A Role of Neural Network in Student Success Survey Analysis

ARTIFICIAL NEURAL NETWORK

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DALLAS COLLEGE

Grit

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Stress

Introduction

- In addition to cognitive abilities (aptitude, intelligence), it is time to explore the impact of noncognitive abilities (passion, determination, perseverance) to student success.
- Grit (one's ability to overcome obstacles to reach a long-term goal) and stress (one's response to a stressful situation) are two main factors to determine the student success that we are interested in this research study.

Method

- 200 students of color at two mid-size public community colleges in Texas were asked to take three assessments: Grit Assessment, the Perceived Stress Survey, and the Brief COPE scale.*
- Demographic information of the above students were also collected.

* The data set was originally collected for a different research of Dr. LaJuanda Bonham Jones (Dallas College).

Descriptive statistics of data sample

Gender

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1 – Male	58	29.0	29.0	29.0
	2 - Female	142	71.0	71.0	100.0
	Total	200	100.0	100.0	

Select your age category.

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1 – Under 18	21	10.5	10.5	10.5
	2 – 18-24	89	44.5	44.5	55.0
	3 – 25-34	36	18.0	18.0	73.0
	4 – 35 or older	54	27.0	27.0	100.0
	Total	200	100.0	100.0	

Descriptive statistics of data sample

Parents educational attainment

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1 – No college	90	45.0	45.0	45.0
	2 – Some colleges but no degree	65	32.5	32.5	77.5
	3 – college degree	45	22.5	22.5	100.0
	Total	200	100.0	100.0	

First-generation

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	0 – no	110	55.0	55.0	55.0
	1 – yes	90	45.0	45.0	100.0
	Total	200	100.0	100.0	

Descriptive statistics of data sample

Ethnicity - Selected Choice

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	2 – African American	88	44.0	44.0	44.0
	3 - Hispanic	104	52.0	52.0	96.0
	4 - Other	8	4.0	4.0	100.0
	Total	200	100.0	100.0	

Employment status - Selected Choice

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1 – Not working	64	32.0	32.0	32.0
	2 – Currently working	136	68.0	68.0	100.0
	Total	200	100.0	100.0	

Grit assessment (brief version of 8 questions)

- New ideas and projects sometimes distract me from previous ones.
- Setbacks don't discourage me.
- I have been obsessed with a certain idea or project for a short time but later lost interest.
- I am a hard worker.

- ❑ Very much like me
- ❑ Mostly like me
- ❑ Somewhat like me
- ❑ Not much like me
- ❑ Not like me at all

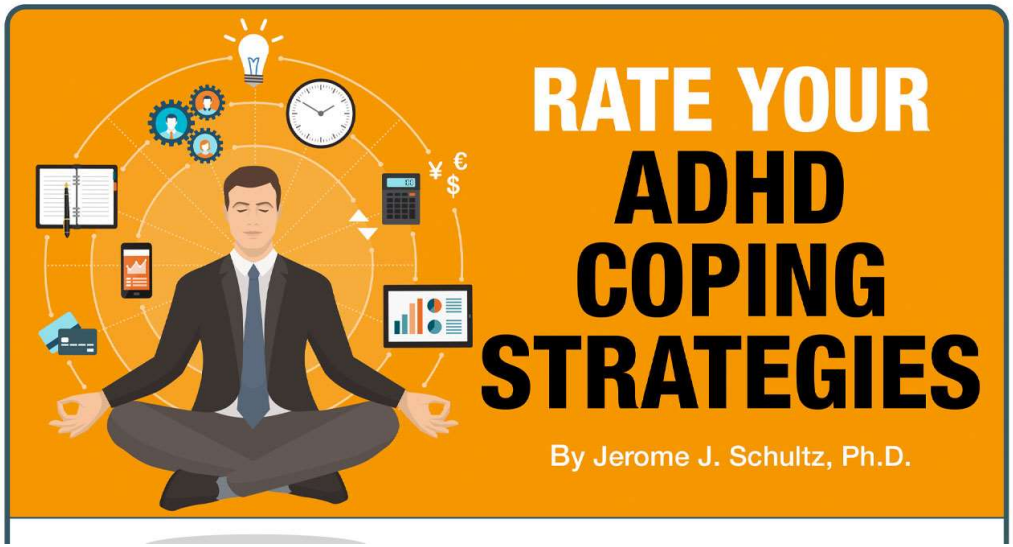
Perceived Stress Assessment (brief version of 10 questions)

- In the last month, how often have you been upset because of something that happened unexpectedly?
- In the last month, how often have you felt that you were unable to control the important things in your life?
- In the last month, how often have you felt nervous or "stressed"?
- In the last month, how often have you felt confident about your ability to handle your personal problems?
- In the last month, how often have you felt that things were going your way?

☐ Never
☐ Almost never
☐ Sometimes
☐ Fairly often
☐ Very often

Cope Assessment (brief version of 28 questions)

- I've been turning to work or other activities to take my mind off things.
- I've been concentrating my efforts on doing something about the situation I'm in.
- I've been saying to myself "this isn't real".
- I've been using alcohol or other drugs to make myself feel better.
- I've been getting emotional support from others.
- I've been giving up trying to deal with it.
- I've been taking action to try to make the situation better.
- I've been refusing to believe that it has happened.

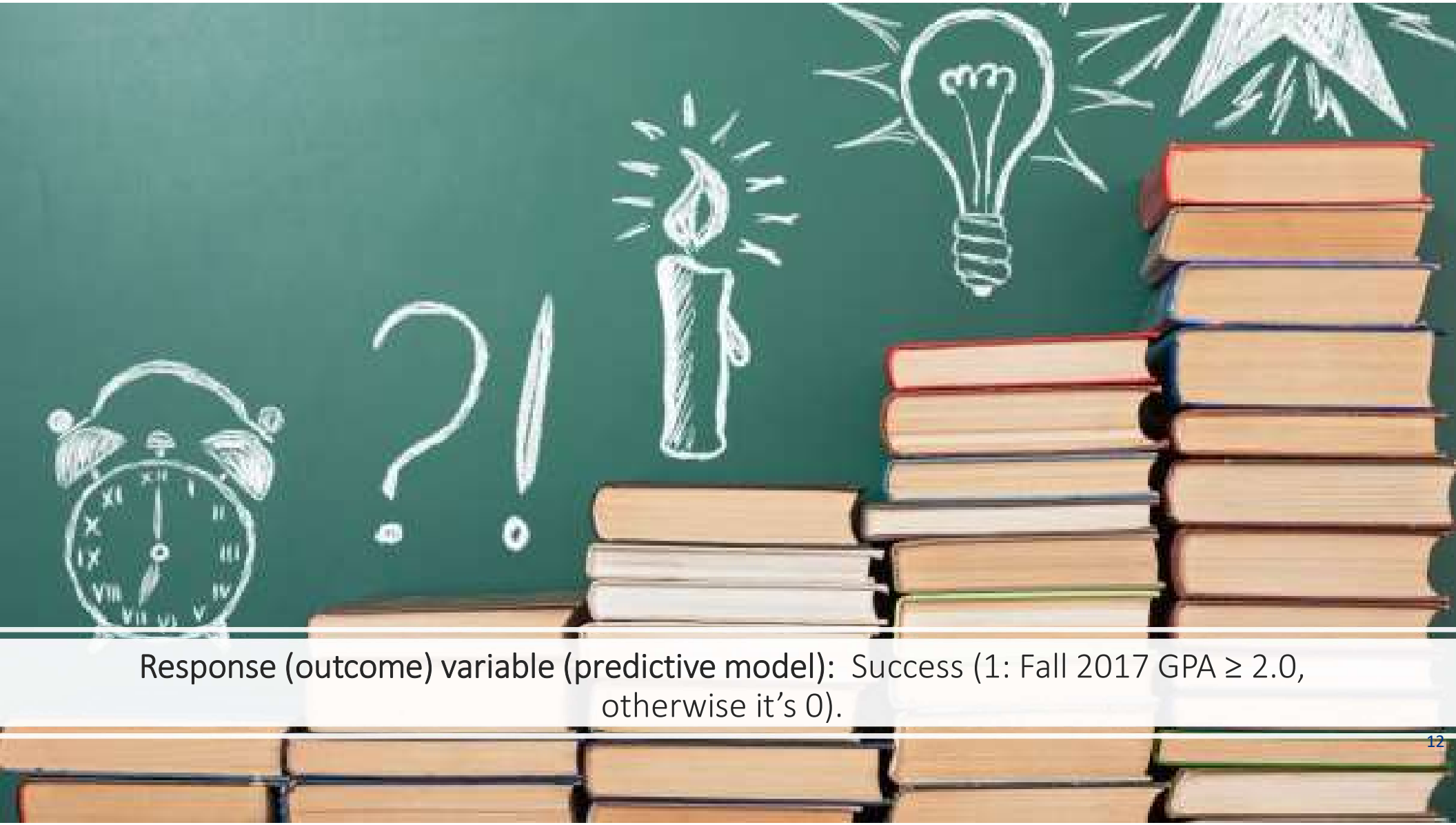


I haven't been doing this at all

I've been doing this a little bit

I've been doing this a medium amount

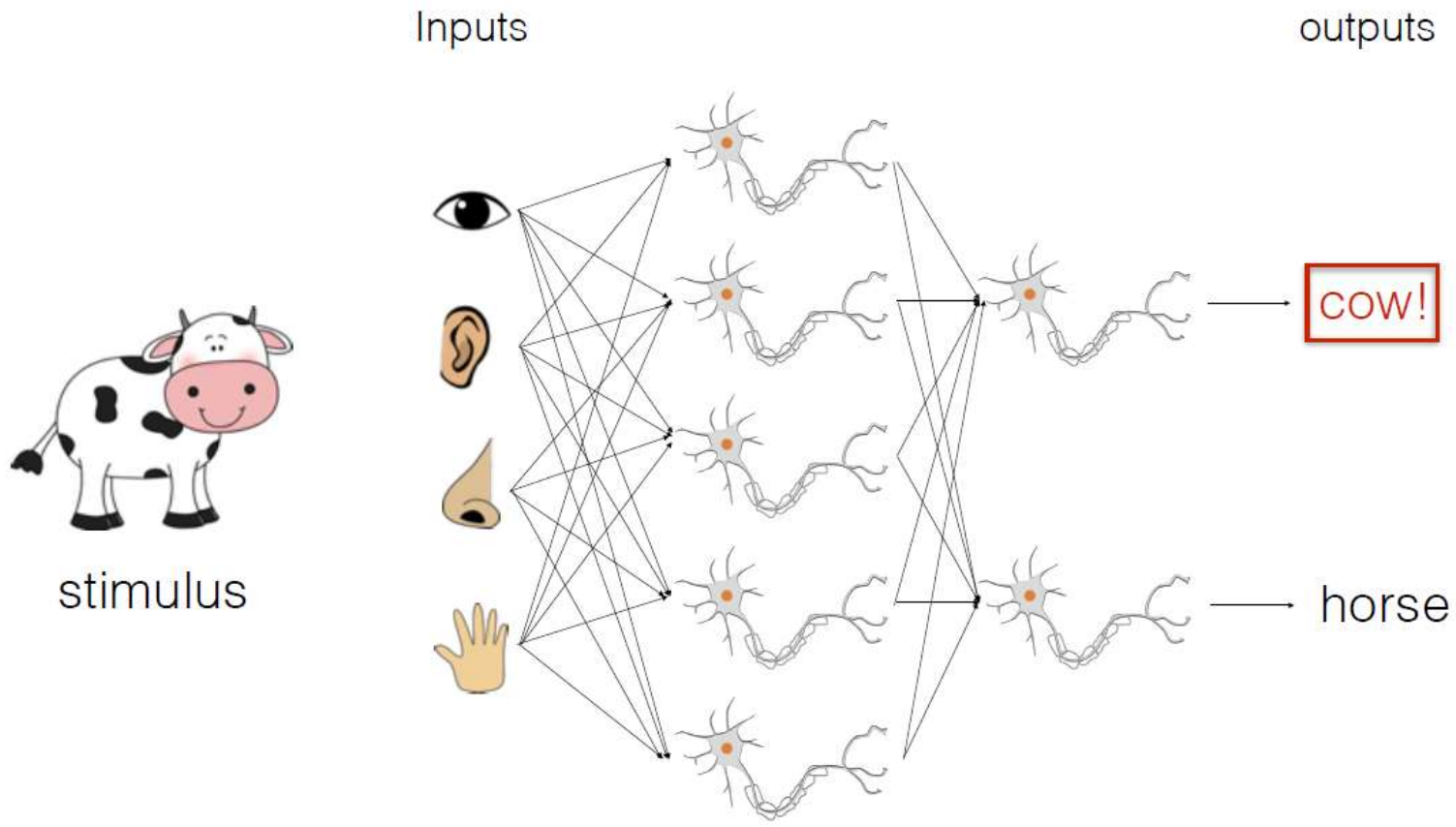
I've been doing this a lot



Response (outcome) variable (predictive model): Success (1: Fall 2017 GPA ≥ 2.0, otherwise it's 0).

Neural Network

Neural Network is the representation of brain's learning approach

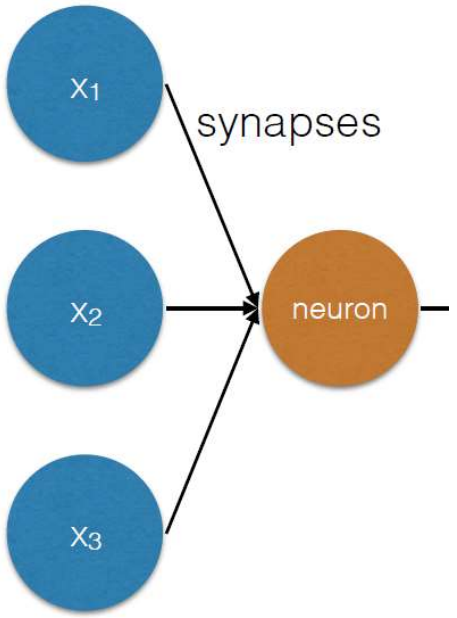


Artificial neuron

- Perceptron (artificial neuron) is a mathematical model of a biological neuron
- Activation of neuron: value computed by a neuron model

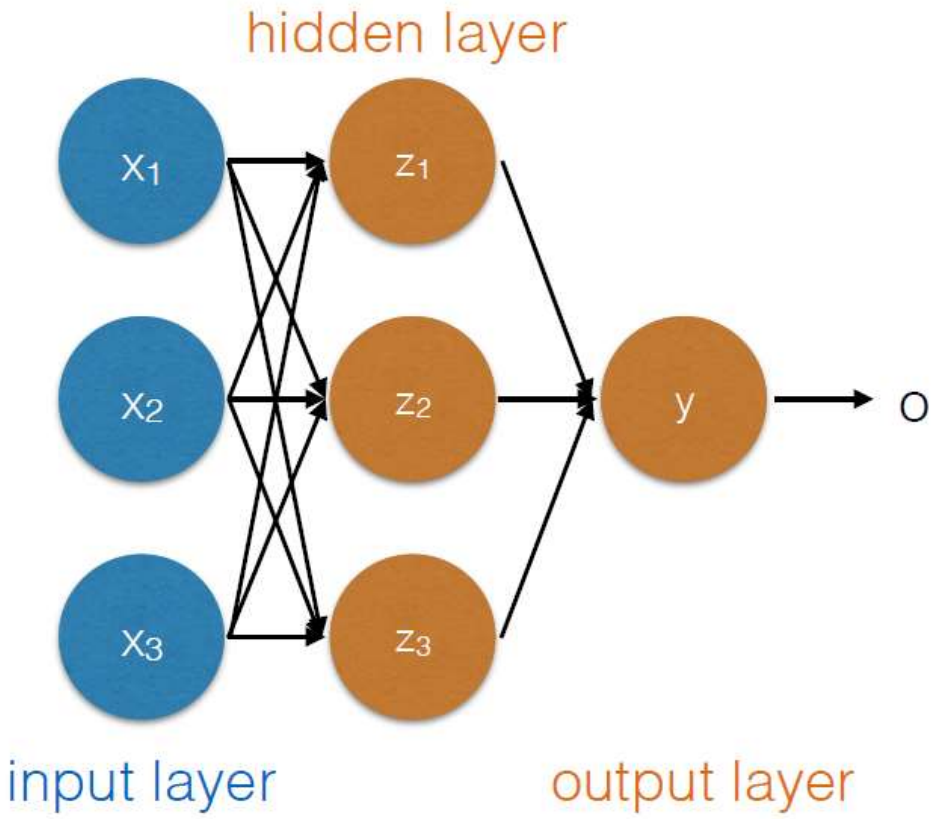
$$z = \sigma(\alpha_0 + \alpha' x)$$

  - input vector: $x = (x_1, x_2, x_3)$, weights $\alpha = (\alpha_1, \alpha_2, \alpha_3)$ and α_0 (bias parameter).
  - Activation function σ is typically chosen to be the sigmoid (step and radial-basis function are commonly used).



Artificial neural networks

- Neural networks is a combination of many signal neuron models.
- z1, z2, z3: hidden unit (not directly observed).
- Synapses: connections represent weights.
- Neural networks can have either one hidden layer (vanilla neural net/single hidden layer back – propagation network/single layer perceptron) or multiple hidden layers.



- **The Multilayer Perceptron (MLP) procedure produces a predictive model for one or more dependent (target) variables (Nominal, ordinal or scale) based on the values of the predictor variables.**
- **In this case, the target variable is Nominal variable - success (1 = Yes, Fall 2017 GPA ≥ 2.0; 0 = No, Fall 2017 GPA < 2.0).**

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*Multilayer Perceptron Network.
MLP success (MLEVEL=N) BY Gender Age_group Parenst_edu_level First_gen Ethnici
ty Emp_status G1 G2
    G3 G4 G5 G6 G7 G8 S1 S2 S3 S4 S5 S6 S7 S8 S9 S10 C1 C2 C3 C4 C5 C6 C7 C8 C
9 C10 C11 C12 C13 C14 C15
    C16 C17 C18 C19 C20 C21 C22 C23 C24 C25 C26 C27 C28 WITH Number_enrl_cours
es Number_working_hr_A
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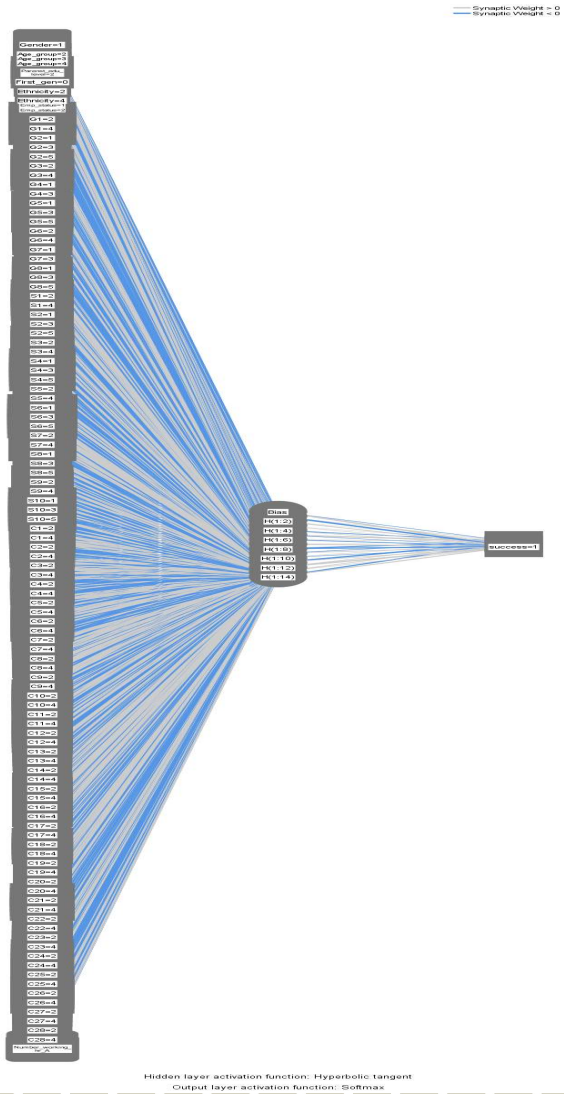


- Feed-forward architecture: the connections in the network flow forward from the input layer to the output layer.
- The input layer contains the predictors.
- The hidden layer contains unobservable nodes/units.
- The output layer contains the responses (success).
- The MLP network can allow a second hidden layer (not in this example); each unit of the second hidden layer is a function of the units in the first hidden layer, and each response is a function of the units in the second hidden layer.
- Bias Unit: In a typical artificial neural network each neuron/activity in one "layer" is connected - via a weight - to each neuron in the next activity. Each of these activities stores some sort of computation, normally a composite of the weighted activities in previous layers. A bias unit is an "extra" neuron added to each pre-output layer that stores the value of 1. Bias units aren't connected to any previous layer and in this sense don't represent a true "activity".

Model Summary

Model Summary

Training	Cross Entropy Error	35.968
	Percent Incorrect Predictions	11.4%
	Stopping Rule Used	1 consecutive step(s) with no decrease in error[a]
	Training Time	0:00:00.67
Testing	Cross Entropy Error	5.387
	Percent Incorrect Predictions	2.0%

Dependent Variable: success

a. Error computations are based on the testing sample.

- A summary of the neural network results by partition and overall, including the error, the relative error/percentage of incorrect predictions, the stopping rule used to stop training, and the training time.
- The error is the sum-of-squares error when the identity, sigmoid, or hyperbolic tangent activation function is applied to the output layer. It is the cross-entropy error when the softmax activation function is applied to the output layer.
- Relative errors/percentages of incorrect predictions are displayed depending on the dependent variable measurement levels.

Confusion matrix

Classification

Sample	Observed	Predicted 0	Predicted 1	Percent Correct
Training	0	1	13	7.1%
	1	0	100	100.0%
	Overall Percent	0.9%	99.1%	88.6%
Testing	0	1	1	50.0%
	1	0	47	100.0%
	Overall Percent	2.0%	98.0%	98.0%

Dependent Variable: success

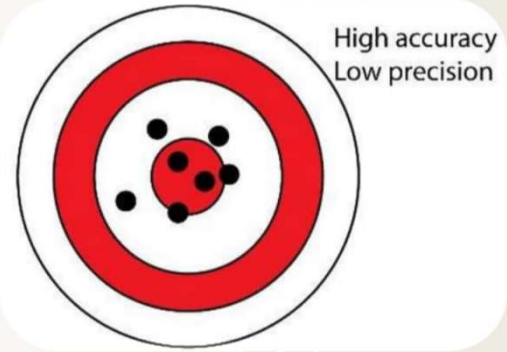
Accuracy Rate Calculation:

Training Accuracy Rate

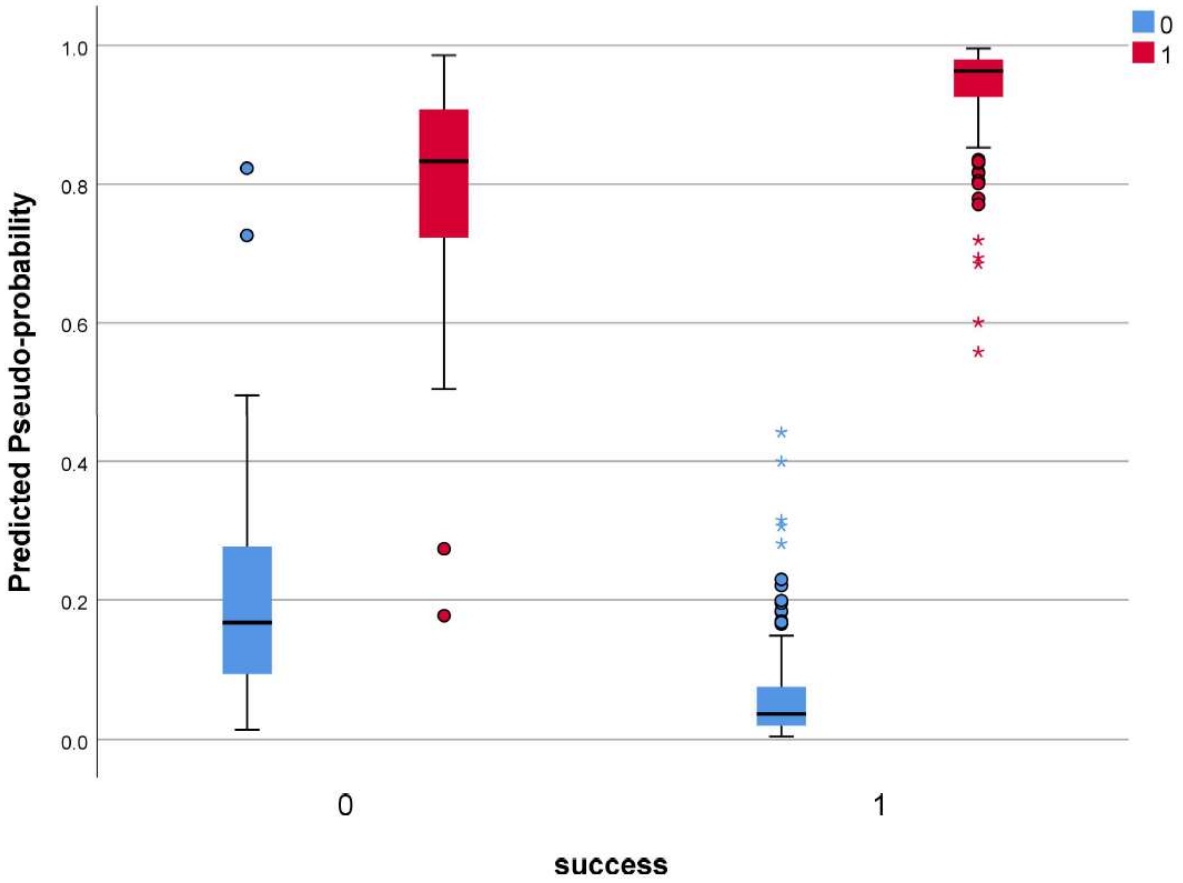
$$= \frac{(TP+TN)}{(TP+FP+TN+F\ )} = \frac{(100+1)}{(100+13+1+0)} = 88.6\%$$

Accuracy

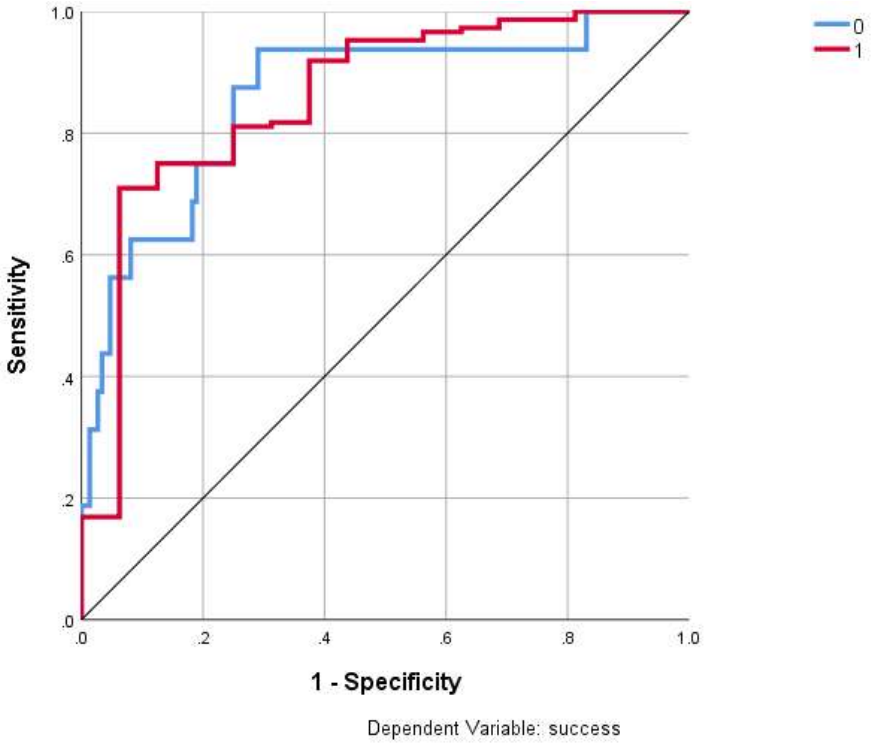
Accuracy



Predicted by observed chart



The ROC curve (Receiver Operating Characteristic)



Dependent Variable: success

Area Under the Curve

		Area
success	0	.859
	1	.859

- Plotting the Sensitivity-true positive rate (TPR)/probability of detection against the (1-specificity)-false positive rate (FPR)/probability of false alarm at various threshold settings.
- It can also be called a plot of the power as a function of the Type I Error of the decision rule. The ROC curve is thus the sensitivity as a function of fall-out.
- AUC is desirable for the following two reasons:
  - Scale-invariant. It measures how well predictions are ranked, rather than their absolute values.
  - Classification-threshold-invariant. It measures the quality of the model's predictions irrespective of what classification threshold is chosen.

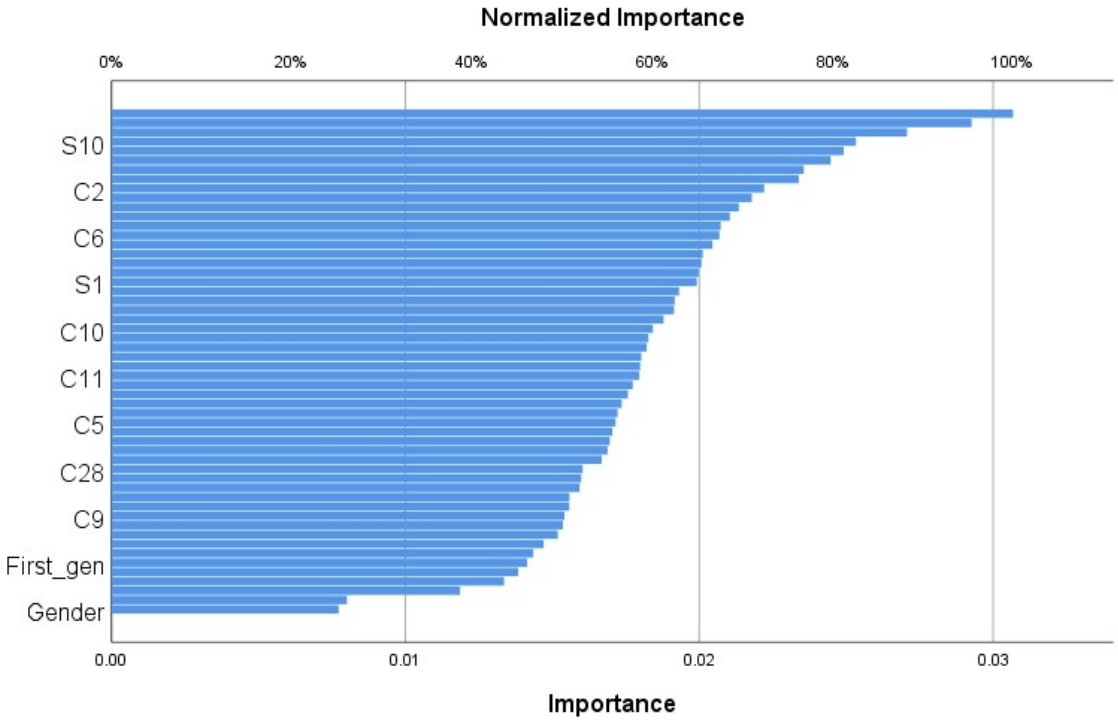
Independent Variable Importance

Independent Variable Importance

	Importance	Normalized Importance
Gender	.008	25.2%
Age_group	.015	49.5%
Parenst_edu_level	.020	65.1%
First_gen	.014	46.1%
Ethnicity	.012	38.6%
Emp_status	.008	26.1%
G1	.024	79.8%
G2	.015	47.9%
G3	.020	66.7%
G4	.014	45.1%
G5	.019	62.9%
G6	.017	55.3%
G7	.013	43.5%
G8	.018	57.8%
S1	.020	64.9%
S2	.019	62.4%
S3	.021	67.6%
S4	.023	76.2%
S5	.016	52.1%
S6	.027	88.2%
S7	.025	81.2%
S8	.016	51.9%
S9	.019	62.5%
S10	.025	82.6%
C1	.024	76.8%
C2	.022	72.4%
C3	.019	61.2%
C4	.021	69.6%
C5	.017	55.9%
C6	.021	67.4%
C7	.018	58.8%
C8	.017	56.1%
C9	.015	50.2%
C10	.018	60.1%
C11	.018	58.5%
C12	.018	59.4%
C13	.017	54.4%
C14	.015	50.1%
C15	.017	56.6%
C16	.018	57.3%
C17	.014	46.8%
C18	.018	59.6%
C19	.016	50.8%
C20	.016	50.8%
C21	.022	71.0%
C22	.017	55.0%
C23	.018	58.6%
C24	.020	65.6%
C25	.020	65.4%
C26	.021	68.6%
C27	.017	55.6%
C28	.016	52.3%
Number_enrl_courses	.029	95.4%
Number_working_hr	.031	100.0%

- The importance of an independent variable is a measure of how much the network's model-predicted value changes for different values of the independent variable.
- Normalized importance is simply the importance values divided by the largest importance values and expressed as percentages.

Normalized Importance



- The importance chart is simply a bar chart of the values in the importance table, sorted in descending value of importance.
- But we cannot tell the "direction“ of the relationship between these variables and the predicted probability of default.

Conclusion and Discussion

Conclusion

- We use a multilayer perceptron neural network (trained by the back-propagation algorithm) to identify the main predictors as well as predict the student success rate.
- According to neural network analysis, the most powerful predictors of student success rate were:
  - ✓ number working hour (number_working_hr, normalized importance = 100%),
  - ✓ number of enrolled courses (number_enrl_course, normalized importance = 95.4%),
  - ✓ responses from question 6 perceived stress assessment - In the last month, how often have you found that you could not cope with all the things that you had to do? (S6, normalized importance = 88.2%),
  - ✓ responses from question 10 perceived stress assessment - In the last month, how often have you felt difficulties were piling up so high that you could not overcome them? (S10, normalized importance = 82.6%),
  - ✓ responses from question 7 perceived stress assessment - In the last month, how often have you been able to control irritations in your life? (S7, normalized importance = 81.2%)

Discussion

- As we can see, according to the results, stress levels play an important role in student success rate.
- Students seem to be overworked and are taking on a lot of responsibilities.
- Future studies on perceived stress should put additional focus on indicators/multifaceted methods that may better reflect how these cognitive processes elicit a response.
- We could also increase the sample size (find a way to increase student participation in the survey) and include class information such as class difficulty level, tutoring session attendance, etc.

Contact Info

- Feel free to send your question/suggestion/ discussion to:

  Daniel Le

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References

- **Survey dataset from "The role of grit and stress in the success of First – Generation minority students at the community college", Dr. LaJuanda Bonham Jones (Dallas College).**
- **Why are college students so stressed?**
  https://www.youtube.com/watch?v=0EUx0YgGebQ
- GRIT: Traits that Matter for School, Work, and Life

  https://www.youtube.com/watch?v=vzle_Puyg5o
- Neural Network In 5 Minutes | What Is A Neural Network? | How Neural Networks Work | Simplilearn

  https://www.youtube.com/watch?v=bfmFfD2RIcg
- **Dr. Yun, Jonghyun, Data mining lecture note, UTA Math Department, 2019.**

THANK YOU FOR LISTENING!