it succeeds in cultivating its human capital, especially those individuals who have the potential to become leaders in STEM (Friedman, 2005; Domestic Policy Council, 2006; National Academy of Sciences, 2010). In top STEM graduate departments all over the world, a major objective is to have seasoned experts and leaders in STEM help develop skills and knowledge in promising novices, so they can become the future leaders of the STEM work force.

Previous studies have shown that individual differences between advisees do indeed matter in the development of excellence in STEM. Accomplishments in STEM, such as obtaining advanced degrees, making creative contributions (peer-reviewed publications, patents) and obtaining a tenure track position, have been associated with general intellectual ability (Ceci & Williams, 2010; Gibson & Light, 1967; Harmon, 1961; Kuncel, Hezlett, & Ones, 2004), specific abilities such as spatial and quantitative abilities (Austin & Hanisch, 1990; Gohm, Humphreys, & Yao, 1998; Humphreys & Lubinski, 1996; Humphreys, Lubinski, & Yao, 1993; Humphreys & Yao, 2002; Gottfredson, 1986, 2003; Smith, 1964; Super & Bachrach, 1957; Lubinski, 2010), vocational interests (Benbow & Minor, 1986; Hansen & Campbell, 1985; Savickas & Spokane, 1999; Strong, 1943), and motivation (Roe, 1951; Zuckerman, 1977; Ericsson, Krampe, & Tesch-Römer, 1993). In this study, the role that graduate advisors play, above and beyond the sex, abilities, interests, and motivation of the advisees themselves, will be evaluated.

Schlosser and Gelso (2001) define an advisor as "the faculty member who has the greatest responsibility for helping guide the advisee through the graduate program" (p.158). Other names commonly used to refer to the advisor are major professor, chair of the dissertation committee, committee chair, and dissertation chair. An advisor can contribute to developing STEM excellence in a myriad of ways. He/she can provide an advisee with coaching (e.g., help an advisee navigate effectively through the academic world, help structure their research projects), sponsorship (e.g., nominate an advisee for awards), increased exposure and visibility (e.g., by introducing an advisee to his/her professional network), challenging assignments (to help develop domain specific knowledge and skills), role modeling (model professional attitudes and behaviors), support and encouragement (e.g., timely positive feedback) (Kram, 1985; Green & Bauer, 1995; Williamson & Cable, 2003).

Although the advisor-advisee relationship has been hypothesized to be a crucial part of graduate education (Gelso, 1979, 1993), only few attempts have been made to measure the quality of this relationship (Noe, 1988; Hollingworth & Fassinger, 2002; Schlosser & Gelso, 2001; Crisp, 2009). Schlosser and Gelso (2001) were among the first to design a questionnaire, the Advisory Working Alliance Inventory (AWAI-S), specifically to assess the advisor-advisee relationship in graduate school from the advisee's perspective. It purports to measure the quality of the advisory working alliance, that is, "that portion of the relationship that reflects the connection between the advisor and advisee that is made during work towards a common goal" (Schlosser & Gelso, 2001, p.158). Previous studies have shown that the AWAI-S is positively associated with perceived expertness, attractiveness, and trustworthiness of the advisor, and the advisee's research self efficacy, research competence, interest in science and practice, satisfaction with advisor, grade point average and scholarly productivity (Schlosser & Gelso, 2001, 2005; Schlosser & Kahn, 2007; Rice et al., 2009; Kahn & Schlosser, 2010).

However, all of these studies show at least one of following limitations.

First, outcomes are mostly assessed by subjective, self-reported surveys, such as interest in science, research self-efficacy, satisfaction with advisory relationship, and self-reported scholarly activity. Studies using objective performance indicators are rare.

Second, most outcomes are short term (e.g., satisfaction in graduate school, GPA in graduate school). Although a good and productive experience in graduate school is valuable, it is important also to evaluate the long term effects of the quality of the advising relationship.

Finally, rarely do studies control for individual differences among graduate students, which are relatively stable at the beginning of graduate school. As stated earlier, there is a rich body of research showing that excellence in STEM is related to abilities, interests, and motivation. If advisees that are more able, interested, and motivated tend to have a better relationship with their advisor, one would expect a positive association between the quality of the advisory working alliance and advisee excellence in STEM, regardless of whether the AWAI-S adds value beyond these personal attributes in the prediction of STEM outcomes.

In this study, short and long term measures of genuine STEM outcomes will be utilized: earning a STEM PhD, securing a STEM tenure track faculty position at a university, securing a STEM tenure track faculty position at a research intensive university, and securing a STEM occupation involving leadership and responsibility commensurate with a STEM tenure track faculty position at a research intensive university. Moreover, to evaluate the value added by individual differences in the AWAI-S, abilities, interests, achievement motivation, and sex of the student assessed at the beginning of graduate school will be controlled. The central research question is: Does the quality of the graduate student-advisor working relationship as assessed by the AWAI-S add value to the prediction of these long term outcomes among top STEM graduate students, above and beyond individual differences in abilities, interests, need for achievement, and sex assessed at the beginning of graduate school?

CHAPTER II

METHODS

Participants

Participants were drawn from Cohort 5 of the Study of Mathematically Precocious Youth (SMPY; Lubinski & Benbow, 2006). They were selected and first surveyed in 1992 (time point 1; T1) as first- and second-year graduate students (n = 714, 48% females, 52% males; Lubinski, Benbow, Shea, Eftekhari-Sanjani, & Halvorson, 2001), attending US math/science departments ranked among the top 15 by Gourman (1989) and the National Research Council (1987). Women were oversampled to achieve approximately equal numbers of both sexes (Lubinski et al., 2001). Completing the T1 paper survey yielded $15 cash. They were surveyed again in 2003-2004 (n = 603, 48% females, 52% males; Lubinski, Benbow, Webb, & Bleske-Rechek, 2006), which will be referred to as T2. Completing the T2 web based survey yielded an Amazon gift card of $20. For this study, only participants indicating at T1 that they intended to obtain a PhD were included (n = 622). Five hundred thirty seven of them completed the survey at T2 (86%). Four other participants (2 males, 2 females) who ultimately earned a PhD, but initially at T1 did not indicate that they intended to do so, were also included. Of the resulting 537 participants, 38 completed less than 5 items of the AWAI-S and were omitted, resulting in a final sample of 499 participants (47% female, 53% male). At the time of the first survey, the mean age of the participants was 23.9 (SD = 1.74). Eighty-five percent of the participants were Caucasian, 1% were African American, 2% were Hispanic, 8% were Asian, and 4% did not provide their race.

Measures

Student characteristics.

The following student characteristics were measured or collected at T1.

Abilities. The quantitative and the verbal subtest of the Graduate Record Examination (GRE) were used to measure quantitative and verbal abilities. GRE scores were recorded from official score reports that participants included with their T1 survey. The quantitative subtest (M = 741, SD = 59) revealed a marked a ceiling effect, with 15% of the female students and 29% of the male students having a top possible score of 800.

Interests. The Strong (Harmon, Hansen, Borgen, & Hammer, 1994) measures 6 General Occupational Themes, based on Holland's (1985) RIASEC dimensions: Realistic (interest in working with things or working outdoors and need for structure), Investigative (interest in sciences, particularly mathematics and physical sciences, and a preference to work independently), Artistic (interest in writing, art, or other creative expression and little need for structure), Social (interest in people and in helping professions), Enterprising (interest in leadership roles, especially if they lead to achieving economic goals), and Conventional (preference for structured environments, a well-defined chain of command, and office practices).

Need for Achievement. The achievement subscale of the Adjective Check List (ACL; Gough & Heilbrun, 1983) was used to measure how much the participant strives to be outstanding in pursuits of socially recognized significance. In the ACL, participants are presented with 300 adjectives and are asked to indicate which of them they consider as self-descriptive. People with a high need for achievement typically choose adjectives such as ambitious, energetic, assertive, and self-confident.

Quality of the advising relationship.

The advisor-advisee working alliance from the student's perspective was assessed using the student version of the Advisory Working Alliance Inventory (AWAI-S; Schlosser & Gelso, 2001). In the 2003 survey (T2), respondents were asked to indicate their level of agreement with 30 items on a 5-point Likert-type scale, ranging from 1 (*strongly disagree*) to 5 (*strongly agree*). The AWAI-S has 3 subscales. *Rapport* (Cronbach's $\alpha = .92$) measures how well the advisor and advisee got along interpersonally (e.g., I got the feeling that my advisor did not like me very much). *Apprenticeship* ($\alpha = .90$) measures the degree to which the advisor facilitated the professional development of the advisee (e.g., My advisor helped me conduct my work within a plan). And, *Identification-individuation* ($\alpha = .83$) measures how much the advisee wanted or did not want to be like his/her advisor (e.g., I did *not* want to be like my advisor). For the total score, the Cronbach's α was .95. All reported alpha's were calculated using the data of this study.

The subscales were highly inter-correlated (see Table 1). A factor analysis yielded a strong first factor explaining 42% of the variance, with subsequent factors explaining no more than 5% of the variance each. A visual inspection of the scree plot did not show a marked drop in the eigenvalues, except for after the first principal component. In addition, the internal consistency of the total scale was high (Cronbach's $\alpha = .95$). Therefore, in subsequent analyses we used the total score on the AWAI-S as an overall measure of the quality of the Advisory Working Alliance from the student's perspective. Results for the individual subscales can be found in Appendices G, N, and O.

Criteria.

Obtaining the PhD. Participants reported in the T2 survey whether they had obtained their PhD.

Securing a STEM tenure track faculty position. Employment information from the 2003 survey as well as a Google search in 2007 using the participant's name was used to determine if the participant had a STEM tenure track faculty position.

Securing a STEM tenure track faculty position at a research intensive university. When a participant had a STEM tenure track faculty position, the Carnegie Classification for the Ranking of Institutions (Carnegie Foundation for the Advancement of Teaching, 2000) was utilized to determine whether the institution they were affiliated with was a research intensive university.

Upcoming STEM leader. Participants with STEM job positions in academia, government, and industry with leadership and responsibility commensurate with a STEM tenure track position at a research intensive university can be considered upcoming STEM leaders. To classify individuals as being upcoming STEM leaders, the same criteria as Robertson (2012) were used. Participants were classified on the basis of their job position, income, patents, and publications. Job titles were generated by two engineering deans at Vanderbilt University and coupled with incomes that suggest an occupation of leadership and responsibility commensurate with a tenure track position at a research intensive university (see Appendix A). In addition, participants not meeting these criteria, but who were publishing in refereed outlets or securing patents at high rates were also included. Thus, the criteria used to classify a participant as being an upcoming STEM leader were the following. First, they had to have an occupation in STEM. Second, they had to meet at least one of the following criteria: 1) have a tenure track faculty position at a Research intensive university (Carnegie Foundation for the Advancement of Teaching, 2000), 2) have an income of at least $90,000 per year, 3) have a senior government or industry position and earn at least $70,000 per year, 4) have been granted at least three patents between the time they obtained their terminal degree and 2003 or have obtained at least .33 per year on average during this time, 5) have authored or co-authored at least nine refereed science or engineering articles between the time they obtained their terminal degree and 2003 or at least 1.3 articles per year on average during this time. Those that were not categorized as being an upcoming STEM leader were screened again in 2007 and re-categorized if at that time they had attained the criteria. A more detailed explanation of this categorization can be found in Robertson (2012).

Analyses

All outcomes were modeled with logistic regression, a generalized linear model (McCullagh & Nelder, 1989) that uses a Bernoulli random component and a logit (the logarithm of the odds) link function to fit the data to a logistic curve (Agresti, 2007). PROC LOGISTIC of the SAS software, version 9.2 of the SAS system for Windows was used for performing the analyses (SAS Institute; SAS and all other SAS Institute products or service names are registered trademarks of SAS Institute).

Second, the nesting of students within advisor was examined to investigate if it could bias the findings. There were 46 pairs, 17 triplets, 2 quadruplets and 3 quintuplets of advisees that had the same advisor. Most advisors (n = 284) had only one advisee, however. Upon investigating the residuals, no significant correlation was found between residuals of advisees who had the same advisor. Also, doing the analyses with only one advisee per advisor included yielded the same pattern of results. Therefore, the nested structure was ignored in subsequent analyses.

Third, Multiple Imputation was used to handle missing data (Rubin, 1976, 1987; Schafer, 1997). Of the 499 included participants, 59 (12%) missed GRE scores, 5 (1%) missed all RIASEC interest measures, 6 (1%) did not complete the ACL (need for achievement). Sixty-five participants (13%) had at least one missing data point. Multiple imputation (Rubin, 1976; 1987) is shown to better recover the actual data structure than listwise deletion (King, Honaker, & Kenneth, 2001). A Markov Chain Monte Carlo (MCMC) method (Schafer, 1997) in SAS procedure MI was used to impute missing values. Following Rubin (1996), 5 datasets were imputed. The MIANALYZE procedure was used to combine the analyses of the multiply imputed datasets (Rubin, 1987; Schafer, 1997).

Following indices were used to evaluate the value added of the AWAI-S.

1) A Wald test (Wald, 1943) tests the significance of the regression coefficients in the logistic regression model (see Table 2). Statistical significance is a necessary but not sufficient condition for a predictor to add value. In addition, a Likelihood Ratio Test was performed, which yielded similar results (see Appendix B).

2) Receiver Operating Characteristic (ROC) curves were used to compare classification accuracy of a model with and without the AWAI-S as a predictor (for an example see Figure 1). The x-axis indicates the specificity (those that did not obtain the outcome and have been correctly classified as such), the y-axis the sensitivity (those that obtained the outcome and have been correctly classified as such). Using the estimated probabilities obtained from the logistic regression model, the sensitivity and specificity is calculated for all possible cut off values. To obtain the ROC curves, the resulting bivariate points (specificity and sensitivity for each cut off value) are connected. The dashed line represents a model with as predictors the abilities, interests, need for achievement, and sex of the advisees. The solid line represents a model with the same predictors, but with the AWAI-S added to them. The difference in the area under the curve (AUC) between the dashed and the solid line shows the increase in classification accuracy by adding the AWAI-S to the model. A statistical test for comparing two AUC's has been developed by DeLong, DeLong, and Clarke-Pearson (1988).

Although intuitively appealing, statistical significance of a new variable added to a predictor set does not always correspond to a statistically significant increase in the AUC. (Demler, Pencina, & D'Agostino, 2011; Pencina, D'Agostino, D'Agostino, & Vasan, 2008). Demler, Pencina, and D'Agostino (2011) explained this phenomenon by showing that for a logistic regression model this is only asymptotically true if the assumption of multivariate normality of the predictor variables holds.

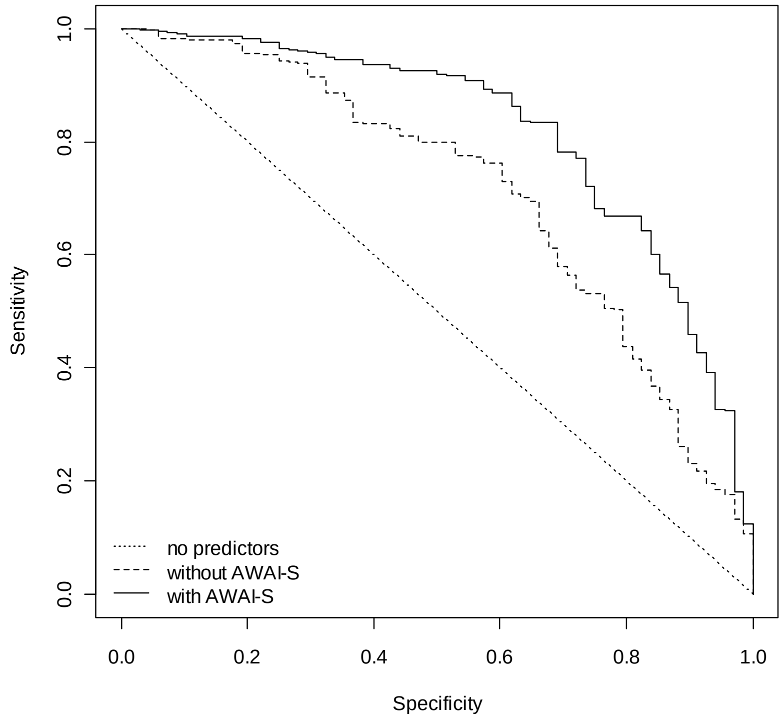


Figure 1: Hypothetical Receiver Operating Characteristic (ROC) curves express the classification accuracy of the corresponding logistic regression models. Using the estimated probabilities obtained from the logistic regression model, the sensitivity and specificity are calculated for all possible cut off values. The x-axis indicates the specificity (those that did not obtain the outcome and have been correctly classified as such), the y-axis indicates the sensitivity (those that obtained the outcome and have been correctly classified as such). To obtain the ROC curves, the resulting bivariate points (specificity and sensitivity for each cut off value) are connected The dotted line represents a model with no predictors. The dashed line represents a model with as predictors the abilities, interests, need for achievement, and sex of the advisees. The solid line represents a model with the same predictors, but with the AWAI-S added to them. The difference in the area under the curve (AUC) between the dashed and the solid line shows the increase in classification accuracy by adding the AWAI-S to the model.

The model predictors in this study are not multivariate normally distributed. GRE-Q was severely skewed due to ceiling effects (especially for males), and our predictor set also included a categorical predictor, namely sex of the advisee. Therefore the Delong test for difference between AUCs is conservative.

The next two indices also provide tests for classification improvement but are not dependent on multivariate normality.

3) Net Reclassification Improvement (NRI; Pencina et al., 2008) is based on the idea that classification accuracy of a model improves if, by adding a variable, the predicted probability of those that obtained the outcome increases and the predicted probability of those that did not obtain the outcome decreases. First, for those that obtained the outcome, calculate the difference between the proportion of individuals increasing in predicted probability and the proportion of individuals decreasing in predicted probability. Second, calculate the corresponding difference for those that did not obtain the outcome. Last, calculate the difference of those two differences.

4) Integrated Discrimination Improvement (IDI; Pencina et al., 2008, p.159) measures a model's ability to improve integrated (average) sensitivity without sacrificing integrated (average) specificity. It is calculated by computing the difference between improvement in average sensitivity and the potential decrease in average specificity.

To obtain regression coefficients and their corresponding Wald tests, results were combined across imputed data sets as described by Rubin (1987) and Schafer (1997). All other indices were computed for all 5 imputed data sets individually (see Appendix B for average, minimum, and maximum fit indices across imputed data sets). For constructing the figures, individual predicted probabilities were averaged across datasets.

CHAPTER III

RESULTS

Table 1 shows correlations and descriptive statistics for non-dichotomous predictor variables, i.e. all but sex of the advisee. The regression coefficients of the logistic regression and their standard errors are presented in Table 2. Table B1 (see Appendix B) shows model fit indices averaged over all imputed data sets and between brackets the corresponding maximum and minimum values across imputed datasets.

We evaluated the value added of the AWAI-S above and beyond the abilities, interests, need for achievement and sex of the advisee in the prediction of obtaining a STEM PhD, obtaining a STEM tenure track faculty position, obtaining a STEM tenure track faculty position at a research intensive university, and being an upcoming STEM leader. The size of the value added is graphically presented in Figure 2a through 2d. The area between the two ROC curves quantifies the difference in classification accuracy between a model with and a model without the AWAI-S as a predictor. The difference in AUC, the NRI, and the IDI were large when predicting obtaining a STEM PhD, small for obtaining a STEM tenure track faculty position and obtaining a STEM tenure track faculty position at a research intensive university, and not statistically significantly different from zero for predicting being an upcoming STEM leader.

In the remainder of this section, the strength of association between the outcome and the AWAI-S, and the added value of the AWAI-S will be discussed for each of our outcomes.

Obtaining a STEM PhD

Of the 499 participants, 431 (86%) had obtained their PhD. Figure 2a compares ROC-curves for a model without (dashed curve) and a model with (solid curve) the AWAI-S included as a predictor. The area between the dashed and the solid line in Figure 2a represents the added value of the AWAI-S in the prediction of obtaining a PhD. Adding the AWAI-S increased the average AUC from .71 to .82 (for all imputed data sets, Delong $p < .001$). Across imputed datasets, the NRI ranged from .77 to .81 ($p < .001$) and the IDI ranged from .127 to .129 ($p < .001$). Based on these results it can be concluded that the AWAI-S adds value in the prediction of obtaining a PhD.

Odds ratio's can be obtained by exponentiation of the regression coefficients in Table 2. They express how the odds of obtaining the PhD will change with changes in the AWAI-S, keeping all other variables in the regression equation constant. An increase of one SD in the total score on the AWAI-S is associated with a 180% (= 100 * ($e^{1.03}$ - 1)) increase in the odds of obtaining the PhD, 95% CI [105%, 283%]. In the full model, need for achievement and investigative interest were significantly positively related to obtaining the PhD. Enterprising interest was negatively related to obtaining the PhD.

Obtaining a STEM tenure track faculty position

Out of 499, 100 (20%) obtained a STEM tenure track faculty position, among which 64 (13% of total) at a research intensive university. For obtaining a STEM tenure track faculty position, ROC-curves are presented in Figure 2b. The average AUC increased from .66 to .69. The Delong statistic ranged from 1.39 to 1.683 (with corresponding p-values of .082 and .046). The mean estimated NRI was .286, the mean estimated IDI was .019. All estimated NRI and IDI statistics were significant ($p < .01$).

Figure 2a: Obtaining a PhD

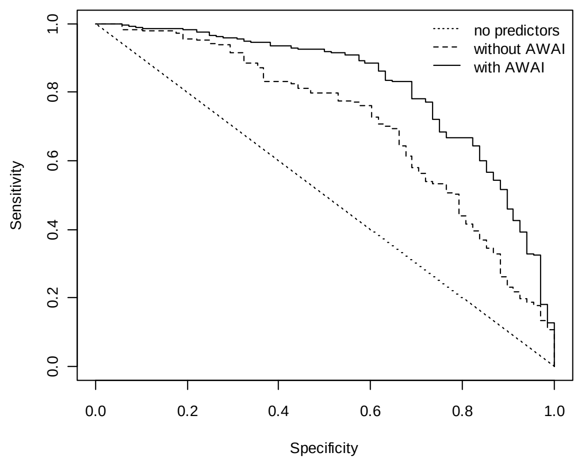


Figure 2b: Obtaining a Tenure Track Faculty Position

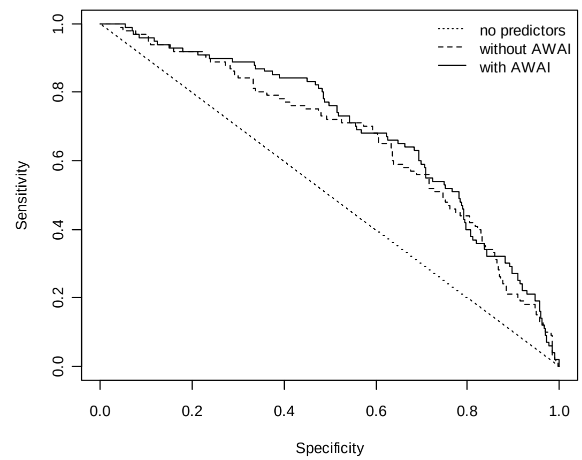


Figure 2c: Obtaining a Tenure Track Faculty Position at a RIU

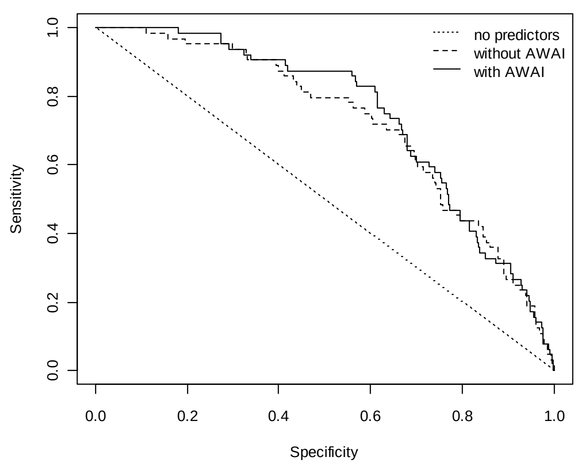
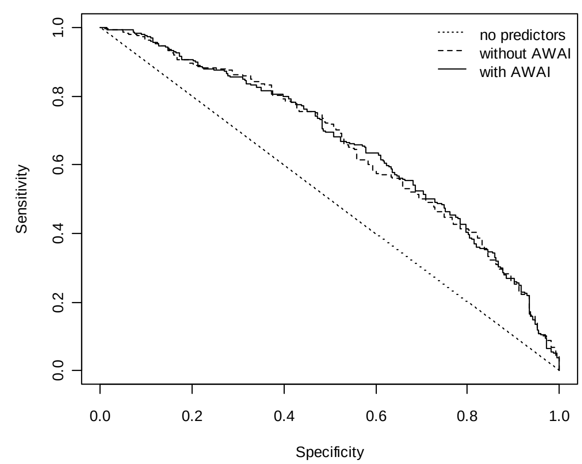


Figure 2d: Upcoming STEM Leader



Figures 2a-2d: Receiver Operating Characteristic (ROC) curves for obtaining a STEM PhD (2a), obtaining a STEM tenure track faculty position (2b), obtaining a STEM tenure track faculty position at a research intensive university (2c) and obtaining a job positions with leadership and responsibility commensurate with a STEM tenure track position at a research intensive university (2d). The x-axis indicates the specificity (those that did not obtain the outcome and have been correctly classified as such), the y-axis the sensitivity (those that obtained the outcome and have been correctly classified as such). Using the estimated probabilities obtained from the logistic regression model, the sensitivity and specificity are calculated for all possible cut off values. To obtain the ROC curves, the resulting bivariate points (specificity and sensitivity for each cut off value) are connected in the order of increasing cut off values. The dashed line represents a model with as predictors the abilities, interests, need for achievement, and sex of the advisees. The solid lines represents a model with the same predictors, but with the AWAI-S added to them. The difference in the area under the curve (AUC) between the dashed and the solid line shows the increase in classification accuracy by adding the AWAI-S to the model.

Table 1

Means, Standard Deviations and Correlations for All Non-Dichotomous Predictor Variables

	Mean	SD	Min	Max	1	2	3	4	5	6	7	8	9	10	11	12	13
1. GRE-quantitative	744.30	55.84	550	800	**440**												
2. GRE-verbal	624.27	91.36	290	800	0.39	**440**											
3. Realistic	50.89	8.85	29	72	0.07	0.05	**494**										
4. Investigative	59.35	5.45	38	69	0.04	0.07	0.38	**494**									
5. Artistic	51.63	9.58	24	66	-0.02	0.19	0.24	0.35	**494**								
6. Social	47.58	9.86	21	74	-0.05	-0.10	0.25	0.36	0.25	**494**							
7. Enterprising	39.49	7.59	27	70	-0.10	-0.18	0.30	0.18	0.10	0.40	**494**						
8. Conventional	44.16	8.61	26	75	0.05	-0.10	0.31	0.25	-0.12	0.38	0.61	**494**					
9. Need for Achievement	50.34	8.61	17	72	-0.09	-0.10	-0.02	0.10	-0.04	0.09	0.16	0.09	**493**				
10. AWAI total score	107.60	19.63	38	148	0.09	0.04	-0.02	0.03	-0.06	-0.03	-0.08	0.06	0.08	**499**			
11. Rapport	43.40	8.12	11	55	0.10	0.06	-0.04	0.03	-0.07	-0.04	-0.10	0.04	0.10	0.92	**499**		
12. Apprentice	47.67	9.65	18	70	0.06	0.03	-0.01	0.03	-0.05	-0.01	-0.06	0.07	0.05	0.92	0.74	**499**	
13. Identification	16.54	3.96	5	25	0.09	0.03	-0.03	0.02	-0.03	-0.01	-0.03	0.07	0.07	0.81	0.72	0.63	**499**

Note: The diagonal elements (in bold) are the number of complete cases, correlations are below the diagonal.
For N = 440: $r > .09$ $p < .05$; $r > .12$, $p < .01$; $r > .16$, $p < .001$
For N = 499: $r > .09$ $p < .05$; $r > .12$, $p < .01$; $r > .15$, $p < .001$

Table 2

Coefficients of the Logistic Regressions for Predicting STEM PhD, STEM Tenure Track, STEM Tenure Track at a Research Intensive University (RIU), and Being an Upcoming STEM Leader.

	STEM PhD	STEM Tenure Track	STEM Tenure Track at RIU	Upcoming STEM Leader
Intercept	2.43[0.25]***	-1.75[0.19]***	-2.51[0.26]***	-0.04[0.14]
GRE-Q	0.27[0.16]	0.13[0.14]	0.30[0.20]	0.22[0.11]*
GRE-V	-0.07[0.17]	0.07[0.15]	0.29[0.21]	-0.06[0.11]
Realistic	-0.09[0.18]	0.06[0.14]	0.09[0.17]	0.12[0.11]
Investigative	0.38[0.16]*	-0.06[0.15]	0.01[0.18]	0.32[0.11]**
Artistic	0.11[0.18]	-0.03[0.14]	-0.25[0.17]	-0.06[0.11]
Social	0.01[0.17]	0.27[0.15]	0.10[0.18]	-0.33[0.12]**
Enterprising	-0.42[0.19]*	-0.46[0.18]**	-0.29[0.21]	0.02[0.13]
Conventional	-0.06[0.21]	0.06[0.17]	0.01[0.21]	-0.14[0.13]
Need for Achievement	0.40[0.15]**	0.37[0.13]**	0.44[0.16]**	0.11[0.10]
Is male	-0.04[0.32]	0.41[0.25]	0.56[0.32]	0.49[0.20]*
AWAI total score	**1.03[0.16]*** **	**0.39[0.13]*** *	**0.40[0.16]***	**0.11[0.10]**
Increase in Odds Ratio with 1SD increase in the AWAI total score	180%	48%	49%	12%

Coefficients for the logistic regressions for each criterion variable. Standard errors are bracketed.
* p < .05, ** p < .01, *** p < .001

An increase of 1 SD in the total score on the AWAI-S is associated with a 48% CI [14%, 91%] increase in the odds of obtaining a STEM tenure track faculty position (see Table 2). In the full model, need for achievement was positively related to obtaining a STEM tenure track faculty position. Enterprising interest was negatively related to this outcome.

For obtaining a STEM tenure track faculty position at a research intensive university, ROC curves are presented in Figure 2c. The average AUC increased from .716 to .739. Delong statistics ranged from 1.17 to 1.37, none of which reached significance. The mean NRI was .261, the mean IDI was .012, both significant on a .05 level across all data sets.

An increase of 1 SD in the total score on the AWAI-S is associated with a 49%, CI [9%, 104%] increase in the odds of obtaining a STEM tenure track faculty position at a research intensive university (see Table 2). Also in the full model, need for achievement was positively related to obtaining a STEM tenure track faculty position at a research intensive university.

Upcoming STEM leader

Out of 499, 273 (55%) were classified as being an upcoming STEM leader. ROC curves are presented in Figure 2d. Adding the AWAI-S increased the average AUC from .652 to .656. None of the data sets yielded a significant Delong test. The mean NRI was .114, which was not significant for any of the datasets. The IDI was .003 for all datasets, which was not significant. It can be concluded that adding the AWAI-S to our predictor set does not improve discrimination.

A 1SD increase in the total score on the AWAI was associated with a 12% increase in the odds of being classified as such, 95% CI [-8%, 36%], which was not significant (see Table 2). In the full model, Being male, investigative interest and GRE-Q were significantly positively related to being an upcoming STEM leader, whereas a significant negative relationship was found with social interest.

CHAPTER IV

DISCUSSION

This longitudinal study examined the value added by the quality of the advisor-advisee relationship, as measured by the AWAI-S (Schlosser & Gelso, 2001), for predicting objective, long term educational and occupational outcomes among top STEM graduate students, taking into account individual differences in abilities, interests, need for achievement, and sex at the onset of graduate school. In the prediction of earning a STEM doctorate, the added value of the AWAI-S above and beyond the aforementioned individual differences was large. For securing a STEM tenure track faculty position and securing a STEM tenure track faculty position at a research intensive university, the results indicate a small but meaningful amount of added value. In the prediction of obtaining a position involving leadership and responsibility commensurate with a STEM tenure track position at a research intensive university, adding the AWAI-S did not improve the discrimination. These findings add to previous studies that found a positive associations of the AWAI-S with outcomes such as the advisee's research self efficacy, research competence, interest in science and practice, satisfaction with advisor, grade point average and scholarly productivity (Schlosser & Gelso, 2001, 2005; Schlosser & Kahn, 2007; Rice et al., 2009; Kahn & Schlosser, 2010). But one may wonder how many of these findings would hold up if distal measures of individual differences (abilities, interests, and personality) would have been taken into account. Much of the discrimination observed in the model including the AWAI-S was anticipated for by assessments early in graduate school. The current study underscores the importance of taking into account distal measures of individual differences (abilities, interests, and personality) with established predictive validity when studying the added value of a new construct or measure. This methodological approach has sharpened inferences in health psychology (Gottfredson, 2004) and industrial-organizational psychology (Judge, Jackson, Shaw, Scott, & Rich, 2007).

Based on the criteria examined in this study, the construct(s) assessed by the AWAI-S appears to be more operative at earlier stages of career development, and its added value seems to wane over time. In the course of a career, different kinds of mentorship may be required as different challenges are encountered in the world of work and as the nature of accomplishments changes. Yet, earning a STEM doctorate and securing a STEM tenure track position are important outcomes.

Although these findings are far from definitive, they do suggest future research for which the AWAI-S could be utilized. For example, the individual differences assessed by the AWAI-S might be most relevant for early academic accomplishments or for achieving academic milestones rather than those occurring later in life or more removed from academic settings. Also, it would be interesting to administer the AWAI-S not only at different time points throughout one's academic career, but later in life as well, inasmuch as perceptions of advisors and mentors may change over time and in both directions. Measuring the advisor-advisee relationship from the advisors perspective, or from the perspective of multiple students with the same advisor, could also shed a different light on our findings.

This study has several limitations. First, the predictor set utilized at T1 was underdetermined. Spatial ability was not assessed, and the GRE-Q was severely restricted in range; both attributes have been linked to advanced degrees and high-level occupations in STEM (Wai, Lubinski, & Benbow, 2009). Furthermore, interests could be measured with a collection of more focused basic interest scales (BIS; Liao, Armstrong, & Rounds, 2008). It is an empirical question as to whether the positive findings for the added value of the AWAI-S would be maintained, if these determinants were appropriately assessed and controlled for. In addition, many other criteria could be used to examine the applied and theoretical importance of the AWAI-S. Also, the AWAI-S was administered in 2003, approximately 10 years after initial selection. One may argue that evaluating the advisory working alliance can best be done after the collaboration has ended, and a student has gone through all stages of graduate school. A possible disadvantage is that some of our outcomes (obtaining a STEM PhD, obtaining a STEM tenure track faculty position) may have retrospectively altered the perception of the advisory relationship. Not obtaining the PhD may have decreased their perceived quality of the advisory relationship at T2. Finally, because the sample in this study consisted of top STEM graduate students, it is possible that the individual differences assessed by the AWAI-S have more value for more typical STEM graduate students.

Conclusion

Although the published findings on the AWAI-S to date do not justify specific applied recommendations, when coupled with the positive results reported here, on a select group of several hundred STEM graduate students, using objective and distal criteria, the AWAI-S has shown to be a promising tool for future longitudinal research.

APPENDIX A

JOB TITLE CLASSIFICATION

Table A1

Job Titles and Fields Classified as Non-Science and Engineering: Executive Positions

	Job Title	Job Specialty
1	Analyst	Management consulting
2	Associate	Management consulting
3	Associate	Hedge fund analysis
4	Associate	Management Consulting
5	Associate Analyst	Health economics
6	Associate Director	Academic programming
7	Director of Customer Advocacy	Difficult customer management
8	Director of Global Research	Asset management
9	Director of Operations	Operations management
10	Director, Business Development	
11	Finance Manager	Finance
12	Group Leader	Consumer products R&D
13	Group Program Manager	Consumer web site
14	Head of Desk Trading	Trading
15	Instructional Specialist	
16	Manager	Marketing research & business development
17	Manager of Universal Services	Analysis and management
18	Managing Director	Private company investing
19	Managing Director	Research in the field of marketing
20	Managing Director	Financial services / banking
21	Partner	Business consulting
22	Planning Analyst	Strategic planning and analysis
23	President	Marketing analytics
24	Principal	Venture capital
25	Product Manager	Marketing
26	Project Manager	
27	Project Manager	Heavy civil construction
28	Project Manager	Industrial capital projects
29	Safety Project Manager	Automotive Safety
30	Senior Analyst/Developer	Commodities trading and sales systems
31	Senior Associate	Management consulting
32	Senior Vice President	Quantitative financial research
33	Sr. Regulatory Associate	Regulatory affairs international - CMC
34	Strategy Consultant	Automotive
35	Vice President	Quality control

Table A2

Job Titles and Fields Classified as Non-Science and Engineering: Non-Executive Positions.

	Job Title	Job Specialty
1	Account Consultant	Sales
2	Adjunct professor	Radiology
3	Assistant Professor	Operations management
4	Assistant Professor	Emergency medicine
5	Assistant Professor	Speech science
6	Assistant Professor	Management and organizations
7	Associate	Litigation - Intellectual property
8	Associate Professor	Operations management
9	Attorney	Patent litigation
10	Attorney (associate)	Patent law
11	Co-owner	Native plant sales
12	Consultant/Investor	Technology consulting/Real estate devel.
13	Digital Artist	3D modeling
14	Economist	Corporate governance, org. behavior
15	Herbalife Distributor	Health & nutrition
16	Lawyer	Intellectual property
17	Museum Education Teacher	Teaching activities of 1840s to kids
18	Patent Attorney	Intellectual property
19	Patent Attorney	Medical apparatus patents and software
20	Patent Counsel	Chemical and biotechnology patent prosecution
21	Physician	
22	Physician	
23	Research Assistant Professor	Science education
24	Research Associate	Consumer products R&D
25	Roman Catholic Priest	Parish work
26	Technical Consultant	Technical editing
27	Winemaker	Making still red and white wine

Table A3

Job Titles and Fields of Jobs Classified as Senior-Level Positions

	Job Title	Job Specialty
1	AAAS Congressional Science Fellow	
2	CEO	Biotech company
3	CEO	Computer software & other tech.
4	Chief Scientific Officer	textile chemistry
5	Chief, Division of USEPA	Drinking water regulations
6	CTO	Detection of online payment fraud
7	Design Manager	Integrated circuit design
8	Development Manager	Simulation software development
9	Director of business consulting	Software development
10	Director, Microwave Engineering	Semiconductor design
11	Director of Product Development	Catalog of scientific products
12	Director of Product Engineering	Instrumentation Design
13	Director of Product Management	Software
14	Director, Tech. & Strategic Rsch.	Tech. & market analysis
15	Director of Theoretical Physics	
16	Director, Bio. Process Improvement	Jack of all trades
17	Director, Intellectual Property	Patents and intellectual property
18	Engineer/Branch Head	Satellite communications
19	Engineering Group Leader	Semiconductor processing
20	Engineering Group Leader	Semiconductor industry
21	Executive	Electronics manufacturing
22	Founder, Director of Business Devel.	Bio-surgery
23	Founder and CTO	Software devel. for data mining
24	General Manager	Chemical manufacturing
25	Group Leader	Medicinal chemistry
26	Group Leader	Gene expression
27	Head, Chemistry & H.T. Discovery	High throughput synthesis
28	Lead Clinical Research Scientist	R&D of antiepileptic drugs
29	Lead Network Modeling Engineer	Software development
30	Lead Scientist	Inorganic chemistry
31	Lead System Engineer	Nuclear power plant systems
32	Manager	Technology-based consulting
33	Manager Research & Development	Anti-aging skin care products
34	Manager, Cancer Discovery Chem.	Chemistry research management
35	Manager, Micro-fluidics Engineering	Chemical engineering
36	Manager, Systems Development	Mathematical software devel.
37	Office Chief	Environmental engineering
38	Planetary Scientist, Aerospace Engineer	Lead for human analog missions
39	President & CEO	B2B software

Table A3, continued

	Job Title	Job Specialty
40	Principal Engineer	Microprocessor process engineering
41	Principal Engineer	Medical device R&D
42	Principal Engineer	Environmental engineering
43	Principal Research Scientist	Cell Biology
44	Principal Research Scientist	Mouse molecular genetics
45	Principal Scientist	Signal transduction/biochemistry
46	Principal scientist	Gas and ambient air analysis
47	Principal Scientist	Discharge lighting
48	Principal Scientist	Protein crystallography
49	Principal Software Engineer	Computer graphics
50	Principal Technical Staff Member	Telecom engineer
51	Product Engineering Group Leader	Flash memory
52	Product Line Manager	Multiprocessor semiconductors
53	Program Director/Group Leader	Molecular biology of oncology
54	Program Manager, R&D	Organic chemistry
55	Project Leader	Ultrafast laser spectroscopy
56	Project Leader	Material science / chemistry
57	Project Manager	GMP production facility/software
58	Project Manager	Semiconductor process integration
59	R&D Manager	Mobile internet software
60	Regional Manager	Plastics / Industry
61	Regional Medical Scientist	Pharmaceuticals R&D
62	Scientific Application Manager	Gene expression, bioinformatics
63	Section Manager	IT - currently intranet technologies
64	Senior Biomedical Engineer	Project management & software devel.
65	Senior Chemist	Analytical chemistry
66	Senior Chemist	Product development
67	Senior Chemist	Organometallic chem. & polymers
68	Senior Criticality Safety Engineer	Criticality safety
69	Senior Director	Biocatalysis in pharmaceuticals
70	Senior Engineer	Tech. devel., medical devices
71	Senior Engineer	Aircraft integration and test engineer
72	Senior Engineer	Millimeter wave design & devel.
73	Senior Engineer II	Software simulations
74	Senior Engineer II	Electrical engineering
75	Senior engineering staff	Communications system analysis
76	Senior Fellow	Analytical chemistry
77	Senior Fellow	Infectious disease
78	Senior Geotechnical Engineer	Geotechnical engineering

Table A3, continued

	Job Title	Job Specialty
79	Senior Member of Technical Staff	Analog circuit design
80	Senior Member of Technical Staff	Materials science
81	Senior Member of Technical Staff	Software research and development
82	Senior Member of Technical Staff	Energetic materials chemistry
83	Senior Member of Technical Staff	Electrical engineering
84	Senior Principal Research Engineer	Surfactant science
85	Senior Process Engineer	Semiconductor manufacturing
86	Senior Process Engineer	Lithography
87	Senior Project Engineer	Solid state electronics
88	Senior Quality Assurance Engineer	Software
89	Senior Research Biochemist	Immunology
90	Senior Research Chemist	Formulation science
91	Senior Research Chemist	Polymer and organic synthesis
92	Senior Research Engineer	Process modeling and optimization
93	Senior Research Investigator	Medicinal chemistry
94	Senior Research Scientist	Chemistry
95	Senior research scientist	Physics/materials science
96	Senior Research Scientist	Synthetic polymer chemistry
97	Senior Research Scientist	Toothbrush R&D
98	Senior Research Scientist	Combinatorial chemistry
99	Senior Research Scientist	Geophysical inversion problems
100	Senior Research Scientist	Inorganic materials and ceramics
101	Senior Research Scientist	Bio-organic chemistry
102	Senior Rf Engineer	Rf circuit design
103	Senior Scientist	Medicinal chemistry
104	Senior Scientist	Biomedical engineering
105	Senior Scientist	Chemical engineering
106	Senior Scientist	Hydrodynamics, numerical modeling
107	Senior Scientist	Pharmaceutical chemistry
108	Senior Scientist	Biotech assay development
109	Senior Scientist	Metabolic chemistry
110	Senior Scientist II	Medicinal chemistry
111	Senior Scientist II - Group Leader	Synthetic organic chemistry
112	Senior Software Engineer	Computer programming development
113	Senior Software Engineer	C programming for mechanical CAD
114	Senior Software Engineer	C++
115	Senior Software Engineer	Signal processing
116	Senior Software Engineer	
117	Senior staff engineer	Operations analysis
118	Senior Staff Scientist	Nuclear MR spectroscopy

Table A3, continued

	Job Title	Job Specialty
119	Senior Staff Software Engineer	UNIX system software design
120	Senior Systems Analyst	Software testing
121	Senior Systems Analyst	Clinical information systems
122	Senior Technical Associate	Research
123	Senior Technical Staff Member	Computer sciences
124	Software Development Manager	Mathematical software
125	Sr. Research Scientist	Cell biology
126	Sr. Subsurface Engineer	Oil/gas well completions
127	Sr. CAD Researcher	Comp. architecture performance analysis
128	Sr. Engineering Manager	Semiconductor processing devel.
129	Sr. Environmental Engineer	Environmental compliance
130	Sr. Manager	Database marketing
131	Sr. Member of Technical Staff	Semiconductor device technology
132	Sr. Principal Research Engineer	Chemical reaction engineering
133	Sr. Process Engineer	Semiconductor processing
134	Sr. Research Engineer	Fuel cell research
135	Sr. System Engineer	DSP engineer
136	Sr. VP/Chief Technology Officer	Product development
137	Supervisor	Computer vision, machine learning
138	Systems Engineer Senior Staff	Radar system engineering
139	Team Leader/Tech. Staff	Software development
140	Technology Leader	Chemical engineering
141	Technology Manager	Resins and coatings; silicones
142	Technology Manager	Chemist
143	VP of Engineering, Founder	High performance optical components
144	VP of Business Development	Software mergers and acquisitions
145	VP, Senior Analyst	Biotechnology
146	Named Fellow	Physics of particle accelerators
147	Named Fellow	Immunology

APPENDIX B

FIT INDICES FOR LOGISTIC REGRESSION MODELS

Table B1

Mean Fit Indices for the Logistic Regressions for Predicting STEM PhD, STEM Tenure, STEM Tenure Track at a RIU, and Being an Upcoming STEM Leader.

Outcome	PhD		Tenure Track	
Model	no AWAI	AWAI	no AWAI	AWAI
SAS Pseudo R-squared	0.072 [0.069 , 0.074]	0.163 [0.161 , 0.165]	0.051 [0.049 , 0.055]	0.069 [0.067 , 0.073]
SAS Max. Rescaled Pseudo R-squared	0.131 [0.125 , 0.135]	0.297 [0.293 , 0.301]	0.081 [0.078 , 0.087]	0.109 [0.106 , 0.115]
Hosmer and Lemeshow χ^2	7.399 [3.202 , 12.718]	6.039 [3.379 , 9.102]	8.682 [4.399 , 13.298]	10.783 [5.867 , 14.884]
P-Value Hosmer and Lemeshow χ^2	0.533 [0.122 , 0.921]	0.643 [0.334 , 0.908]	0.415 [0.102 , 0.819]	0.298 [0.061 , 0.662]
Area Under the Curve (AUC)	0.710 [0.706 , 0.713]	0.820 [0.818 , 0.823]	0.661 [0.655 , 0.670]	0.688 [0.685 , 0.693]
AUC Lower Limit 95% CI	0.643 [0.638 , 0.646]	0.766 [0.763 , 0.769]	0.601 [0.595 , 0.609]	0.630 [0.627 , 0.636]
AUC Upper Limit 95% CI	0.777 [0.774 , 0.780]	0.875 [0.873 , 0.877]	0.722 [0.716 , 0.730]	0.746 [0.743 , 0.751]
Delong Test (Delong et al., 1988)		3.814 [3.752 , 3.911]		1.545 [1.395 , 1.683]
P-Value Delong Test		0.000 [0.000 , 0.000]		0.063 [0.046 , 0.082]
Net Reclassification Improvement (NRI)		0.781 [0.767 , 0.805]		0.286 [0.278 , 0.293]
P-Value NRI		0.000 [0.000 , 0.000]		0.005 [0.004 , 0.007]
Integrated Discrimination Improvement (IDI)		0.127 [0.126 , 0.128]		0.019 [0.019 , 0.020]
P-Value IDI		0.000 [0.000 , 0.000]		0.001 [0.001 , 0.001]
Akaike Information Criterion	382 [380.83 , 383.81]	332 [331.13 , 333.92]	495 [493.62 , 496.80]	488 [486.26 , 489.17]
-2logL	360 [358.83 , 361.81]	308 [307.13 , 309.92]	473 [471.62 , 474.80]	464 [462.26 , 465.17]
Likelihood Ratio Test (LRT)		51.836 [51.702 , 52.095]		9.463 [9.308 , 9.627]
P-Value of LRT		0.000 [0.000 , 0.000]		0.002 [0.002 , 0.002]

Note: Mean fit indices are shown for models without and with the total score on the AWAI-S as a predictor (all models include abilities, interests, need for achievement and sex as predictors. The minimum and maximum for the 5 imputations are bracketed.

Table B1, continued

Outcome	Tenure Track at RIU		Upcoming STEM Leader	
Model	no AWAI	AWAI	no AWAI	AWAI
SAS Pseudo R-squared	0.067 [0.063 , 0.073]	0.079 [0.075 , 0.085]	0.074 [0.070 , 0.077]	0.077 [0.073 , 0.080]
SAS Max. Rescaled Pseudo R-squared	0.124 [0.117 , 0.136]	0.147 [0.141 , 0.159]	0.099 [0.094 , 0.103]	0.102 [0.098 , 0.106]
Hosmer and Lemeshow χ^2	4.168 [3.481 , 5.478]	13.876 [6.635 , 18.795]	4.043 [1.750 , 9.150]	4.480 [2.777 , 8.046]
P-Value Hosmer and Lemeshow χ^2	0.836 [0.706 , 0.901]	0.167 [0.016 , 0.576]	0.813 [0.330 , 0.988]	0.791 [0.429 , 0.948]
Area Under the Curve (AUC)	0.716 [0.707 , 0.728]	0.739 [0.729 , 0.748]	0.652 [0.649 , 0.656]	0.656 [0.653 , 0.659]
AUC Lower Limit 95% CI	0.652 [0.640 , 0.664]	0.680 [0.667 , 0.692]	0.604 [0.601 , 0.608]	0.608 [0.605 , 0.612]
AUC Upper Limit 95% CI	0.781 [0.774 , 0.792]	0.798 [0.792 , 0.805]	0.699 [0.696 , 0.704]	0.703 [0.701 , 0.707]
Delong Test (Delong et al., 1988)		1.254 [1.168 , 1.371]		0.811 [0.701 , 0.971]
P-Value Delong Test		0.105 [0.085 , 0.121]		0.210 [0.166 , 0.242]
Net Reclassification Improvement (NRI)		0.261 [0.231 , 0.290]		0.114 [0.094 , 0.141]
P-Value NRI		0.027 [0.015 , 0.042]		0.106 [0.058 , 0.147]
Integrated Discrimination Improvement (IDI)		0.012 [0.011 , 0.014]		0.003 [0.003 , 0.003]
P-Value IDI		0.031 [0.019 , 0.048]		0.100 [0.092 , 0.107]
Akaike Information Criterion	369 [366.56 , 371.97]	365 [361.98 , 367.24]	671 [669.72 , 673.36]	671 [670.36 , 673.89]
-2logL	347 [344.56 , 349.97]	341 [337.98 , 343.24]	649 [647.72 , 651.36]	647 [646.36 , 649.89]
Likelihood Ratio Test (LRT)		6.605 [6.158 , 7.070]	0.074 [0.070 , 0.077]	1.441 [1.355 , 1.565]
P-Value of LRT		0.010 [0.008 , 0.013]	0.099 [0.094 , 0.103]	0.230 [0.211 , 0.244]

Note: Mean fit indices are shown for models without and with the total score on the AWAI-S as a predictor (all models include abilities, interests, need for achievement and sex as predictors. The minimum and maximum for the 5 imputations are bracketed.

APPENDIX C

OBSERVED PROPORTIONS OF SUCCESS PER QUARTILE

Figure C1: Obtaining the PhD

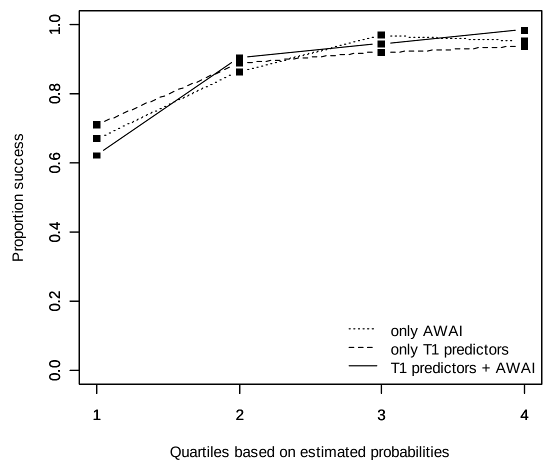


Figure C2: Obtaining a tenure track faculty position

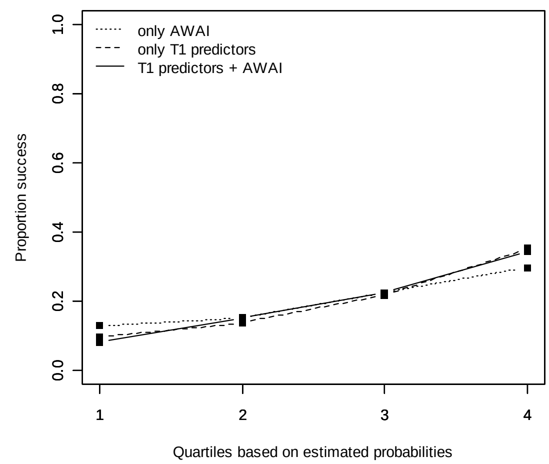


Figure C3: Obtaining a tenure track faculty position at a RIU

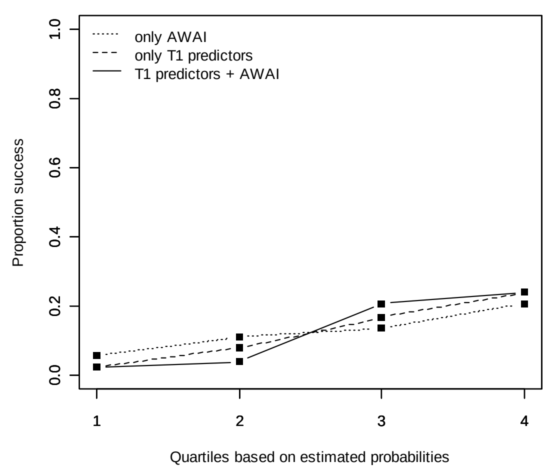
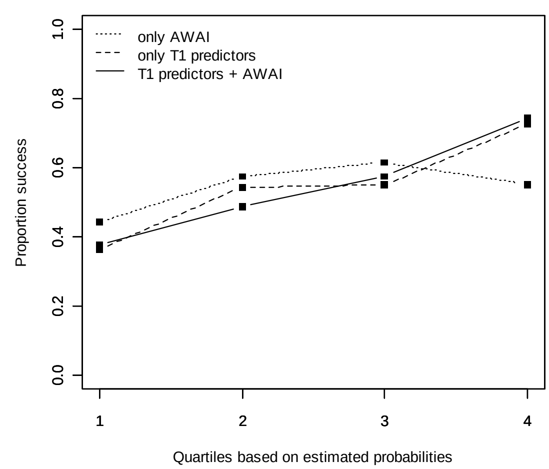


Figure C4: Upcoming STEM leader



Figures C1-C4: Observed proportions of success for each quartile of estimated probabilities. Subjects are assigned to quartiles based on their estimated probability from the logistic regression model. Quartiles are plotted on the x-axis, the proportion of subjects that obtained the outcome is plotted on the y-axis. The dotted lines represent a model with only the AWAI-S as a predictor. The dashed lines represent a model with as predictors the abilities, interests, need for achievement, and sex of the advisees measured at T1. The solid lines represent a model with the same predictors, but with the AWAI-S added to them.

APPENDIX D

PROBABILITY OF THE OUTCOMES AS A FUNCTION OF THE TOTAL SCORE ON THE AWAI-S

Figure D1: Obtaining the PhD

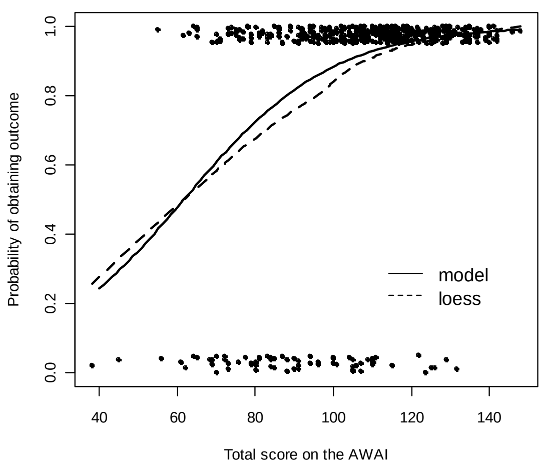


Figure D2: Obtaining a tenure track faculty position

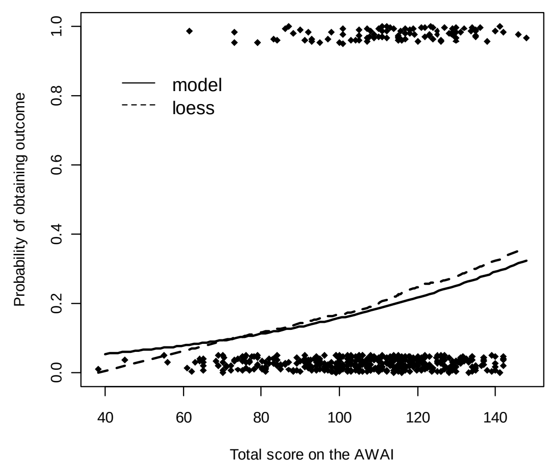


Figure D3: Obtaining a tenure track faculty position at a RIU

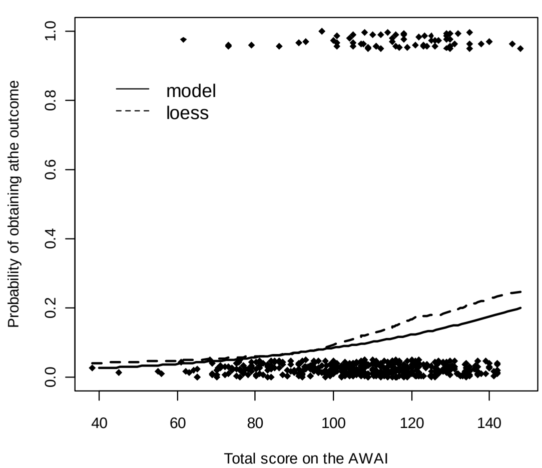
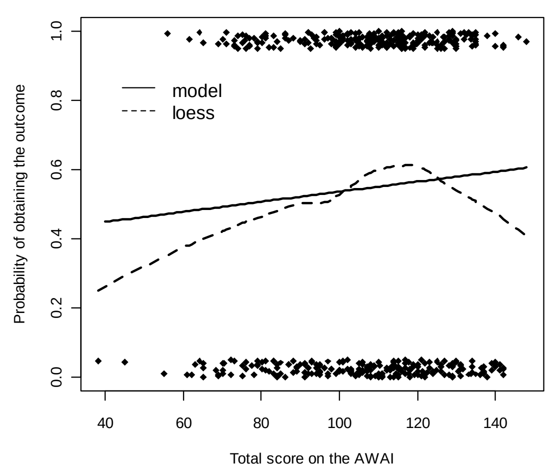


Figure D4: Being an upcoming STEM leader



Figures D1-D4: Logistic regression curves for obtaining a STEM PhD (D1), obtaining a STEM tenure track faculty position (D2), obtaining a STEM tenure track faculty position at a research intensive university (D3) and obtaining a job positions in STEM with leadership and responsibility commensurate with a STEM tenure track position at a research intensive university (D4). These figures represent the probability of obtaining the outcome as a function of the total score on the AWAI-S. The x-axis represents the total score on the AWAI-S. The y-axis indicates the probability of obtaining the outcome. The solid line represents the logistic regression model's estimated probability of obtaining the outcome for an average student (i.e., all other variables set to their mean score). The dashed line is the locally weighted least squares regression function (loess). The black dots at the top represent those participants who obtained the outcome, the dots at the bottom those who did not. The horizontal position of the dots represents their corresponding total score on the AWAI-S.

APPENDIX E

EXPECTED PROPORTIONS VERSUS OBSERVED PROPORTIONS

Figure E1: Obtaining the PhD

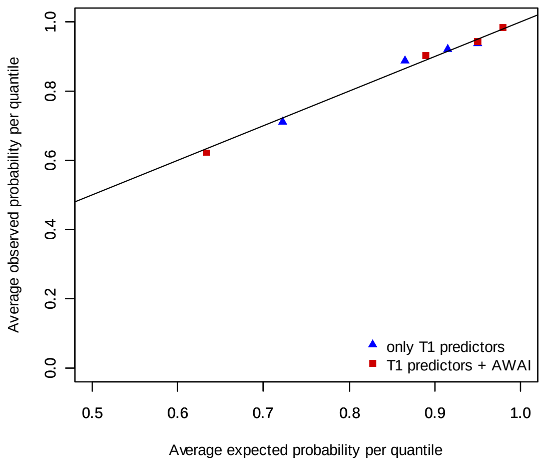


Figure E2: Obtaining a tenure track faculty position

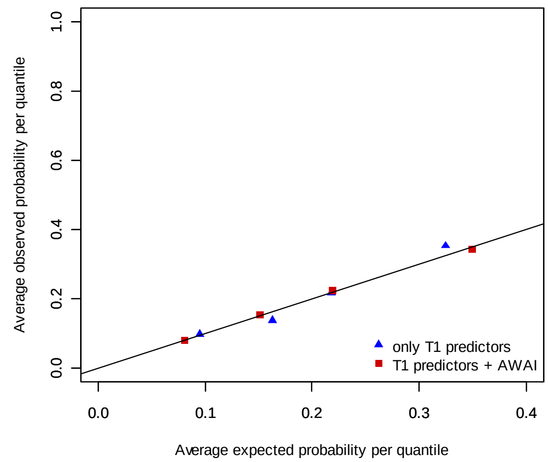


Figure E3: Obtaining a tenure track faculty position at a RIU

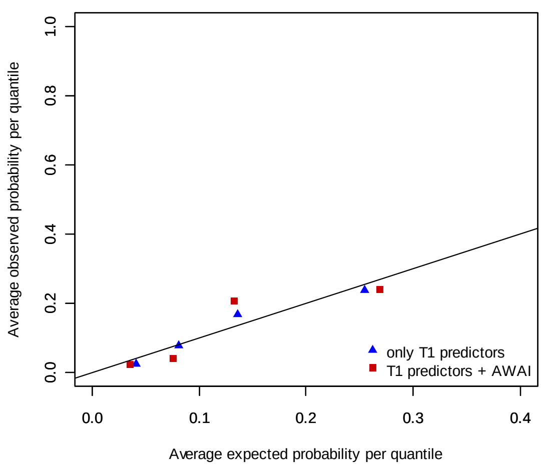
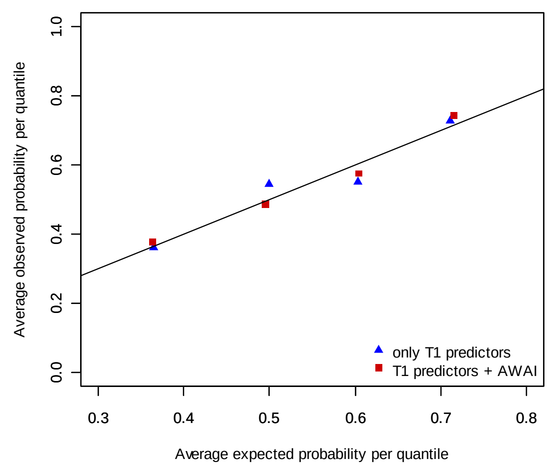


Figure E4: Upcoming STEM leader



Figures E1-E4: Expected proportions of success (x-axis) are plotted against observed proportions of success (y-axis) for every quartile. Subjects are assigned to quartiles based on their estimated probability from the logistic regression model. The blue triangles represent a model with as predictors the abilities, interests, need for achievement, and sex of the advisees measured at T1. The red squares represent a model with the same predictors, but with the AWAI-S added to them. The solid straight line indicates were the expected and observed proportions are equal (y = x).

APPENDIX F

ROC CURVES FOR A MODEL WITH ONLY THE AWAI-S AS A PREDICTOR

Figure F1: Obtaining a PhD

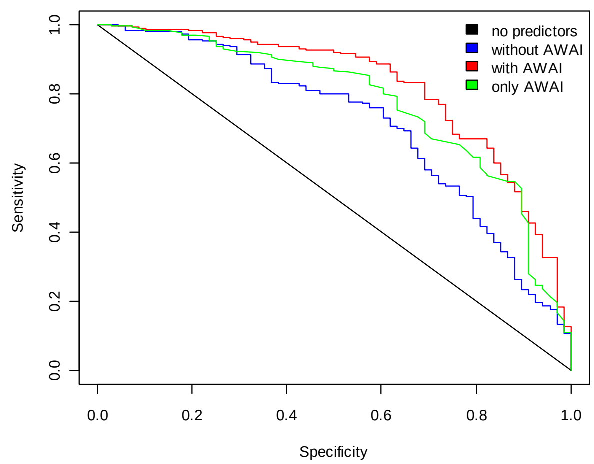


Figure F2: Obtaining a Tenure Track Faculty Position

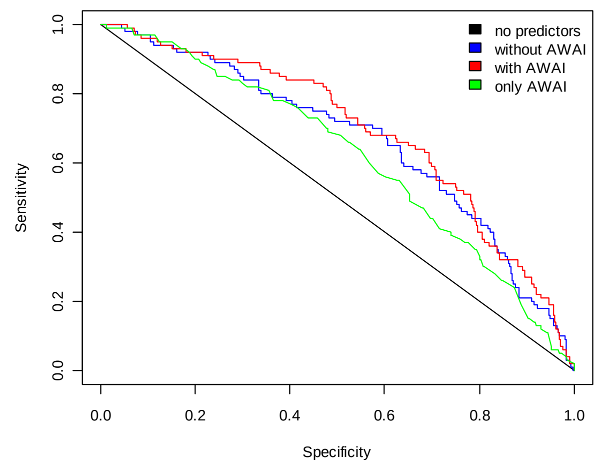


Figure F3: Obtaining a Tenure Track Faculty Position at a RIU

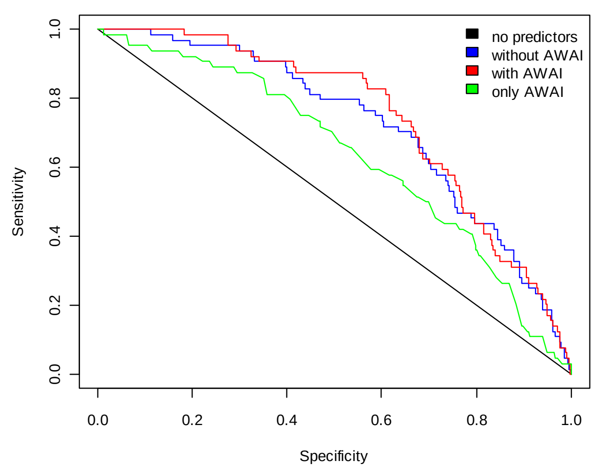


Figure F4: Upcoming STEM Leader

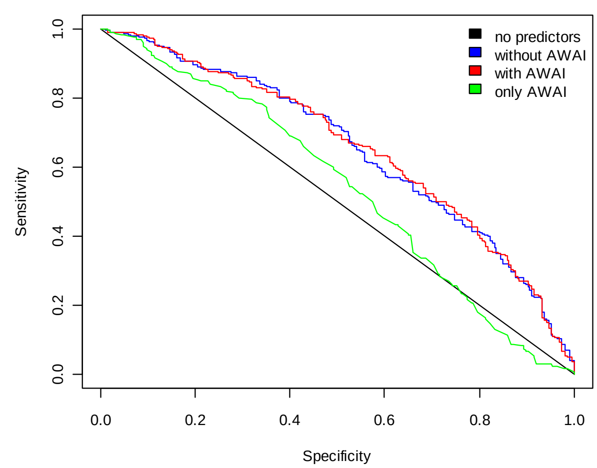


Figure F1-F4: Receiver Operating Characteristic (ROC) curves for obtaining a PhD (F1), obtaining a STEM tenure track faculty position (F2), obtaining a STEM tenure track faculty position at a research intensive university (F3) and obtaining a job positions with leadership and responsibility commensurate with a STEM tenure track position at a research intensive university (F4). The x-axis indicates the specificity (those that did not obtain the outcome and have been correctly classified as such), the y-axis the sensitivity (those that obtained the outcome and have been correctly classified as such). The black lines represent a model without predictors. The blue lines represent a model with as predictors the abilities, interests, need for achievement, and sex of the advisees. The red lines represent a model with the same predictors, but with the AWAI-S added to them. The green lines represent a model with only the AWAI-S as a predictor.

APPENDIX G

ROC CURVES FOR MODELS WITH THE SUBSCALES AS A PREDICTOR

Figure G1: Obtaining a PhD

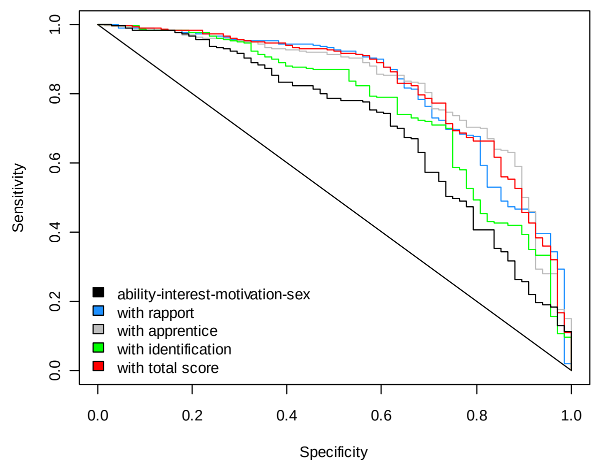


Figure G2: Obtaining a Tenure Track Faculty Position

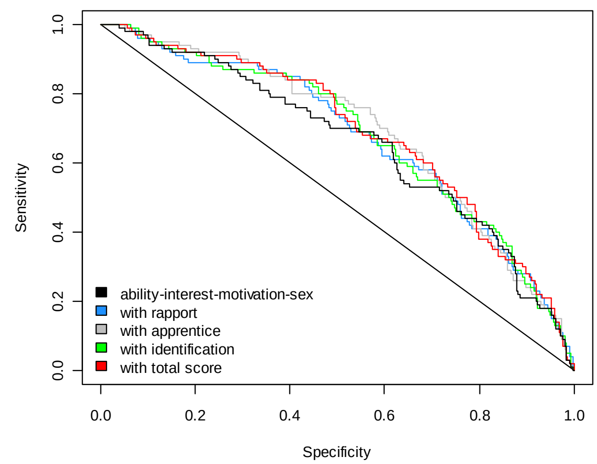


Figure G3: Obtaining a Tenure Track Faculty Position at a RIU

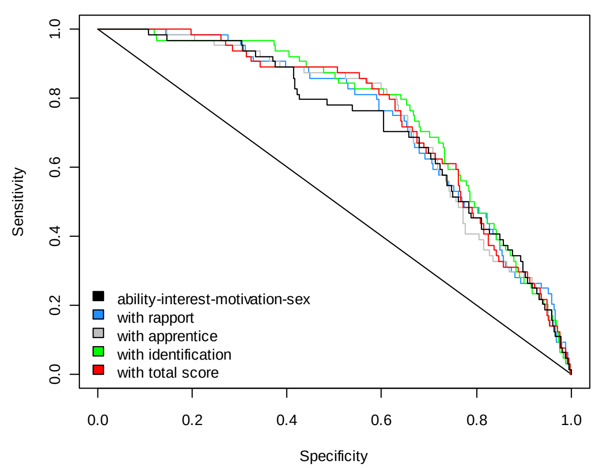


Figure G4: Upcoming STEM Leader

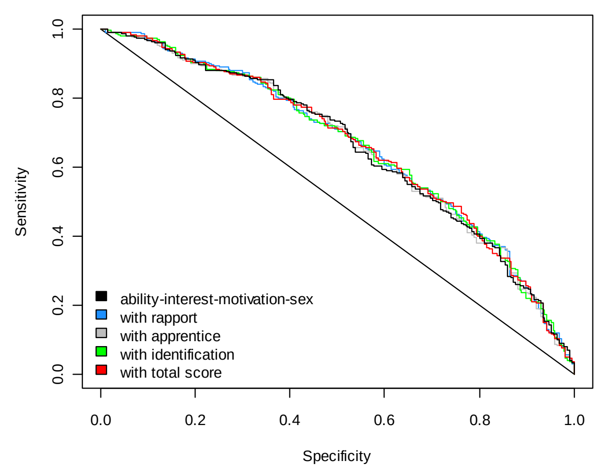


Figure G1-G4: Receiver Operating Characteristic (ROC) curves for obtaining a PhD (F1), obtaining a STEM tenure track faculty position (F2), obtaining a STEM tenure track faculty position at a research intensive university (F3) and obtaining a job positions with leadership and responsibility commensurate with a STEM tenure track position at a research intensive university (F4). The x-axis indicates the specificity (those that did not obtain the outcome and have been correctly classified as such), the y-axis the sensitivity (those that obtained the outcome and have been correctly classified as such). The straight lines represent a model without predictors. The black lines represent a model with as predictors the abilities, interests, need for achievement, and sex of the advisees. The blue, grey, green, and red lines represent a model with the same predictors, but separately (not cumulatively) added to them the Rapport subscale, the Apprenticeship subscale, the Identification subscale, or the total score on the AWAI-S, respectively.

APPENDIX H

SCATTER PLOTS EXPLAINING THE NET RECLASSIFICATION INDEX

Figure H1: Obtaining a PhD

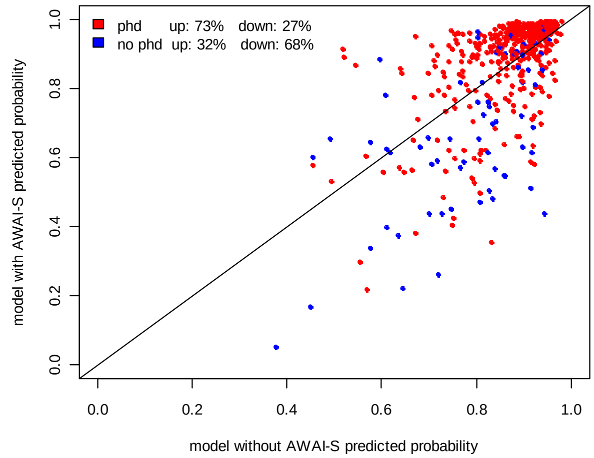


Figure H2: Obtaining a Tenure Track Faculty Position

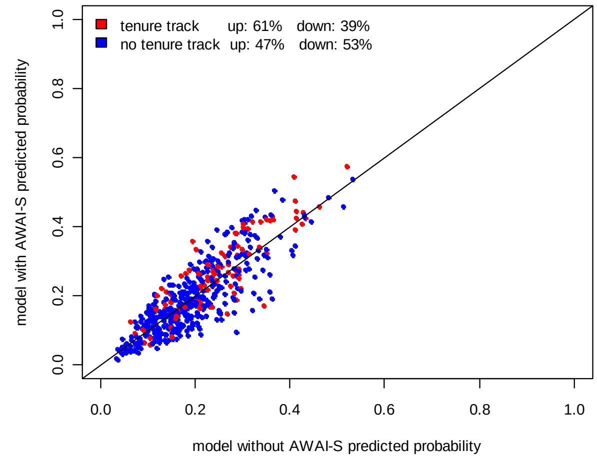


Figure H3: Obtaining a Tenure Track Faculty Position at a RIU

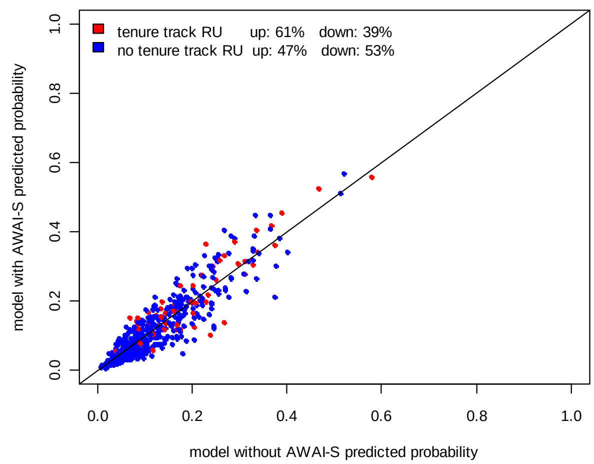


Figure H4: Upcoming STEM Leader

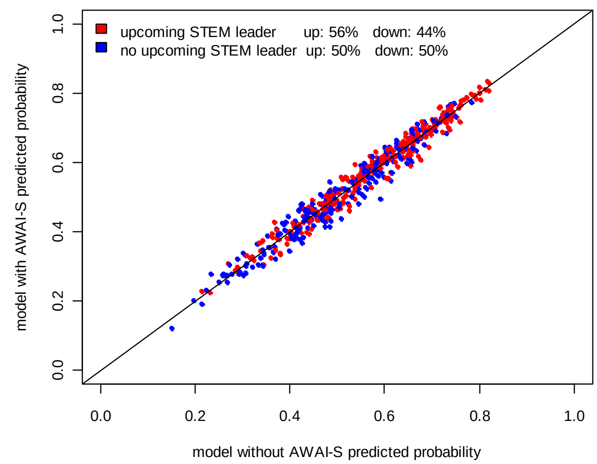


Figure H1-H4: Scatter plots with on the x-axis the predicted probabilities for a model with as predictors the abilities, interests, need for achievement, and sex of the advisees, and on the y-axis the predicted probabilities for a model with the same predictors and the AWAI-S added to them. Outcomes are obtaining a STEM PhD (H1), obtaining a STEM tenure track faculty position (H2), obtaining a STEM tenure track faculty position at a research intensive university (H3) and obtaining a job positions with leadership and responsibility commensurate with a STEM tenure track position at a research intensive university (H4). Red dots are those that obtained the outcome, blue dots represent those that did not obtain the outcome. The legend indicates for each group (obtained or did not obtain the outcome) what proportion of group members increased or decreased in predicted probability when adding the AWAI-S as a predictor to the predictor set.

APPENDIX I

PLOTS EXPLAINING THE INTEGRATED DISCRIMINATION IMPROVEMENT

Figure I1: Obtaining a PhD

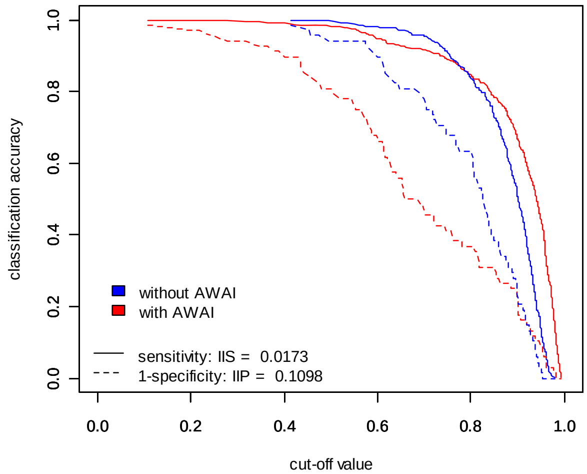


Figure I2: Obtaining a Tenure Track Faculty Position

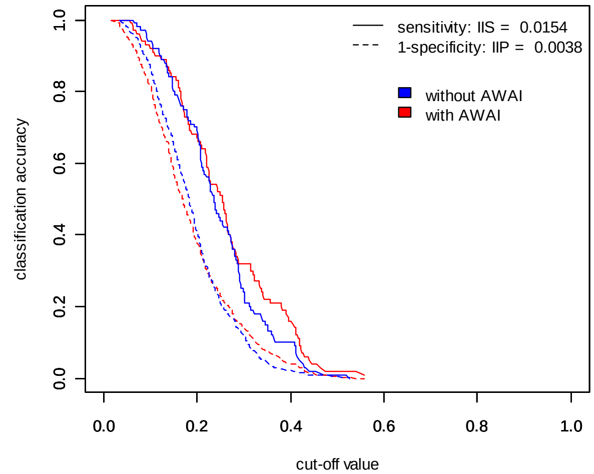


Figure I3: Obtaining a Tenure Track Faculty Position at a RIU

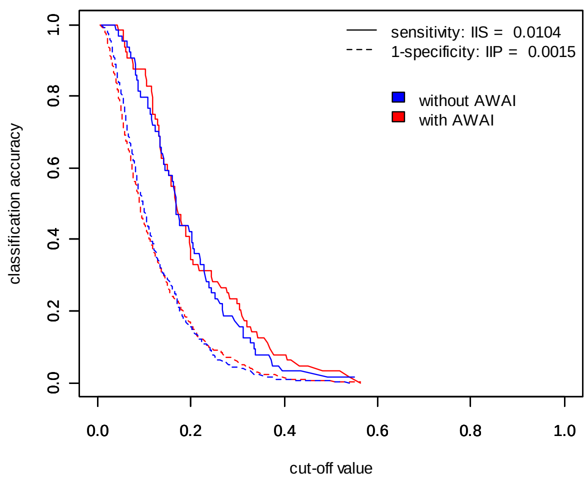


Figure I4: Upcoming STEM Leader

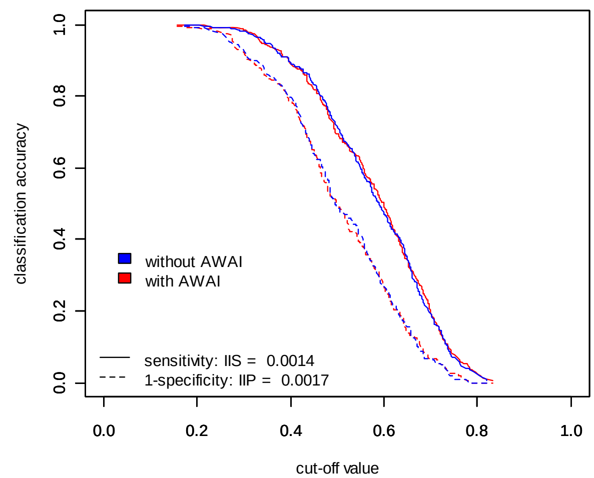


Figure I1-I4: Sensitivity and 1 – specificity plotted against the cut off values. Outcomes are obtaining a STEM PhD (H1), obtaining a STEM tenure track faculty position (H2), obtaining a STEM tenure track faculty position at a research intensive university (H3) and obtaining a job positions with leadership and responsibility commensurate with a STEM tenure track position at a research intensive university (H4). The blue lines represent a model with as predictors the abilities, interests, need for achievement, and sex of the advisees. The red lines represent a model with the same predictors, but with the AWAI-S added to them. The solid line represents the sensitivities, the dashed line represents 1 minus the specificities. The area between the solid curves and the dashed curves shows the increase in integrated sensitivity (IIS) and the increase in integrated specificity (IIP), respectively. The exact area between the curves is indicated in the legend. The IDI is the sum of the IIS and the IIP.
Note that the x-axis measures 1 minus the specificity, so if the dashed red line is to the left of the dashed blue line, that represents an increase in specificity.

APPENDIX J

ADVISORY WORKING ALLIANCE INVENTORY – STUDENT PERSPECTIVE

RAPPORT SUBSCALE

1 I got the feeling that my advisor did not like me very much.*
2 I do *not* think that my advisor believed in me.*
3 My advisor did not encourage my input into our discussions.*
4 My advisor was *not* kind when commenting about my work.*
5 I did *not* feel respected by my advisor in our work together.*
6 My advisor offered me encouragement for my accomplishments.
7 My advisor welcomed my input into our discussions.
8 My advisor took my ideas seriously.
9 I did *not* think that my advisor had my best interests in mind.*
10 I felt uncomfortable working with my advisor.*
11 I was often intellectually "lost" during meetings with my advisor.*

APPRENTICESHIP SUBSCALE

12 My advisor introduced me to professional activities (e.g., conferences, submitting articles for journal publication).
13 My advisor helped me conduct my work within a plan.
14 My advisor has invited me to be a responsible collaborator in his/her work.
15 My advisor helped me to establish a timetable for the tasks of my graduate training.
16 Meetings with my advisor were unproductive.*
17 My advisor helped me recognize areas where I could improve.
18 My advisor facilitated my professional development through networking.
19 I consistently implemented suggestions made by my advisor.
20 I learned from my advisor by watching him/her.
21 I was an apprentice of my advisor.
22 My advisor did *not* help me to stay on track in our meetings.*
23 My advisor strived to make program requirements as rewarding as possible.
24 My advisor did *not* educate me about the process of graduate school.*
25 My advisor was available when I need her/him.

IDENTIFICATION SUBSCALE

26 I did *not* want to be like my advisor.*
27 I tended to see things differently from my advisor.*
28 I did *not* want to be similar to my advisor in the process of conducting work.*
29 My advisor and I had different interests.*
30 I felt like my advisor expects too much from me.*

* Asterisks indicate negatively worded items that were reverse scored

APPENDIX K

FACTOR LOADINGS FOR AN EXPLORATORY FACTOR ANALYSIS WITH A VARIMAX ROTATION

(SEE NEXT PAGE)

	item	factor 1	factor 2	factor 3	communality	uniqueness	average	item-total
1	did.not.like.me	**0.64**	0.21	0.31	0.55	0.45	4.08	0.68
2	believed.in.me	**0.76**	0.27	0.24	0.70	0.30	3.97	0.75
3	encourage.input	**0.76**	0.29	0.20	0.70	0.30	4.05	0.74
4	kindness	**0.61**	0.15	0.45	0.59	0.41	3.99	0.69
5	respect	**0.71**	0.27	0.39	0.73	0.27	3.88	0.79
6	encouragement	**0.55**	0.43	0.34	0.60	0.40	3.67	0.77
7	welcomes.input	**0.72**	0.25	0.26	0.64	0.36	4.04	0.72
8	ideas.seriously	**0.70**	0.34	0.23	0.65	0.35	4.11	0.75
9	best.interest	**0.48**	0.36	0.46	0.57	0.43	3.83	0.75
10	comfortable	**0.54**	0.36	0.42	0.59	0.41	3.82	0.77
11	lost	**0.35**	0.15	0.05	0.15	0.85	3.94	0.37
12	profession.activities	0.43	**0.50**	-0.02	0.43	0.57	3.73	0.60
13	help.plan	0.18	**0.75**	0.22	0.65	0.35	3.36	0.68
14	collaborator	0.41	**0.48**	0.01	0.40	0.60	3.49	0.59
15	establish.timetable	0.12	**0.73**	0.19	0.58	0.42	2.90	0.63
16	productive	0.39	**0.53**	0.39	0.60	0.40	3.85	0.77
17	improvement	0.29	**0.56**	0.13	0.41	0.59	3.38	0.60
18	networking	0.38	**0.49**	0.17	0.41	0.59	2.96	0.66
19	implement.suggestions	0.00	**0.35**	0.18	0.15	0.85	3.76	0.33
20	learn.by.watching	0.27	**0.48**	0.23	0.36	0.64	3.45	0.60
21	am.apprentice	0.23	**0.50**	0.12	0.31	0.69	3.13	0.54
22	stay.on.track	0.30	**0.55**	0.25	0.46	0.54	3.69	0.67
23	rewarding	0.36	**0.54**	0.32	0.53	0.47	2.94	0.73
24	educates.about.gs.process	0.21	**0.60**	0.24	0.46	0.54	3.27	0.64
25	available	0.21	**0.48**	0.20	0.32	0.68	3.75	0.54
26	want.to.be.like	0.27	0.36	**0.70**	0.69	0.31	3.02	0.73
27	see.things.differently	0.32	0.22	**0.68**	0.62	0.38	3.12	0.67
28	want.to.be.similar	0.16	0.27	**0.67**	0.54	0.46	3.37	0.59
29	different.interests	0.33	0.20	**0.53**	0.43	0.57	3.14	0.60
30	expects.too.much	0.44	0.10	**0.35**	0.32	0.68	3.88	0.52
	SS loadings	6.09	5.44	3.62				
	Proportion Variance	0.20	0.18	0.12				
	Cumulative Variance	0.20	0.38	0.50				

APPENDIX L

FIT INDICES FOR AN AVERAGE DATA SET

outcome	PhD		Tenure Track		Tenure Track at RIU		Upcoming STEM Leader	
Model	no AWAI	AWAI	no AWAI	AWAI	no AWAI	AWAI	no AWAI	AWAI
SAS Pseudo R-squared	0.07	0.16	0.05	0.07	0.07	0.08	0.07	0.08
SAS Max. Rescaled Pseudo R-squared	0.13	0.30	0.08	0.11	0.13	0.15	0.10	0.10
Hosmer and Lemeshow χ^2	11.84	1.47	5.42	12.90	3.02	16.71	8.77	4.51
P-Value Hosmer and Lemeshow χ^2	0.158	0.993	0.712	0.115	0.933	0.033	0.362	0.808
Area Under the Curve (AUC)	0.71	0.82	0.66	0.69	0.72	0.74	0.66	0.66
AUC Lower Limit 95% CI	0.64	0.77	0.60	0.63	0.65	0.68	0.61	0.61
AUC Upper Limit 95% CI	0.78	0.87	0.72	0.75	0.78	0.80	0.70	0.71
Delong Test (Delong et al., 1988)		3.77		1.55		1.29		0.68
P-Value Delong Test		0.000		0.061		0.098		0.247
Net Reclassification Improvement (NRI)		0.805		0.298		0.281		0.106
P-Value NRI		0.000		0.004		0.018		0.119
Integrated Discrimition Improvement (IDI)		0.127		0.019		0.012		0.003
P-Value IDI		0.000		0.001		0.029		0.130
Akaike Information Criterion	381.98	332.17	495.63	488.08	369.61	364.97	671.14	671.75
-2logL	359.98	308.17	473.63	464.08	347.61	340.97	649.14	647.75
Likelihood Ratio Test (LRT)		51.81		9.55		6.64		1.39
P-Value of LRT		0.000		0.002		0.010		0.238

Note: Indices are shown for models without and with the total score on the AWAI-S as a predictor (all models include abilities, interests, need for achievement and sex as predictors).

APPENDIX M

REGRESSION COEFFICIENTS AND FIT INDICES FOR A MODEL WITH ONLY THE AWAI-S AS A PREDICTOR

Table M1

Logistic regression coefficients for obtaining a STEM PhD as the outcome.

Model	no AWAI	only AWAI	with AWAI
Intercept	2.00 [0.21]***	2.22 [0.17]	2.43 [0.25]***
GRE-Q	0.28 [0.14]*		0.27 [0.16]
GRE-V	-0.07 [0.16]		-0.07 [0.17]
Realistic	-0.13 [0.16]		-0.09 [0.18]
Investigative	0.40 [0.15]**		0.38 [0.16]*
Artistic	0.10 [0.17]		0.11 [0.18]
Social	-0.02 [0.16]		0.01 [0.17]
Enterprising	-0.57 [0.18]**		-0.42 [0.19]*
Conventional	0.14 [0.19]		-0.06 [0.21]
Need for Achievement	0.45 [0.14]**		0.40 [0.15]**
Is male	0.13 [0.3]		-0.04 [0.32]
AWAI total score		1.04 [0.15]***	1.03 [0.16]***

Table M2

Fit indices for obtaining a STEM PhD as the outcome.

model	only AWAI	with AWAI
SAS Pseudo R-squared	0.116	0.163 [0.161,0.165]
SAS Max. Rescaled Pseudo R-squared	0.211	0.297 [0.293,0.301]
Hosmer and Lemeshow χ^2	15.536	6.039 [3.379,9.102]
P-Value Hosmer and Lemeshow χ^2	0.05	0.643 [0.334,0.908]
Area Under the Curve (AUC)	0.776	0.82 [0.818,0.823]
AUC Lower Limit 95% CI	0.716	0.766 [0.763,0.769]
AUC Upper Limit 95% CI	0.835	0.875 [0.873,0.877]
Delong Test (Delong et al., 1988)		2.414 [2.284,2.564]
P-Value Delong Test		0.008 [0.005,0.011]
NRI		0.625 [0.552,0.699]
P-Value NRI		0.000[0.000,0.000]
IDI		0.071 [0.067,0.074]
P-Value IDI		0.000[0.000,0.000]
Akaike Information Criterion	339.983	332.389 [331.128,333.919]
-2logL	335.983	308.389 [307.128,309.919]
Likelihood Ratio Test (LRT)		27.594 [26.064,28.855]
P-Value of LRT		0.000[0.000,0.000]

Note: Indices are shown for a model with only the AWAI-S as a predictor and a model with abilities, interests, achievement motivation, advisee sex, and the AWAI-S as predictors. The Delong test, the NRI, the IDI, and the likelihoods ratio test now measure if adding the individual differences variables to the model improves the model fit.

Table M3

Logistic regression coefficients for obtaining a STEM tenure track faculty position as the outcome.

Model	no AWAI	only AWAI	with AWAI
Intercept	-1.74 [0.19]***	-1.44 [0.12]	-1.75 [0.19]***
GRE-Q	0.14 [0.14]		0.13 [0.14]
GRE-V	0.08 [0.15]		0.07 [0.15]
Realistic	0.04 [0.14]		0.06 [0.14]
Investigative	-0.05 [0.14]		-0.06 [0.15]
Artistic	-0.03 [0.14]		-0.03 [0.14]
Social	0.26 [0.14]		0.27 [0.15]
Enterprising	-0.5 [0.17]**		-0.46 [0.18]**
Conventional	0.12 [0.17]		0.06 [0.17]
Need for Achievement	0.4 [0.13]**		0.37 [0.13]**
Is male	0.48 [0.25]		0.41 [0.25]
AWAI total score		0.45 [0.13]***	0.39 [0.13]**

Table M4

Fit indices for obtaining a STEM tenure track faculty position as the outcome.

Model	only AWAI	with AWAI
SAS Pseudo R-squared	0.028	0.069 [0.067,0.073]
SAS Max. Rescaled Pseudo R-squared	0.045	0.109 [0.106,0.115]
Hosmer and Lemeshow χ^2	2.533	10.783 [5.867,14.884]
P-Value Hosmer and Lemeshow χ^2	0.96	0.298 [0.061,0.662]
Area Under the Curve (AUC)	0.618	0.688 [0.685,0.693]
AUC Lower Limit 95% CI	0.558	0.63 [0.627,0.636]
AUC Upper Limit 95% CI	0.678	0.746 [0.743,0.751]
Delong Test (Delong et al., 1988)		2.632 [2.581,2.744]
P-Value Delong Test		0.004 [0.003,0.005]
NRI		0.429 [0.343,0.473]
P-Value NRI		0.000 [0.000,0.001]
IDI		0.045 [0.043,0.05]
P-Value IDI		0.000[0.000,0.000]
Akaike Information Criterion	489.643	488.234 [486.259,489.169]
-2logL	485.643	464.234 [462.259,465.169]
Likelihood Ratio Test (LRT)		21.409 [20.474,23.384]
P-Value of LRT		0.000[0.000,0.000]

Note: Indices are shown for a model with only the AWAI-S as a predictor and a model with abilities, interests, achievement motivation, advisee sex, and the AWAI-S as predictors. The Delong test, the NRI, the IDI, and the likelihoods ratio test now measure if adding the individual differences variables to the model improves the model fit.

APPENDIX M (continued)

Table M5

Logistic regression coefficients for obtaining a STEM tenure track faculty position at a RIU as the outcome.

Model	no AWAI	only AWAI	with AWAI
Intercept	-2.5 [0.25]***	-2.01 [0.15]	-2.51 [0.26]***
GRE-Q	0.31 [0.2]		0.3 [0.2]
GRE-V	0.31 [0.21]		0.29 [0.21]
Realistic	0.07 [0.17]		0.09 [0.17]
Investigative	0.02 [0.17]		0.01 [0.18]
Artistic	-0.26 [0.17]		-0.25 [0.17]
Social	0.09 [0.18]		0.1 [0.18]
Enterprising	-0.33 [0.21]		-0.29 [0.21]
Conventional	0.07 [0.2]		0.01 [0.21]
Need for Achievement	0.47 [0.16]**		0.44 [0.16]**
Is male	0.64 [0.31]*		0.56 [0.32]
AWAI total score		0.51 [0.15]***	0.4 [0.16]*

Table M6

Fit indices for obtaining a STEM tenure track faculty position at a RIU as the outcome.

Model	only AWAI	with AWAI
SAS Pseudo R-squared	0.024	0.079 [0.075,0.085]
SAS Max. Rescaled Pseudo R-squared	0.046	0.147 [0.141,0.159]
Hosmer and Lemeshow χ^2	6.432	13.876 [6.635,18.795]
P-Value Hosmer and Lemeshow χ^2	0.599	0.167 [0.016,0.576]
Area Under the Curve (AUC)	0.635	0.739 [0.729,0.748]
AUC Lower Limit 95% CI	0.565	0.68 [0.667,0.692]
AUC Upper Limit 95% CI	0.706	0.798 [0.792,0.805]
Delong Test (Delong et al., 1988)		3.025 [2.748,3.227]
P-Value Delong Test		0.001 [0.001,0.003]
NRI		0.607 [0.513,0.689]
P-Value NRI		0.000[0.000,0.000]
IDI		0.06 [0.053,0.067]
P-Value IDI		0.000[0.000,0.000]
Akaike Information Criterion	373.958	365.292 [361.979,367.237]
-2logL	369.958	341.292 [337.979,343.237]
Likelihood Ratio Test (LRT)		28.666 [26.721,31.979]
P-Value of LRT		0.000[0.000,0.000]

Note: Indices are shown for a model with only the AWAI-S as a predictor and a model with abilities, interests, achievement motivation, advisee sex, and the AWAI-S as predictors. The Delong test, the NRI, the IDI, and the likelihoods ratio test now measure if adding the individual differences variables to the model improves the model fit.

Table M7

Logistic regression coefficients for being an upcoming STEM leader as the outcome.

Model	no AWAI	only AWAI	with AWAI
Intercept	-0.08 [0.14]	0.18 [0.09]	-0.06 [0.14]
GRE-Q	0.23 [0.11]*		0.22 [0.11]*
GRE-V	-0.06 [0.11]		-0.06 [0.11]
Realistic	0.11 [0.11]		0.12 [0.11]
Investigative	0.32 [0.11]**		0.32 [0.11]**
Artistic	-0.06 [0.11]		-0.06 [0.11]
Social	-0.33 [0.12]**		-0.33 [0.12]**
Enterprising	0 [0.13]		0.02 [0.13]
Conventional	-0.11 [0.13]		-0.14 [0.13]
Need for Achievement	0.12 [0.1]		0.11 [0.1]
Is male	0.51 [0.2]*		0.49 [0.2]*
AWAI total score		0.16 [0.09]	0.11 [0.1]

Table M8

Fit indices for being an upcoming STEM leader as the outcome.

Model	only AWAI	with AWAI
SAS Pseudo R-squared	0.006	0.077 [0.073,0.08]
SAS Max. Rescaled Pseudo R-squared	0.008	0.102 [0.098,0.106]
Hosmer and Lemeshow χ^2	8.636	4.48 [2.777,8.046]
P-Value Hosmer and Lemeshow χ^2	0.374	0.791 [0.429,0.948]
Area Under the Curve (AUC)	0.542	0.656 [0.653,0.659]
AUC Lower Limit 95% CI	0.49	0.608 [0.605,0.612]
AUC Upper Limit 95% CI	0.593	0.703 [0.701,0.707]
Delong Test (Delong et al., 1988)		3.751 [3.66,3.862]
P-Value Delong Test		0.000[0.000,0.000]
NRI		0.36 [0.328,0.402]
P-Value NRI		0.000[0.000,0.000]
IDI		0.069 [0.066,0.073]
P-Value IDI		0.000[0.000,0.000]
Akaike Information Criterion	688.655	671.97 [670.36,673.892]
-2logL	684.655	647.97 [646.36,649.892]
Likelihood Ratio Test (LRT)		36.685 [34.763,38.295]
P-Value of LRT		0.000[0.000,0.000]

Note: Indices are shown for a model with only the AWAI-S as a predictor and a model with abilities, interests, achievement motivation, advisee sex, and the AWAI-S as predictors. The Delong test, the NRI, the IDI, and the likelihoods ratio test now measure if adding the individual differences variables to the model improves the model fit.

APPENDIX N

REGRESSION COEFFICIENTS FOR SUBSCALES AS PREDICTORS

Table N1

Logistic regression coefficients for obtaining the PhD as the outcome and the subscales as the predictors.

Outcome: PhD	Rapport		Apprenticeship		Identification		Total score	
Intercept	2.35	[0.24]***	2.43	[0.25]***	2.14	[0.22]***	2.43	[0.25]***
GRE-Q	0.28	[0.15]	0.29	[0.15]	0.27	[0.15]	0.27	[0.15]
GRE-V	-0.13	[0.17]	-0.08	[0.17]	-0.1	[0.17]	-0.1	[0.17]
Realistic	-0.09	[0.17]	-0.11	[0.18]	-0.1	[0.16]	-0.08	[0.18]
Investigative	0.37	[0.16]*	0.38	[0.16]*	0.4	[0.16]*	0.38	[0.16]*
Artistic	0.15	[0.18]	0.1	[0.18]	0.09	[0.17]	0.12	[0.18]
Social	0	[0.17]	0.02	[0.17]	0	[0.17]	0.01	[0.17]
Enterprising	-0.41	[0.19]*	-0.45	[0.19]*	-0.52	[0.19]**	-0.42	[0.19]*
Conventiol	-0.04	[0.21]	-0.02	[0.21]	0.03	[0.2]	-0.07	[0.21]
Need for Achievement	0.39	[0.15]**	0.43	[0.15]**	0.41	[0.14]**	0.4	[0.15]**
Is male	0	[0.31]	-0.08	[0.32]	0.13	[0.3]	-0.04	[0.32]
Scale	**0.93**	**[0.14]*****	**0.99**	**[0.15]*****	**0.65**	**[0.15]*****	**1.03**	**[0.16]*****

Note: The bottom row is the coefficient for the subscale indicated at the top of the column. For example, .93 is the logistic regression coefficient for the Rapport scale in a model with abilities, interests, achievement motivation, sex and the Rapport subscale as predictors, .99 is the logistic regression coefficient for the Apprenticeship subscale.

APPENDIX N (continued)

Table N2

Logistic regression coefficients for obtaining a STEM tenure track faculty position as the outcome and the subscales as the predictors.

	Rapport		Apprenticeship		Identification		Total score	
Intercept	-1.74	[0.19]***	-1.72	[0.19]***	-1.75	[0.19]***	-1.74	[0.19]***
GRE-Q	0.13	[0.14]	0.14	[0.14]	0.13	[0.14]	0.13	[0.14]
GRE-V	0.07	[0.15]	0.08	[0.15]	0.09	[0.15]	0.07	[0.15]
Realistic	0.06	[0.14]	0.06	[0.14]	0.06	[0.14]	0.06	[0.14]
Investigative	-0.05	[0.15]	-0.05	[0.15]	-0.04	[0.15]	-0.05	[0.15]
Artistic	-0.04	[0.14]	-0.04	[0.14]	-0.05	[0.14]	-0.04	[0.14]
Social	0.26	[0.14]	0.25	[0.14]	0.27	[0.14]	0.26	[0.14]
Enterprising	-0.45	[0.18]*	-0.43	[0.18]*	-0.46	[0.18]**	-0.44	[0.18]*
Conventiol	0.07	[0.17]	0.06	[0.17]	0.07	[0.17]	0.06	[0.17]
Need for Achievement	0.36	[0.13]**	0.38	[0.13]**	0.37	[0.13]**	0.36	[0.13]**
Is male	0.42	[0.25]	0.38	[0.25]	0.46	[0.25]	0.4	[0.25]
Scale	**0.32**	**[0.13]***	**0.38**	**[0.13]****	**0.31**	**[0.12]***	**0.39**	**[0.13]****

Note: The bottom row is the coefficient for the subscale indicated at the top of the column. For example, .32 is the logistic regression coefficient for the Rapport scale in a model with abilities, interests, achievement motivation, sex and the Rapport subscale as predictors, .38 is the logistic regression coefficient for the Apprenticeship subscale.

APPENDIX N (continued)

Table N3

Logistic regression coefficients for obtaining a STEM tenure track faculty position at a RIU as the outcome and the subscales as the predictors.

	Rapport		Apprenticeship		Identification		Total score	
Intercept	-2.53	[0.26]***	-2.49	[0.26]***	-2.56	[0.26]***	-2.52	[0.26]***
GRE-Q	0.28	[0.19]	0.29	[0.19]	0.28	[0.2]	0.28	[0.19]
GRE-V	0.29	[0.21]	0.3	[0.21]	0.31	[0.22]	0.29	[0.22]
Realistic	0.09	[0.17]	0.07	[0.17]	0.08	[0.17]	0.08	[0.17]
Investigative	0.01	[0.18]	0.02	[0.18]	0.04	[0.18]	0.02	[0.18]
Artistic	-0.25	[0.18]	-0.25	[0.18]	-0.26	[0.18]	-0.25	[0.18]
Social	0.1	[0.18]	0.09	[0.18]	0.12	[0.18]	0.1	[0.18]
Enterprising	-0.3	[0.21]	-0.3	[0.21]	-0.32	[0.21]	-0.29	[0.21]
Conventiol	0.03	[0.21]	0.04	[0.21]	0.03	[0.21]	0.02	[0.21]
Need for Achievement	0.43	[0.16]**	0.48	[0.16]**	0.45	[0.16]**	0.45	[0.16]**
Is male	0.58	[0.32]	0.58	[0.32]	0.64	[0.32]*	0.57	[0.32]
Scale	**0.42**	**[0.18]***	**0.27**	**[0.15]**	**0.44**	**[0.15]****	**0.41**	**[0.16]***

Note: The bottom row is the coefficient for the subscale indicated at the top of the column. For example, .42 is the logistic regression coefficient for the Rapport scale in a model with abilities, interests, achievement motivation, sex and the Rapport subscale as predictors, .27 is the logistic regression coefficient for the Apprenticeship subscale.

APPENDIX N (continued)

Table N4

Logistic regression coefficients for being an upcoming STEM leader as the outcome and the subscales as the predictors.

	Rapport		Apprenticeship		Identification		Total score	
Intercept	-0.07	[0.14]	-0.07	[0.14]	-0.07	[0.14]	-0.07	[0.14]
GRE-Q	0.22	[0.11]*	0.23	[0.11]*	0.22	[0.11]*	0.22	[0.11]*
GRE-V	-0.09	[0.11]	-0.09	[0.11]	-0.09	[0.11]	-0.09	[0.11]
Realistic	0.11	[0.11]	0.11	[0.11]	0.11	[0.11]	0.11	[0.11]
Investigative	0.31	[0.11]**	0.32	[0.11]**	0.32	[0.11]**	0.31	[0.11]**
Artistic	-0.05	[0.11]	-0.05	[0.11]	-0.06	[0.11]	-0.05	[0.11]
Social	-0.34	[0.12]**	-0.34	[0.12]**	-0.34	[0.12]**	-0.34	[0.12]**
Enterprising	0.01	[0.13]	-0.01	[0.13]	0	[0.13]	0.01	[0.13]
Conventiol	-0.13	[0.13]	-0.12	[0.13]	-0.13	[0.13]	-0.13	[0.13]
Need for Achievement	0.09	[0.1]	0.11	[0.1]	0.1	[0.1]	0.1	[0.1]
Is male	0.49	[0.2]*	0.5	[0.2]*	0.51	[0.2]*	0.49	[0.2]*
Scale	**0.15**	**[0.1]**	**0.05**	**[0.1]**	**0.13**	**[0.09]**	**0.11**	**[0.1]**

Note: The bottom row is the coefficient for the subscale indicated at the top of the column. For example, .15 is the logistic regression coefficient for the Rapport scale in a model with abilities, interests, achievement motivation, sex and the Rapport subscale as predictors, .05 is the logistic regression coefficient for the Apprenticeship subscale.

APPENDIX O

FIT INDICES FOR SUBSCALES AS PREDICTORS

Table O1

Fit indices coefficients for obtaining a PhD as the outcome and the subscales as the predictors.

Model	None	Rapport	Apprenticeship	Identification	Total score
Rsq	0.071[0.07,0.073]	0.155[0.154,0.155]	0.155[0.155,0.157]	0.11[0.109,0.111]	0.163[0.162,0.163]
Max. Rescaled Rsq	0.13[0.127,0.134]	0.282[0.281,0.283]	0.283[0.282,0.285]	0.2[0.199,0.202]	0.297[0.296,0.298]
Hosmer	7.524[3.49,13.07]	12.764[7.188,16.537]	7.153[6.138,9.97]	8.751[7.952,10.045]	3.438[1.827,5.53]
p-value Hosmer	0.532[0.109,0.9]	0.181[0.035,0.516]	0.531[0.267,0.632]	0.368[0.262,0.438]	0.878[0.7,0.986]
AUC	0.653[0.653,0.653]	0.813[0.812,0.814]	0.821[0.82,0.823]	0.761[0.76,0.765]	0.82[0.818,0.822]
AUC LL	0.606[0.606,0.606]	0.757[0.755,0.758]	0.768[0.766,0.769]	0.699[0.697,0.703]	0.766[0.763,0.768]
AUC UL	0.701[0.701,0.701]	0.869[0.868,0.87]	0.874[0.873,0.876]	0.824[0.823,0.827]	0.875[0.873,0.876]
Delong		3.927[3.873,4.013]	3.8[3.767,3.846]	2.293[2.254,2.338]	3.835[3.77,3.875]
p-value Delong		0[0,0]	0[0,0]	0.011[0.01,0.012]	0[0,0]
NRI		0.838[0.833,0.847]	0.862[0.856,0.866]	0.518[0.497,0.527]	0.801[0.776,0.815]
p-value NRI		0[0,0]	0[0,0]	0[0,0]	0[0,0]
IDI		0.118[0.116,0.119]	0.111[0.11,0.112]	0.052[0.05,0.054]	0.128[0.126,0.129]
p-value IDI		0[0,0]	0[0,0]	0[0,0]	0[0,0]
AIC	382.504[381.342,383.172]	337.369[337.111,337.719]	337.121[336.331,337.564]	363.326[362.841,363.749]	332.581[332.297,332.827]
-2logL	360.504[359.342,361.172]	313.369[313.111,313.719]	313.121[312.331,313.564]	339.326[338.841,339.749]	308.581[308.297,308.827]
D		47.135[46.168,47.469]	47.383[47.011,47.837]	21.179[20.501,21.576]	51.924[51.045,52.36]
p of D		0[0,0]	0[0,0]	0[0,0]	0[0,0]

Note: Fit indices for models with only the advisee individual differences (first column, model: none), the Rapport subscale as a predictor added to them (see second column, model: rapport), the Apprenticeship subscale added to the individual differences, the Identification subscale added to the individual differences, and the total score added to the individual differences. The Delong test, the NRI, the IDI, and the likelihoods ratio test measure if adding a subscale as a predictor to the abilities, interests, achievement motivation, and sex of the advisee improves the model fit.

APPENDIX O (continued)

Table O2

Fit indices for obtaining a STEM tenure track faculty position as the outcome and the subscales as the predictors.

model	None	Rapport	Apprenticeship	Identification	Total score
Rsq	0.049[0.046,0.055]	0.061[0.058,0.066]	0.067[0.064,0.072]	0.062[0.059,0.067]	0.067[0.064,0.072]
Max. Rescaled Rsq	0.078[0.073,0.086]	0.097[0.092,0.104]	0.106[0.101,0.114]	0.098[0.094,0.106]	0.106[0.102,0.114]
Hosmer	7.858[4.937,9.494]	8.284[5.796,11.143]	5.693[3.018,8.455]	10.694[3.901,15.066]	8.104[4.027,12.852]
p-value Hosmer	0.462[0.302,0.764]	0.431[0.194,0.67]	0.67[0.39,0.933]	0.303[0.058,0.866]	0.47[0.117,0.855]
AUC	0.653[0.653,0.653]	0.674[0.668,0.682]	0.687[0.681,0.695]	0.677[0.671,0.687]	0.685[0.679,0.694]
AUC LL	0.606[0.606,0.606]	0.615[0.608,0.623]	0.629[0.624,0.638]	0.618[0.612,0.629]	0.627[0.62,0.636]
AUC UL	0.701[0.701,0.701]	0.734[0.727,0.74]	0.744[0.739,0.751]	0.736[0.73,0.745]	0.743[0.737,0.751]
Delong		1.238[1.128,1.367]	1.759[1.719,1.794]	1.326[1.185,1.43]	1.62[1.536,1.696]
p-value Delong		0.109[0.086,0.13]	0.039[0.036,0.043]	0.093[0.076,0.118]	0.053[0.045,0.062]
NRI		0.218[0.187,0.242]	0.249[0.233,0.273]	0.202[0.188,0.223]	0.281[0.263,0.298]
p-value NRI		0.027[0.015,0.047]	0.014[0.007,0.019]	0.037[0.023,0.047]	0.006[0.004,0.009]
IDI		0.013[0.013,0.015]	0.018[0.017,0.019]	0.014[0.013,0.014]	0.019[0.019,0.021]
p-value IDI		0.004[0.003,0.005]	0.002[0.001,0.003]	0.012[0.009,0.014]	0.001[0.001,0.001]
AIC	496.83[493.885,498.229]	492.459[489.912,493.956]	489.463[486.656,491.139]	492.107[489.309,493.506]	489.159[486.523,490.742]
-2logL	474.83[471.885,476.229]	468.459[465.912,469.956]	465.463[462.656,467.139]	468.107[465.309,469.506]	465.159[462.523,466.742]
D		6.371[5.973,6.803]	9.367[9.09,9.667]	6.723[6.576,6.83]	9.672[9.362,10.061]
p of D		0.012[0.009,0.015]	0.002[0.002,0.003]	0.01[0.009,0.01]	0.002[0.002,0.002]

Note: Fit indices for models with only the advisee individual differences (first column, model: none), the Rapport subscale as a predictor added to them (see second column, model: Rapport), the Apprenticeship subscale added to the individual differences, the Identification subscale added to the individual differences, and the total score added to the individual differences. The Delong test, the NRI, the IDI, and the likelihoods ratio test measure if adding a subscale as a predictor to the abilities, interests, achievement motivation, and sex of the advisee improves the model fit.

APPENDIX O (continued)

Table O2

Fit indices for obtaining a STEM tenure track faculty position at a RIU as the outcome and the subscales as the predictors.

model	None	Rapport	Apprenticeship	Identification	Total score
Rsq	0.067[0.059,0.077]	0.079[0.073,0.088]	0.073[0.066,0.082]	0.084[0.076,0.093]	0.08[0.073,0.088]
Max. Rescaled Rsq	0.126[0.111,0.143]	0.148[0.137,0.164]	0.137[0.124,0.154]	0.156[0.142,0.173]	0.149[0.136,0.165]
Hosmer	3.507[2.569,5.641]	7.442[5.26,9.243]	11.193[8.24,14.598]	6.994[3.29,9.213]	10.114[8.324,12.743]
p-value Hosmer	0.884[0.687,0.958]	0.499[0.322,0.73]	0.234[0.067,0.41]	0.54[0.325,0.915]	0.277[0.121,0.402]
AUC	0.653[0.653,0.653]	0.735[0.725,0.749]	0.73[0.717,0.745]	0.751[0.738,0.766]	0.741[0.729,0.755]
AUC LL	0.606[0.606,0.606]	0.676[0.663,0.692]	0.67[0.655,0.688]	0.693[0.678,0.71]	0.682[0.668,0.699]
AUC UL	0.701[0.701,0.701]	0.795[0.787,0.807]	0.79[0.779,0.802]	0.809[0.798,0.822]	0.799[0.79,0.812]
Delong		0.962[0.76,1.146]	0.907[0.769,1.248]	1.786[1.544,2.057]	1.249[1.038,1.531]
p-value Delong		0.17[0.126,0.224]	0.186[0.106,0.221]	0.039[0.02,0.061]	0.109[0.063,0.15]
NRI		0.25[0.221,0.279]	0.086[0.037,0.114]	0.264[0.228,0.335]	0.246[0.2,0.29]
p-value NRI		0.033[0.019,0.049]	0.265[0.198,0.391]	0.028[0.006,0.045]	0.037[0.015,0.068]
IDI		0.013[0.012,0.015]	0.005[0.004,0.006]	0.017[0.016,0.017]	0.012[0.011,0.014]
p-value IDI		0.018[0.01,0.027]	0.156[0.112,0.194]	0.021[0.016,0.027]	0.033[0.02,0.045]
AIC	369.58[364.48,373.761]	364.965[360.306,368.281]	368.289[363.33,372.118]	362.741[357.726,366.91]	364.854[360.058,368.446]
-2logL	347.58[342.48,351.761]	340.965[336.306,344.281]	344.289[339.33,348.118]	338.741[333.726,342.91]	340.854[336.058,344.446]
D		6.615[6.174,7.48]	3.291[3.01,3.643]	8.839[8.669,8.961]	6.726[6.366,7.315]
p of D		0.01[0.006,0.013]	0.07[0.056,0.083]	0.003[0.003,0.003]	0.01[0.007,0.012]

Note: Fit indices for models with only the advisee individual differences (first column, model: none), the Rapport subscale as a predictor added to them (see second column, model: Rapport), the Apprenticeship subscale added to the individual differences, the Identification subscale added to the individual differences, and the total score added to the individual differences. The Delong test, the NRI, the IDI, and the likelihoods ratio test measure if adding a subscale as a predictor to the abilities, interests, achievement motivation, and sex of the advisee improves the model fit.

Table O4

Fit indices for being an upcoming STEM leader as the outcome and the subscales as the predictors.

model	None	Rapport	Apprenticeship	Identification	Total score
Rsq	0.073[0.071,0.075]	0.077[0.075,0.08]	0.073[0.071,0.076]	0.076[0.074,0.078]	0.075[0.073,0.078]
Max. Rescaled Rsq	0.097[0.094,0.1]	0.104[0.101,0.106]	0.098[0.095,0.101]	0.102[0.099,0.105]	0.101[0.098,0.104]
Hosmer	4.259[1.585,7.995]	6.368[4.153,8.704]	2.822[1.082,3.721]	3.29[1.548,5.594]	3.036[1.245,5.062]
p-value Hosmer	0.797[0.434,0.991]	0.61[0.368,0.843]	0.927[0.881,0.998]	0.884[0.693,0.992]	0.907[0.751,0.996]
AUC	0.653[0.653,0.653]	0.657[0.655,0.659]	0.653[0.652,0.656]	0.656[0.654,0.659]	0.656[0.654,0.659]
AUC LL	0.606[0.606,0.606]	0.61[0.608,0.612]	0.606[0.604,0.608]	0.608[0.607,0.611]	0.608[0.607,0.611]
AUC UL	0.701[0.701,0.701]	0.705[0.703,0.707]	0.701[0.7,0.703]	0.704[0.702,0.707]	0.704[0.702,0.706]
Delong		0.881[0.737,1.055]	0.821[0.569,1.096]	0.799[0.551,0.953]	0.848[0.733,1.051]
p-value Delong		0.191[0.146,0.231]	0.209[0.136,0.285]	0.214[0.17,0.291]	0.2[0.147,0.232]
NRI		0.159[0.141,0.173]	-0.009[-0.02,0.002]	0.153[0.139,0.187]	0.105[0.096,0.132]
p-value NRI		0.04[0.027,0.058]	0.54[0.493,0.59]	0.047[0.019,0.062]	0.124[0.07,0.143]
IDI		0.005[0.005,0.005]	0.001[0.001,0.001]	0.004[0.004,0.004]	0.003[0.003,0.003]
p-value IDI		0.061[0.058,0.063]	0.259[0.247,0.271]	0.066[0.06,0.073]	0.103[0.097,0.109]
AIC	671.947[670.837,673.124]	671.489[670.352,672.601]	673.685[672.548,674.859]	672.109[670.965,673.142]	672.561[671.405,673.689]
-2logL	649.947[648.837,651.124]	647.489[646.352,648.601]	649.685[648.548,650.859]	648.109[646.965,649.142]	648.561[647.405,649.689]
D		2.458[2.343,2.524]	0.262[0.227,0.289]	1.838[1.689,1.982]	1.386[1.299,1.442]
p of D		0.117[0.112,0.126]	0.61[0.591,0.634]	0.176[0.159,0.194]	0.239[0.23,0.254]

Note: Fit indices for models with only the advisee individual differences (first column, model: none), the Rapport subscale as a predictor added to them (see second column, model: Rapport), the Apprenticeship subscale added to the individual differences, the Identification subscale added to the individual differences, and the total score added to the individual differences. The Delong test, the NRI, the IDI, and the likelihoods ratio test measure if adding a subscale as a predictor to the abilities, interests, achievement motivation, and sex of the advisee improves the model fit.

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