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558th Flying Training Squadron Sensor Operator Production Analysis

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Abstract: The 558th Flying Training Squadron (FTS) is an Air Force training squadron tasked with training remotely piloted aircraft (RPA) sensor operators. Sensor operators for RPAs are essential for collecting intelligence to inform strategic decisions for military forces. To qualify for this role, individuals must complete the Basic Sensor Operator Course (BSOC) offered by the 558th FTS. The 558th FTS has the goal to achieve a BSOC passing rate of at least 90%; however, the current passing rate is 83%. To improve this statistic, multiple mathematical models were developed using Armed Services Vocational Aptitude Battery (ASVAB) test scores and section scores, an exam meant to determine eligibility for a military career, to identify students who are more likely to be successful in the BSOC course. Our models suggest that ASVAB scores are not correlated with passing or failing BSOC. Therefore, the analytics team recommends not using ASVAB scores to predict the pass/fail rate of BSOC. A more holistic approach to assessing each candidate's desire to be an RPA sensor operator would likely produce more significant results.

Keywords: Logistic Regression, Sensor Operators

1. Introduction

The 558th Flying Training Squadron (FTS) is an Air Force training squadron focused on training remotely piloted aircraft (RPA) sensor operators. As the 558th FTS is the only squadron that conducts the basic sensor operator course (BSOC), all future sensor operators go through the 558th FTS for training. The squadron has a BSOC student production requirement of 236 sensor operators annually. Sensor operators conduct reconnaissance and surveillance of targets of interest using RPA equipment. Sensor operators must complete the BSOC at the 558th FTS to stay in the career field. To pass the BSOC course, students must pass seven exams each with a score of 80% or better. If a student is unable to meet this standard, they wash out (i.e., fail out) of the course and are reassigned to a different career field. An RPA flight needs one pilot and one sensor operator. The 558th FTS has seen an increase in washout rate during the BSOC course. Historically, they saw a 10% attrition rate from the BSOC course, but now the attrition rate is about 17%. If too many students fail out of the training course, the 558th FTS will not be able to supply the number of sensor operators needed to fill the required positions in the Air Force. If the cause of the washout rate can be resolved, the attrition of students at the 558th FTS can be reduced by screening candidates for predictors of washing out. This will lead to more mission-capable operators, and the 558th will be able to utilize their time and resources more efficiently.

1.1 Problem Statement

Recently, students of the 558th FTS BSOC, at Randolph Air Force Base, Texas, have been washing out at a rate of 17%, much higher than the historical 10%. If this rate continues, the 558th BSOC production requirements will not be met, and the mission of the 558th FTS and the RPA career field will be adversely affected.

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1.2 Data

The 558th FTS provided a data frame containing 1628 observations of students' ASVAB testing results. This included their scores in each sub-category of the test (Administrative, General, Electronics, and Mechanical), their total ASVAB score, and whether they passed or failed the BSOC course.

1.3 Related Work

In related situations surrounding increased attrition in military schooling, there is a common thread of either validating or dismissing the Armed Services Vocational Aptitude Battery (ASVAB) test as a predictor of success. If the ASVAB test was found to be an effective predictor, authors would use it to make predictions, but with the caveat that some aspects of the test may be weighted higher than others (Carretta, 2015). If the ASVAB was not found to be a good predictor of attrition, researchers looked at other previously recorded data to make predictions, such as previous education certifications or demographic information (Howse, 2011).

Further, multiple researchers have investigated whether certain personality traits contribute to RPA pilot attrition. For example, in the research paper "Towards Predicting Completion for United States Air Force (USAF) RPA Training," Driggs (2017, p. i), suggests that the leading cause of training attrition has been attributed to a "lack of critical thinking and problem-solving skills" (p. i). The author suggests screening trainees for a broader pool of characteristics could solve the problem of attrition in the RPA training environment (Driggs, 2017). If proven to be a valid predictor, using ASVAB test scores could enable our group to determine which characteristics are significant indicators for attrition.

Using an approach of validating or dismissing the ASVAB test as a predictor of success, the analytics team first evaluated the relationship between ASVAB test scores, as well as individual ASVAB test section scores as they relate to the 558th BSOC pass/fail rate. There was little correlation between ASVAB scores and performance on the 558th FTS's BSOC course (Figure 1). Because the ASVAB test was an ineffective predictor, the analytics team worked with the 558th to identify data that could be statistically significant predictors including skill-specific traits or personality tests. The combination of the above approaches will seek to ascertain and address the 558th FTS's high attrition, possibly by putting more resources and focus on individuals who are predicted to pass the course, and likewise, intervene and help with the students who are predicted to fail the course. However, simply being able to identify individuals who are likely to fail or pass the course will be very helpful.

2. Methodology

The 558th suggested that ASVAB test scores would be a good indicator of the capability to succeed in BSOC. They provided the ASVAB test scores for all their students for the past five years from 2018 through 2022. The 558th also provided the BSOC test scores for all these students. Therefore, within the confines of the dataset, the analytics team first completed an initial data exploratory analysis to look at different trends within the data over time such as any significant change in the test-failure rate over time, if the average scores have drifted over time, and if ASVAB test scores are correlated with BSOC course failure. However, this analysis was limited due to the scope of our dataset. Next, the analytics team looked for correlations to determine if the high washout rate is correlated to ASVAB test performance. To achieve this, the analytics team created two different models. The first model created was a linear model that predicted student grades in the BSOC course based on their ASVAB test scores. The second model was a logistic regression model that predicted a student's probability of success in the entire course based on their ASVAB test scores. These models demonstrated if there was a relationship between ASVAB test scores and the washout rate of students at BSOC. With the relationship established from the model, the analytics team created suggestions for admission or additional testing requirements for the client to increase the admission of students who are more likely to complete the program.

3. Modeling and Analysis

Our team's modeling approach was to first look at patterns in the data, then using that information, apply it to classification models to find out if ASVAB scores were effective predictors of passing or failing. Our initial approach consisted of creating a correlation matrix to evaluate whether there were trends in the data. The most important takeaway from Figure 1 below is the black sections that show that no section of the ASVAB is highly correlated with passing or failing the BSOC.

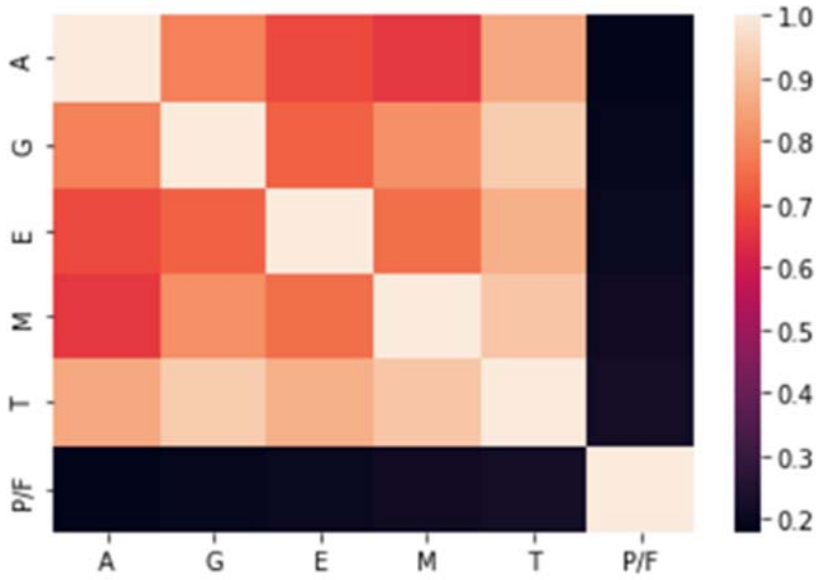

Figure 1. Correlation Matrix of ASVAB Scores and Pass/Fail as a Binary Variable

This exploration made us believe that there could be a solution to predicting attrition using ASVAB scores because there were differences in averages of airmen who pass and who fail. The analytics team then tried to apply this information to create models that predict attrition using ASVAB scores.

Table 1. Average Scores of Airmen who Pass/Fail BSOC

Average Scores	Pass	Fail	T-Test p-value between both means
Administrative	70.92	63.08	3.79E-13
General	68.31	58.39	1.80E-14
Electrical	73.11	64.5	4.76E-18
Mechanical	62.95	49.42	4.55E-18
Total ASVAB Score	275.29	235.40	5.27E-19

The analytics team took the data they were given and randomly split it into a testing set and a training set with 70% training and 30% of the data dedicated to testing. Using the sets of data, a multivariable logistic regression model, described in Equation 1, was created in Stata to learn more about the relationship between the four sections of the ASVAB and the probability of someone passing (Table 2). The relevant information is the Pseudo R2 value and the P>|z| column. The Pseudo R2 value indicates how well a model can predict an outcome given a set of data. A desirable Pseudo R2 is between 0.2 and 0.4. Our Pseudo R2 is less than half of that target range. The P>|z| column represents the p-value of the variables in our model. We are looking for a value of 0.05 or less. A value less than 0.05 indicates the significance of the variable. Only the electronic and mechanical sections of the ASVAB score are significant at a 95% confidence level. Due to their lack of significance, the general score and administrative score should be dropped from the model, but this will also lower the Pseudo R2 value. Although the model will be able to make predictions, the ASVAB model is guaranteed to have less than sufficient predictive power unless additional relevant variables are added to the model because of the lower Pseudo R2 value.

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$$Pass = \beta_0 + \beta_1(Administrative) + \beta_2(General) + \beta_3(Electronics) + \beta_4(Mechanical) \quad (1)$$

Table 2. Logistic Regression of Passing vs. ASVAB Section Scores

Variables	Coefficient	Std. Error	z	P>|z|	95% Confidence	Interval
Admin Score	0.0149843	0.0098958	1.51	0.130	-0.0044111	0.0343797
General Score	-0.0038346	0.0098161	-0.39	0.696	-0.0230738	0.0154046
Electrical Score	0.02416	0.0099594	2.43	0.015	0.0046399	0.0436801
Mechanical Score	0.0247969	0.0078924	3.14	0.002	0.0093281	0.0402657
Constant	-1.671986	0.5529677	-3.02	0.002	-2.755783	-0.5881895

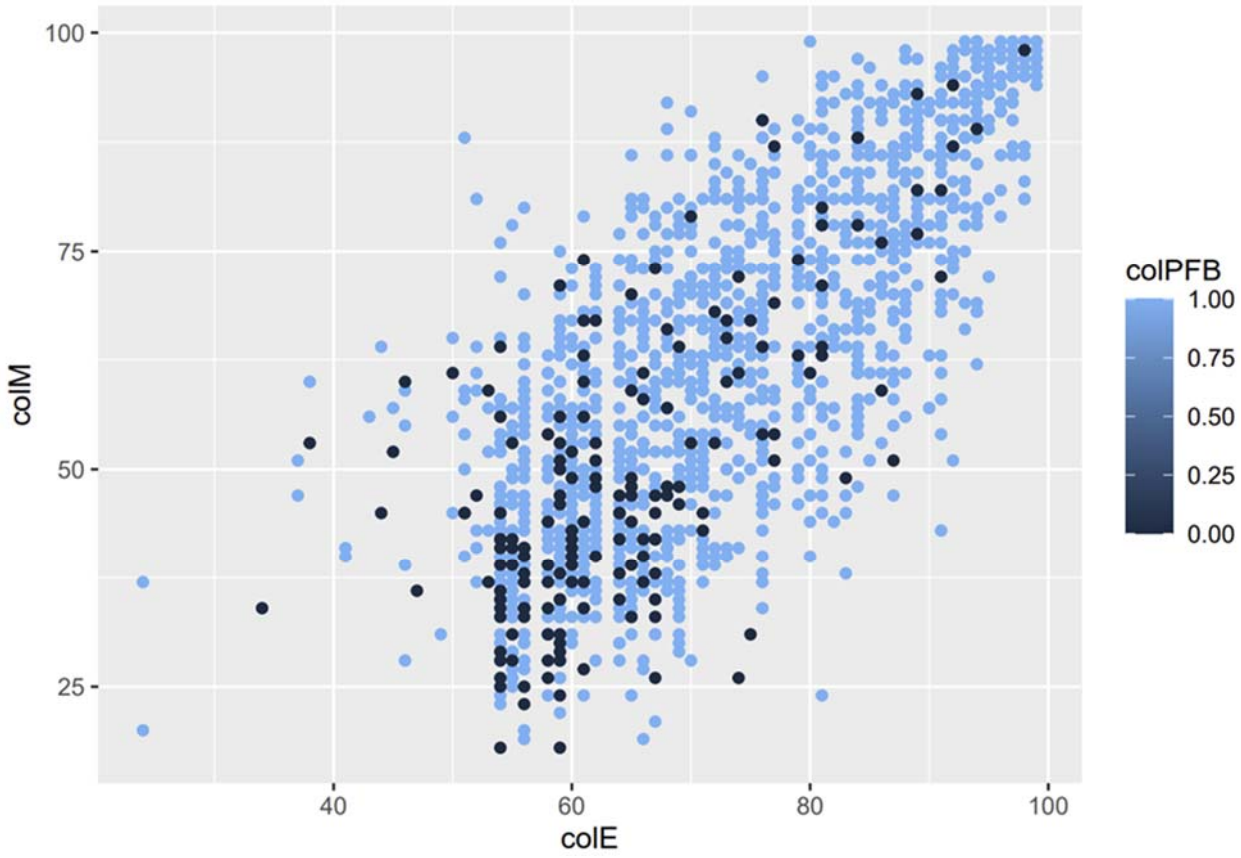

Figure 2. Scatter plot of the Electrical and Mechanical scores and color describing pass or fail

Although there are differences of 8.61 and 13.53 between the mean passing and failing scores for the electrical and mechanical components respectively, the data is unbalanced because there is much more data from the BSOC students that passed than from the students who failed. Figure 2 shows that students who fail the course are all over the spectrum of ASVAB scores and are not only on the lower end of ASVAB scores. Therefore, there is not enough evidence to confidently say that there is a relationship between ASVAB Scores and passing or failing BSOC.

Table 3. KNN, k=3, Confusion Matrix using Electrical and Mechanical scores

	Predicted 0	**Predicted 1**
Actual 0	2	54
Actual 1	17	437

Then, the data was split using a 70/30 training to test set ratio to be applied for KNN analysis. After training several KNN models at varying k values with different classification errors, it was noticed that they all produced a similar result and there was no optimal k value. The confusion matrix for the KNN k=3 model in Table 3 shows that the analytics team can predict the individuals who pass 96.26 % of the time correctly, while individuals who fail only 3.57% of the time correctly. Essentially, the KNN is really good at classifying the people who would pass, but terrible at classifying those who would fail.

4. Conclusions and Recommendations

The analysis showed that the ASVAB score data were not significantly correlated with passing or failing the BSOC course in any significant way. Although passers had, on average, higher scores than those who failed, this data proved to be difficult to apply in our analysis. The model used in Stata showed that the electronic and mechanical sections of the ASVAB had significant correlations with passing the BSOC at a 95% confidence level. However, the Pseudo R2 value was below the desired range of 0.2-0.4, indicating that the model was not predicting the outcome well. Results from the K-Nearest Neighbors model indicated that it was good at predicting who would pass but bad at predicting who would fail. There was a disproportionate amount of passing data compared to failing data which likely contributed to the lack of predictive power in our models. Any model the analytics team developed using ASVAB scores had an insufficient ability to predict if a student failed accurately. ASVAB scores alone should not be used as a relevant predictor of success in the BSOC course.

ASVAB scores have little predictive power in determining who failed the BSOC course, so additional variables need to supplement any modeling of this problem. The Air Force should not use ASVAB scores exclusively to determine eligibility for the RPA sensor operator career field.

5. Next Steps

In the future, the Air Force needs to start collecting more data on their BSOC students such as high school GPA, Air Force job preferences, and psychological exams to expand the data available to evaluate potential RPA sensor operators. ASVAB scores combined with these other predictors of success could be used to create a more comprehensive model for determining success in the RPA career field.

6. Future Work

Investigation into other qualitative metrics may be beneficial when attempting to forecast attrition from BSOC. Psychological tests could be employed to ascertain whether an individual is suited for the career path. Furthermore, interviewing those who do not pass BSOC could provide valuable information about the exact cause of failure. By combining interviews and psychological tests, trends may be identified, and more influential factors may be identified in comparison to ASVAB scores.

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7. References

Brown, N. L., Foroughi, C. K., Coyne, J. T., Sibley, C., Olson, T., & Myrick, S. (2019, November). Predicting attrition and performance in navy and marine corps air traffic control school. In Proceedings of the Human Factors and Ergonomics Society Annual Meeting (Vol. 63, No. 1, pp. 863-867). Sage CA: Los Angeles, CA: SAGE Publications.

Carretta, T. R., Rose, M. R., & Barron, L. G. (2015). Predictive validity of UAS/RPA sensor operator training qualification measures. *The International Journal of Aviation Psychology*, *25*(1), 3-13.

Driggs, J. B. (2017). *Towards predicting completion for United States Air Force (USAF) remotely piloted aircraft (RPA) training*. Arizona State University.

Howse, W. R. (2011). *Knowledge, skills, abilities, and other characteristics for remotely piloted aircraft pilots and operators*. DAMOS AVIATION SERVICES INC GURNEE IL.