Exploring the Effects of Growth Mindset Usernames in STEM Games

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Abstract

One focus of researchers has been on the *growth mindset*, or the belief that intelligence is malleable (Dweck, 2006). This study explores whether merely having a *username* that draws upon a growth mindset (e.g., HardWork) can improve outcomes over a username that draws upon a *fixed mindset* (e.g., GoodGenes). A total of 1876 participants played three games: 1) a CS programming game, 2) the Tower of Hanoi, and 3) a math game. Participants randomly assigned a growth mindset username have significantly higher programming self-beliefs, and spent a significantly longer time on the math game. In contrast, participants assigned a fixed mindset username completed the Tower of Hanoi more often. Given the widespread prevalence of usernames, this study is an important first step in exploring their impacts.

Introduction

According to Dweck (2006), there exists a continuum between *fixed mindsets* (believing that intelligence is fixed) and *growth mindsets* (believing that intelligence is malleable). For example, it has been demonstrated that when children are given

praise, such as "good job; you're very smart," they will more often develop a fixed mindset. In contrast, when children are given praise, such as "good job; you worked very hard," they will more often develop a growth mindset (Kamins & Dweck, 1999; Mueller & Dweck, 1998). Importantly, growth mindsets are associated with greater work, social, and academic achievements (Blackwell, Trzesniewski, & Dweck, 2007; Smiley & Dweck, 1994; Yeager & Dweck, 2012). Taking these results into account, this study explores whether usernames that denote a growth mindset influence players of educational STEM games. To the best of our knowledge, this is the first study to research the effects of assigned usernames.

Related Work

Growth Mindset in Educational Games

Studies have found that encouraging the development of a growth mindset, or the belief that intelligence is malleable, increases player perseverance (O'Rourke, Haimovitz, Ballweber, Dweck, & Popović, 2014; O'Rourke, Peach, Dweck, & Popović, 2016). In addition, other researchers have found that participants who played puzzles with a growth mindset social robot self-reported having a stronger growth mindset, and tried harder during a challenging task (Park, Rosenberg-Kima, Rosenberg, Gordon, & Breazeal, 2017). Additional work in the related area of feedback and encouragement has also demonstrated that dispensing text encouragement at regular intervals improves engagement (Kao & Harrell, 2016).

Naming Practices in Games

Several recent studies have looked at naming in games (Crenshaw & Nardi, 2014; Hagström, 2008; Guitton, 2010; Drachen, Sifa, & Thurau, 2014; Thurau & Drachen, 2011). For example, Guitton (2010) found that female character names in World of Warcraft have more variability than male names, and also contained more vowels than male names (Guitton, 2010). This variability is closely related to players' identity and their visual representations (e.g., avatar). However, as Crenshaw and Nardi note, names also appear in many other instances where graphical representations do not, such as in chat, private messaging, and game forums (Crenshaw & Nardi, 2014). To the best of our knowledge, however, no study to date has assigned usernames and studied their effects.

Programming Self-Beliefs

Programming is an endeavor that students struggle with. Moreover, programming can invoke strong negative emotions (Rogerson & Scott, 2010; Huggard, 2004; Kinnunen & Simon, 2010). This influences programmers' perceptions of their own abilities, diminishing both their self-confidence and their identification with the subject matter (Scott & Ghinea, 2014). Therefore, it becomes important to measure self-beliefs, which have been shown to play an important role in academic development (Blackwell et al., 2007). In this study, we use the Programming Self-Beliefs Scale (Scott & Ghinea, 2014), which measures self-efficacy, self-concept, interest, anxiety, and aptitude mindset as it relates to programming..

The Games

The experiment used three games:

1. The CS programming game, *Mazzy* (Kao & Harrell, 2015)[1], previously used in other studies (Kao & Harrell, 2018) (See Figures 1 & 2).
2. The Tower of Hanoi, which is widely used as a problem solving assessment (Kotovsky, Hayes, & Simon, 1985) (See Figure 3).
3. A math game. In this game, players answer increasingly difficult fill-in-the-blank math questions (See Figure 4).

While the first two games can be completed, the last game cannot (the game can only be repeated and played an indefinite number of times). However, players can quit any of the games at any time.

Methods

This experiment aimed to compare two username conditions: (1) Growth Mindset Username, and (2) Fixed Mindset Username. The goal was to see if participants with these conditions have different game performance and self-beliefs as a result of their username.

Creating Usernames

Usernames were created and validated through a rigorous process using crowdsourcing. See Table 1 for details.

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[1] Gameplay video: http://youtu.be/n2rR1CtVal8

Final Usernames

Final growth mindset usernames were as follows:

- Grow_adapt_evolve
- EmbracingTheStruggle
- HardWork
- Constant_Effort
- FailureLeads2Success
- Working.Through.Difficulties.

Final fixed mindset usernames were as follows:

- KnowingYourAbilities
- RightThe1stTime
- GoodGenes
- Be_Smart
- Play_to_Your_Strengths
- Use.Your.Intelligence.

Conditions

The two username conditions tested were:

a. Growth Mindset Username
b. Fixed Mindset Username

Usernames were used to login to each game (See Figure 5). Usernames then appeared in-game on the bottom left of the screen on a 43 pixel high semi-

transparent black bar. The procedure, instructions, and gameplay were all identical across the two conditions; only the username was different (See Figures 6 and 7).

Quantitative and Qualitative Measures

How long participants played each game was studied, as well as the performance statistics associated with each game. The Programming Self-Beliefs Scale (Scott & Ghinea, 2014) was also administered, which is based on Control-Value Theory (Pekrun & Stephens, 2010; Pekrun, 2006). The Programming Self-beliefs Scale (PSB) questions range from 1: (Strongly Disagree) to 5: (Strongly Agree) and demonstrates adequate reliability and construct validity (Scott & Ghinea, 2014). It was necessary to adapt the wording of some items of this scale to match the context of the CS programming game. It was also necessary to remove one item from the scale ("I am confident that I can understand Java exceptions"), which was not relevant in this context.

Participants

1876 participants were recruited through Mechanical Turk (demographics Table 2). Participants were reimbursed $3.50 for participating in this experiment.

Design

A between-subjects design was used and username type was the between-subject factor. Participants were randomly assigned to a condition.

Procedure

Participants first received a randomly assigned username, which was dependent on their randomly assigned condition. Next, they created an account using a 4-digit PIN as their password. Users then played the three games (CS programming, Tower of Hanoi, and the math game) in a randomized order. Before each game, participants were informed that they could exit the game at any time via a red button in the corner of the screen. Each game had a login screen that prompted them to enter their username and PIN. For only the CS programming game, afterwards participants filled out the programming self-beliefs scale. After playing all three games, participants filled out a demographics survey.

Analysis

Player responses were analyzed using multivariate analysis of variance (MANOVA) in SPSS. The dependent variables were:

- Game_1_Time_Played
- Game_1_Levels_Completed
- Game_1_Total_Hints
- Game_2_Time_Played
- Game_2_Completion
- Game_2_Num_Moves
- Game_3_Time_Played
- Game_3_HighScore
- Game_3_Playthroughs

- PSB Scale Items

The independent variable was username type (i.e., 0 = growth mindset, 1 = fixed mindset) and was a dichotomous variable. To detect the significant differences between username conditions, we utilized one-way MANOVA. These results are reported as significant when $p<0.05$ (two-tailed).

Results

The results of this study show that growth mindset usernames led to significantly higher scores on the Programming Self-Beliefs Scale. Growth mindset usernames also led to significantly higher time played during the math game. However, growth mindset usernames led to a significantly lower likelihood of completing the Tower of Hanoi game. The following lists describe these results in fuller detail.

Aggregate

- Overall MANOVA was significant, $p<0.05$ (see Table 3).

Game Measures

- Univariate tests found six PSB questions to be significant, $p<0.05$ (see Figure 8 and Table 4):
    - I am just not good at programming, $p<0.01$ (Fixed>Growth).
    - I think programming is interesting, $p<0.05$ (Growth>Fixed).
    - I often get tense when I have to debug a program, $p<0.05$ (Fixed>Growth).

    - I feel helpless when trying to solve programming bugs, $p<0.05$ (Fixed>Growth).
    - I have a fixed level of programming aptitude, and not much can be done to change it, $p<0.05$ (Fixed>Growth).
    - To be honest, I do not think I can really change my aptitude for programming, $p<0.001$ (Fixed>Growth).
- Univariate testing found Game_3_Time_Played to be significant, $p<0.05$ (Growth>Fixed). (See Figure 9 and Table 5)
- Univariate testing found Game_2_Completion to be significant, $p<0.05$ (Fixed>Growth). (See Figure 11 and Table 5)
- Statistics for all games can be viewed in Figures 9, 10, 11, 12, and Table 5 (all figures show 95% confidence intervals).

Discussion

Summary of findings:

- Growth mindset condition participants have higher programming self-beliefs
- Growth mindset condition participants spend longer on the math game
- Fixed mindset condition participants are more likely to complete the Tower of Hanoi game

Usernames are as ubiquitous as technology itself. Facebook accounts, games, e-mail addresses, and computer logins are just some of the many examples. This study is the first to demonstrate that usernames impact our behaviors and programming

self-beliefs. Nonetheless, our results are conflicting with respect to growth and fixed mindset usernames. On one hand, outcomes improved with growth mindset usernames in the math game. On the other, outcomes were instead improved with fixed mindset usernames in the Tower of Hanoi. These results suggest that game type is somehow moderating the effects. Our hypothesis is that certain games are more conducive to a fixed or growth mindset. The Tower of Hanoi game only needed to be solved once and may encourage one-time skilled execution (fixed mindset). In contrast, the math game can be played repeatedly after losing, almost subtly encouraging practice, iteration, and improvement (growth mindset). We hypothesize that the task itself (and the framing of the task) is moderating the influence of usernames. However, further investigation is required to determine if this is the case.

Another interesting direction to consider is the Proteus effect, which describes the phenomenon whereby users conform to the expected behaviors associated with how an avatar appears (Yee & Bailenson, 2007). It would be interesting to consider whether these effects occur with a username. For example, whether assigning a more aggressive or more passive sounding username would induce corresponding behavioral changes. Such an effect, if shown, would have influence in a variety of domains.

Limitations

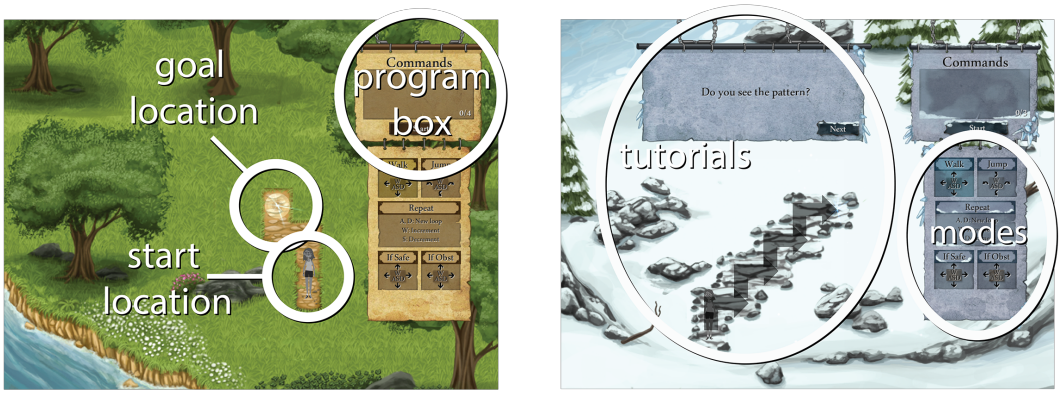
First, given the short duration of the study, there was not an opportunity to observe the long-term impacts of the usernames. Giving participants a computer username

with a growth mindset and observing their behavior over the course of years would elucidate the long-term impacts of having these types of usernames and repeatedly seeing/typing them. Second, assigning usernames such as those used for this study may not be practical, given that most people prefer to choose a username that represents them in some way. There are two potential solutions for this: a) Attach the phrase to an identifier, e.g. "Hard_Working_Rob" (with verbosity being the trade-off), and b) Do the same with the password instead of the username. The latter solution would still have the user repeatedly typing in the same phrase, but it would be invisible to the rest of the world, and would thus be less invasive than changing the username altogether.

In conclusion, this is the first study to date, to the best of our knowledge, that reveals the impacts of usernames on performance, and further demonstrates that usernames can significantly impact behavior and self-beliefs. Given the ubiquity of usernames, this study provides an important first step towards investigating the effects of usernames on both performance and behavior in ways that have been previously overlooked.

Figure 1 & 2

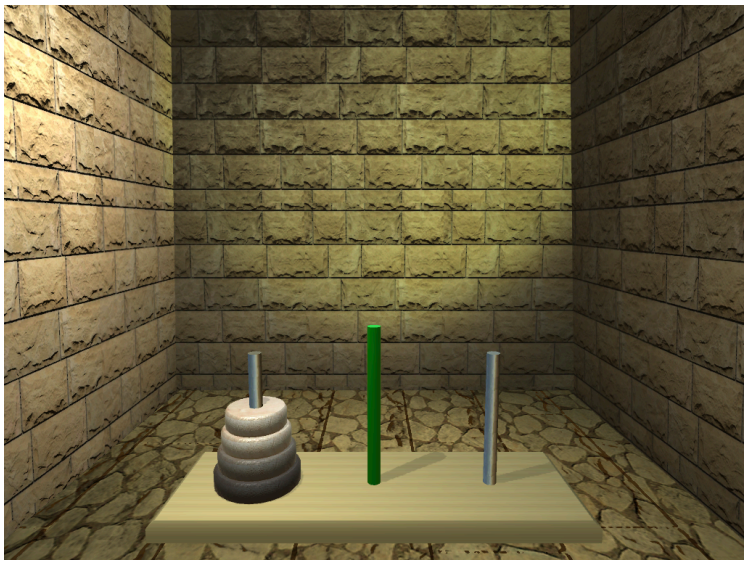
Mazzy Screenshots



Mazzy is a game in which players complete maze-like challenges by creating short computer programs. In total, there are 12 levels in this version of *Mazzy*. Levels 1-5 require only basic commands. Levels 6-9 require using loops. Levels 10-12 require using all preceding commands in addition to conditionals.

Figure 3

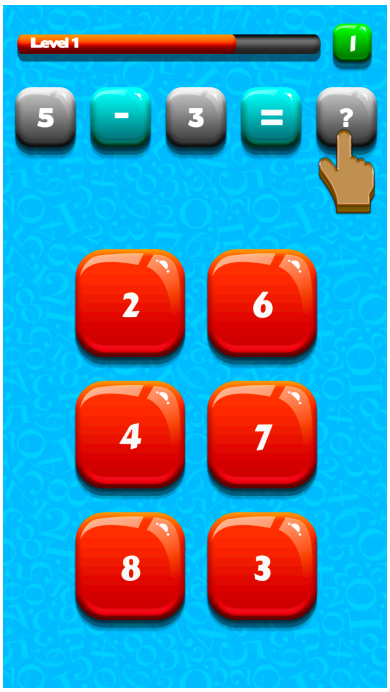
Tower of Hanoi Game



The goal in the puzzle is to move all the disks from the leftmost rod to the middlemost rod, with the following rules: 1) Only one disk can be moved in a single move, 2) Only the topmost disk on a rod can be moved to the top of a different rod, and 3) Disks can only be placed on top of larger disks.

Figure 4

Math Game



In this game, players answer increasingly difficult fill-in-the-blank math questions. There is a countdown timer at the top, and if the timer reaches 0 before the player has selected the correct answer, the current playthrough ends. Wrong answers decrease the timer by a fixed amount. Players can repeat playing the game as many times as they wish.

Figure 5

Login Screen

Figure 6 & 7

Growth and Fixed Conditions

Figure 8

PSB—Graphs

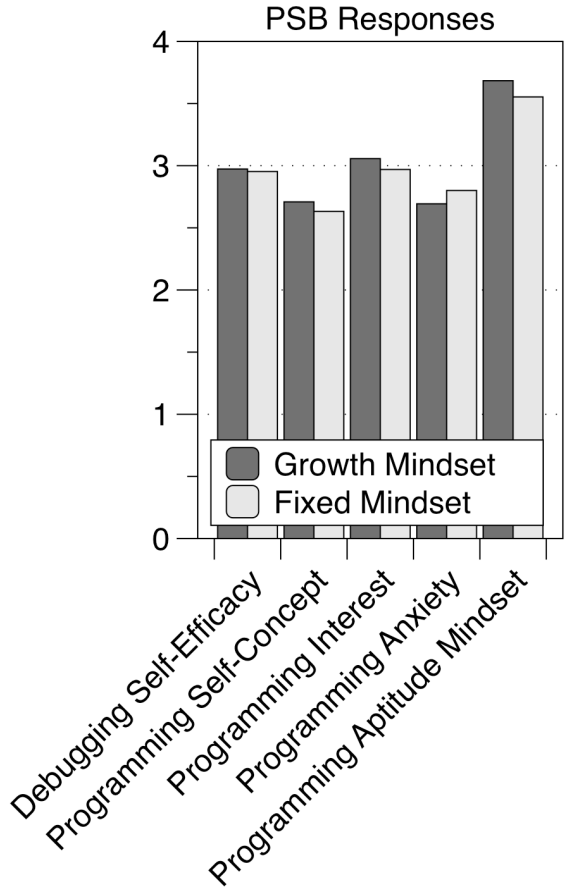


Figure 9

Time Played—Graph

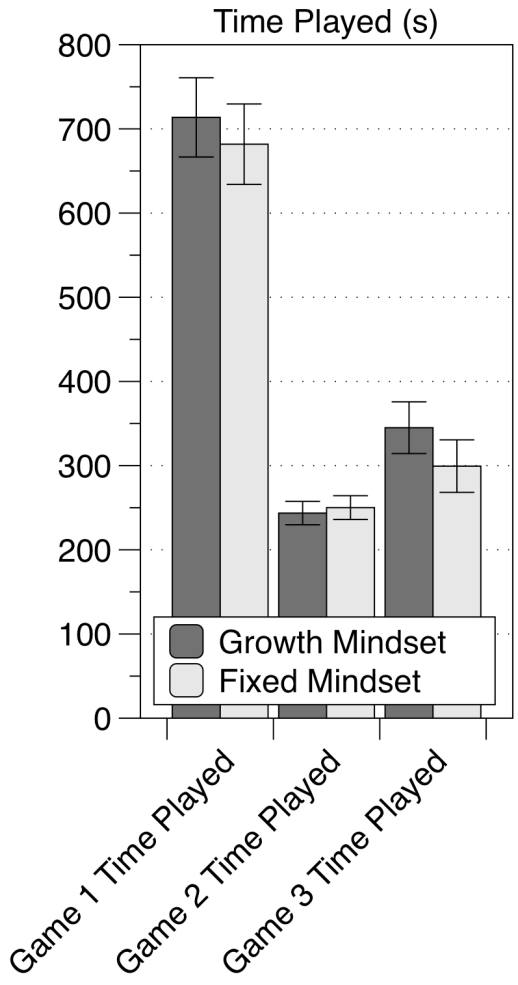


Figure 10

Game 1—Graph

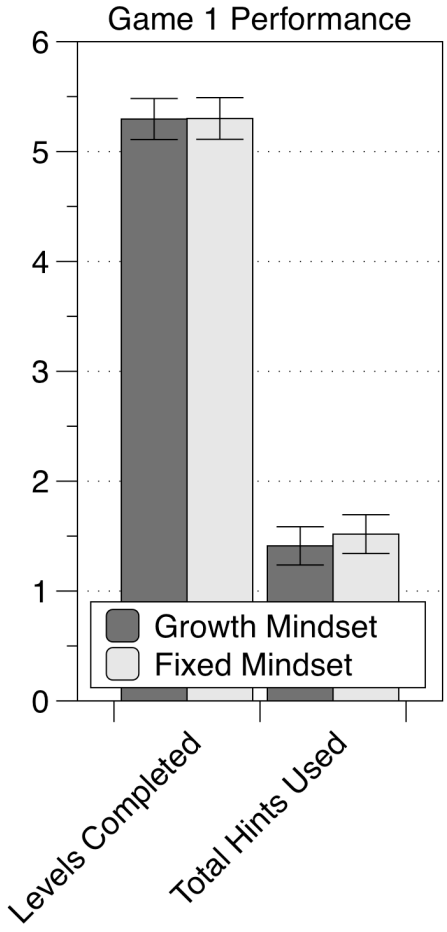


Figure 11

Game 2—Graph

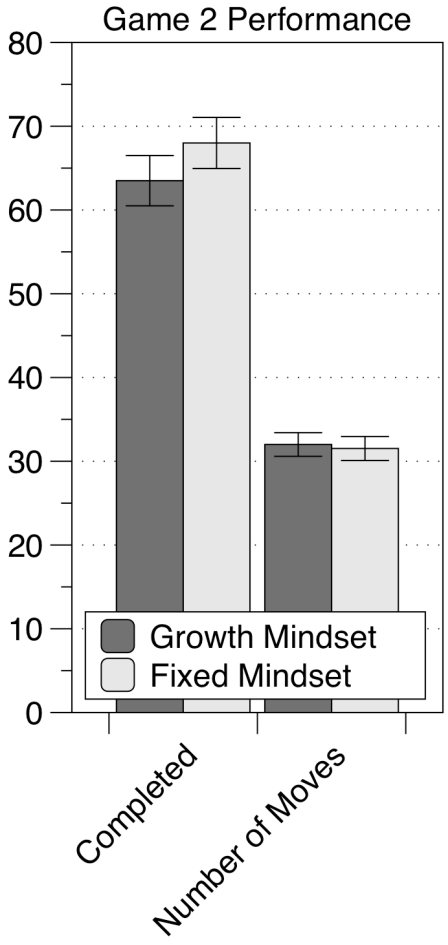


Figure 12

Game 3—Graph

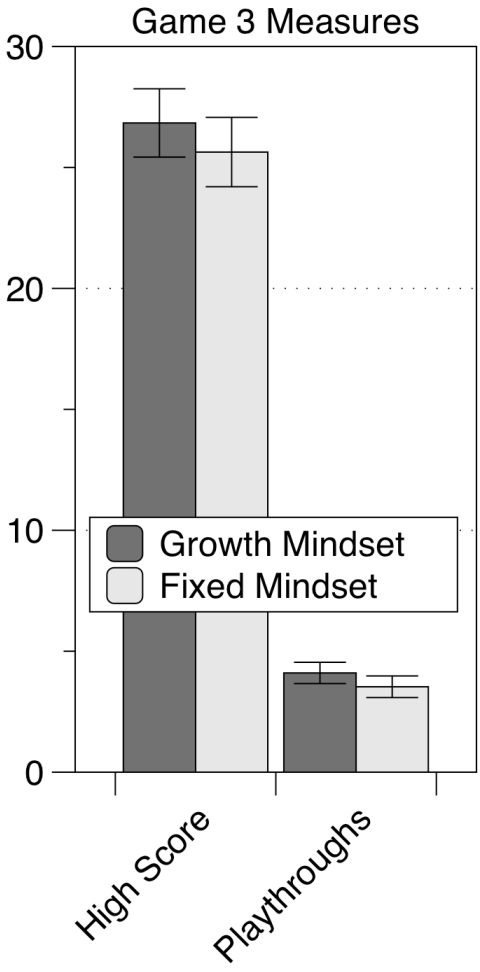


Table 1

Creating Usernames

The following describes the crowdsourced process for generating growth and fixed mindset usernames. Each Mechanical Turk participant is unique across the entire paper. Moreover, choices are always presented in a randomized order.

Step	Description	n
Creating Phrases	Create growth mindset / fixed mindset phrases	112
Duplicate Removal	Remove duplicate phrases	2
Representation	Rate phrases on goodness of representation of mindsets	106
Positivity	Rate phrases on their positivity	104
Potential Usernames	Create potential usernames from final phrases	106
Finalize Usernames	Pick the best usernames for each final phrase	105
Username Positivity	Rate final usernames on their positivity	110

112 Mechanical Turk participants read a 500-word excerpt on mindsets that were taken verbatim from Wikipedia. Each of them then provided five growth mindset phrases and five fixed mindset phrases. These phrases were subsequently put through a process of duplicate removal, using two independent raters. Any phrases that were very similar to a previous phrase were marked for removal. Conflicts in the process were then discussed, and the phrases were re-processed until a consensus was reached. This resulted in 150 unique growth mindset phrases and 156 unique fixed mindset phrases.

After reading the mindset excerpt, 106 Mechanical Turk participants rated the phrases from the previous step on how well they represented either a growth or fixed mindset on a scale of 1 (Strongly Disagree) to 7 (Strongly Agree). Intraclass correlation on the ratings was ICC = 0.99 (two-way random, average measures [Shrout & Fleiss, 1979]), indicating high agreement. Phrases were ranked by their scores. We then took the 50 highest-ranking phrases from each group.

104 Mechanical Turk participants then rated the 100 phrases from the previous step on a scale of -5 (Very Negative) to 5 (Very Positive), ICC = 0.96. The final phrases were selected by randomly choosing one phrase from the 50 growth-mindset phrases, and then picking the corresponding fixed mindset phrase with the closest positivity score. Six phrases were selected this way. The final growth mindset phrases did not differ from the final fixed mindset phrases in their positivity ratings, $p > .05$. 106 Mechanical Turk participants then created a potential username for each of these final phrases, following typical username conventions and constraints.

105 Mechanical Turk participants then selected what they felt were the three best usernames (from the list populated in the previous step) for a given phrase. The usernames that were selected most often by participants became the final username for a given phrase. The usernames were also rated by 110 Mechanical Turk participants on a scale of -5 (Very Negative) to 5 (Very Positive), ICC = 0.92. Final usernames did not differ in their perceived positivity, $p > .05$, or in their length, as measured by the number of typed characters, $p > .05$.

Table 2

Demographics

Characteristic	Category	n	%
Gender	Female	1090	58.1
	Male	786	41.9
Age	18-20	54	2.9
	21-30	700	37.3
	31-40	643	34.3
	41-50	278	14.8
	>50	201	10.7
Ethnicity	White	1434	76.4
	Black or African American	186	9.9
	Asian Indian	50	2.7
	Chinese	37	2.0
	Filipino	22	1.2
	Korean	14	0.8
	American Indian	16	0.9
	Japanese	15	0.8
	Other	102	5.4

1876 participants were recruited through Mechanical Turk. The data set consisted of 41.9% male and 58.1% female participants. Participants self-identified their races/ethnicities as white (76.4%), black or African American (9.9%), Asian Indian (2.7%), Chinese (2.0%), Filipino (1.2%), Korean (0.8%), American Indian (0.9%), Japanese (0.8%), and other (5.4%). Participants were between the ages of 20 and 64 ($M = 35.3$, $SD = 11.0$) and were all from the United States. They spent on average 11.6 minutes playing Mazzy, 4.1 minutes playing Tower of Hanoi, and 5.4 minutes playing the math game. Participants were reimbursed $3.50 for participating in the experiment.

Table 3

Aggregate—MANOVA Multivariate F-tests

Effect		Value	*F*	Hypothesis *df*	Error *df*	Sig.	Partial Eta Squared
Intercept	Pillai's Trace	.976	2768.307[a]	27.000	1849.000	.000	.976
	Wilks' Lambda	.024	2768.307[a]	27.000	1849.000	.000	.976
	Hotelling's Trace	40.424	2768.307[a]	27.000	1849.000	.000	.976
	Roy's Largest Root	40.424	2768.307[a]	27.000	1849.000	.000	.976
NumericCondition	Pillai's Trace	.025	1.743[a]	27.000	1849.000	.010	.025
	Wilks' Lambda	.975	1.743[a]	27.000	1849.000	.010	.025
	Hotelling's Trace	.025	1.743[a]	27.000	1849.000	.010	.025
	Roy's Largest Root	.025	1.743[a]	27.000	1849.000	.010	.025

a. Exact statistic

Table 4

PSB—Descriptive

				95% Confidence Interval	
Dependent Variable	Condition	Mean	Std. Error	Lower Bound	Upper Bound
Answer.PSB.Q1	Growth	3.196	0.042	3.115	3.278
	Fixed	3.143	0.042	3.060	3.226
Answer.PSB.Q2	Growth	3.019	0.040	2.941	3.097
	Fixed	2.945	0.040	2.866	3.024
Answer.PSB.Q3	Growth	2.709	0.041	2.628	2.791
	Fixed	2.773	0.042	2.690	2.855
Answer.PSB.Q4	Growth	2.750	0.042	2.667	2.833
	Fixed	2.913	0.043	2.829	2.998
Answer.PSB.Q5	Growth	2.820	0.039	2.743	2.896
	Fixed	2.751	0.039	2.674	2.828
Answer.PSB.Q6	Growth	2.081	0.039	2.005	2.157
	Fixed	2.083	0.039	2.006	2.161
Answer.PSB.Q7	Growth	2.689	0.039	2.613	2.765
	Fixed	2.609	0.039	2.532	2.686
Answer.PSB.Q8	Growth	2.740	0.042	2.658	2.821
	Fixed	2.671	0.042	2.588	2.754
Answer.PSB.Q9	Growth	2.636	0.041	2.555	2.717
	Fixed	2.557	0.042	2.475	2.639
Answer.PSB.Q10	Growth	3.307	0.040	3.229	3.386
	Fixed	3.223	0.041	3.143	3.303
Answer.PSB.Q11	Growth	3.549	0.040	3.469	3.628
	Fixed	3.427	0.041	3.347	3.508
Answer.PSB.Q12	Growth	2.845	0.043	2.760	2.929
	Fixed	2.913	0.044	2.828	2.999
Answer.PSB.Q13	Growth	2.725	0.042	2.642	2.808
	Fixed	2.852	0.043	2.767	2.936
Answer.PSB.Q14	Growth	2.685	0.042	2.602	2.768
	Fixed	2.781	0.043	2.697	2.866
Answer.PSB.Q15	Growth	2.519	0.042	2.437	2.601
	Fixed	2.657	0.042	2.574	2.740
Answer.PSB.Q16	Growth	2.237	0.039	2.161	2.313
	Fixed	2.361	0.039	2.284	2.438
Answer.PSB.Q17	Growth	2.425	0.039	2.348	2.501
	Fixed	2.509	0.040	2.431	2.586
Answer.PSB.Q18	Growth	2.281	0.040	2.202	2.361
	Fixed	2.470	0.041	2.389	2.550

Table 5

Game Measures—Descriptive

				95% Confidence Interval	
Dependent Variable	Condition	Mean	Std. Error	Lower Bound	Upper Bound
Game1_TimePlayed	Growth	713.702	23.993	666.646	760.757
	Fixed	681.816	24.366	634.028	729.604
Game1_LevelsCompleted	Growth	5.29600	0.0950	5.10900	5.48200
	Fixed	5.30100	0.0970	5.11100	5.49000
Game1_HintsUsed	Growth	1.41100	0.0890	1.23700	1.58500
	Fixed	1.51800	0.0900	1.34200	1.69500
Game2_TimePlayed	Growth	243.617	7.0840	229.725	257.510
	Fixed	250.133	7.1940	236.024	264.242
Game2_Completed	Growth	63.5000	1.5000	60.5000	66.5000
	Fixed	68.0000	1.6000	64.9000	71.0000
Game2_NumMoves	Growth	32.0030	0.7200	30.5920	33.4150
	Fixed	31.5240	0.7310	30.0900	32.9570
Game3_TimePlayed	Growth	345.062	15.663	314.343	375.781
	Fixed	299.407	15.907	268.210	330.605
Game3_HighScore	Growth	26.8390	0.7200	25.4280	28.2510
	Fixed	25.6350	0.7310	24.2020	27.0690
Game3_Playthroughs	Growth	4.10200	0.2250	3.66100	4.54200
	Fixed	3.53100	0.2280	3.08400	3.97900

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