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# The Effects of Performance-Based Education on Evolutionary Attitudes and Literacy

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## ABSTRACT

Creationist opposition to evolution is a major impediment to advancing science education in the US and a growing problem in the UK. Novel education approaches could be instrumental in stemming this opposition. Rapper Baba Brinkman's live show "Rap Guide to Evolution" is one such effort, as it combines hip hop, science, and comedy. To investigate this, pre- and post-performance tests and a one-month follow-up using the Evolutionary Attitudes and Literacy Survey were administered to 92 UK students in conjunction with a "Rap Guide to Evolution" performance. Study compliance was poor, with only five participants completing all three surveys and low posttest reliability. Nonetheless, significant improvement from pretest to retention was detected in evolution exposure, though there was also a decrease in evolutionary knowledge. Regression analysis controlling for gender, current religion, openness to experience, and creationist reasoning also indicated a borderline significant decrease in evolution misconceptions and that the decrease in evolutionary knowledge was predicted mainly by current religion. Though results were mixed, this study is the first of its kind in testing the influence of informal education on evolutionary knowledge and attitudes. Future research will utilize more rigorous protocols and investigate variation in cultural models of resistance to evolution.

## KEYWORDS

Evolution, Attitudes, Literacy, Informal Education, Hip Hop, Comedy, Rap Guide to Evolution, Retention, Music, Performance

## INTRODUCTION

In Darwin's time, initial opposition to the theory of evolution came primarily from within the scientific community; contrastingly, today's opposition comes almost entirely from religion. Previous studies have determined religion to be a key factor in

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the endorsement or rejection of evolution (Ozay Kose, 2010). As such, education will be instrumental in overcoming misconceptions about the subject. In order to improve public perception of evolution, individuals first must have a comprehensive understanding of the subject.

While most people do not go out of their way for the sake of education, they do enthusiastically seek entertainment (Rentfrow, Goldberg, & Zilca, 2011). Combining both pursuits could overcome some impediments to evolution education. Many children's programs already use entertainment and song as tools for learning (Lesser, 1974). Interestingly, music also aids in the ability to retain information for longer periods of time as well as simply creating initial interest in a subject (Sachs & Langan, 2011).

Baba Brinkman, a Canadian rap artist, combines science and music to create an entertaining performance that educates audiences about the theory of evolution. He has performed his show, "Rap Guide to Evolution" (RGE), at music festivals and universities around the world. Because he hopes his show provides audiences at least a basic understanding of evolutionary theory, Brinkman recently chose to assess how well his performances actually aid audiences in understanding and retaining information about evolution.

In this paper, we review a study using the Evolutionary Attitudes and Literacy Survey (EALS) to survey 92 students at Thames College in London before and after a performance of RGE. Participants were also surveyed a third time a month after the performance to test knowledge retention. While we were not able to gather a true understanding of the efficacy of his performance due to lack of full participation and a biased participant pool, the model outlined here provides direction toward better methods for teaching evolutionary theory.

## PERCEPTIONS OF EVOLUTION

The theory of evolution is often considered the greatest unifying theory of science. Yet, the American public does not see it as such. Cross-cultural analysis has revealed that a larger proportion of adults in Japan and 32 European nations accept evolution than in the U.S. (Miller, 2006). The only nation ranked lower than the United States in public acceptance of evolution was Turkey. In analyzing this, Ozay Kose (2010) found that 73% of Turkish students and 79% of Turkish teachers do not accept the theory of evolution on the grounds that "evolution is an idea which has limited evidence or support" and does "not explain how life first arose." The most prevalent reasons for rejecting evolution are a literal interpretation of biblical creation and perceived contradictions in the evidence supporting evolution (Ozay Kose, 2010). While Turkey is a secular nation, it is clear that religious influences have had a significant role in molding public perception of evolution. Creationism is also on the rise across other largely secular European strongholds and even in the birthplace of Charles Darwin (Curry, 2009; Williams, 2008).

The relationship between evolution and religion is such that many would like high school curriculums to include evolution and creationism. Intelligent Design is included in 25% of biology classes, evolution is excluded from 17%, and roughly 16% of high school biology teachers identify as creationists (Berkman, Pacheco, & Plutzer, 2008). Education is important in helping improve the American public's perception of evolution. Proper science, engineering, technology, and mathematics education is important for economic growth and sustainability. However, there are cultural impediments to teaching evolution that cannot always be overcome in the classroom, which may be resolved by novel and less formal approaches, such as through music and art.

### RETENTION STUDIES

Music has been shown to be a powerful educational tool. Even the use of background music can have an impact in the classroom and has been positively correlated to student comfort, confidence, and retention of information literacy concepts (Sachs & Langan, 2011). Music is a very versatile educational tool, can be incorporated in a plethora of ways, and can be interactive to various degrees. *Sesame Street* has used music to educate children since its launch in 1969. Early production research determined music to be of benefit, as it allowed children to attend to the show even while not actively watching (Lesser, 1974).

The effects of other artistic approaches to education have also been studied. To test the efficacy of art installations as a means of communicating science, researchers presented one group of participants with a list of scientific facts while another was exposed to the same facts while working together to create an art installation. While there was not an appreciable difference in knowledge change following the study, long-term retention was higher in the art installation group (Rios & Yankelevich, 2013). The ability to encourage dual-attention is part of what allows artists such as Baba Brinkman to use music as an educational tool.

### RAP GUIDE TO EVOLUTION

Dirk Murray "Baba" Brinkman, Jr. is a playwright and award-winning rap artist. He has a Master of Arts in English from the University of Victoria, Canada, where his thesis compared modern rap battling to *The Canterbury Tales* by Geoffrey Chaucer. After graduation, he began a career as a "rap troubadour" with his one-man show "The Rap Canterbury Tales." In 2008, Mark Pallen, a Birmingham University microbiology professor, commissioned him to compose "Rap Guide to Evolution" (RGE) for a Darwin Day event being organized. Brinkman has since performed RGE at festivals and universities throughout the world, including several runs of an off-Broadway play adaptation. Brinkman's "peer-reviewed" music is an innovative approach to scientific education in that he subjects his lyrics to review by authors of the primary research he discusses in his songs and show and continually updates them as the science changes. RGE incorporates the facts and graphs of a

standard lecture with the ambiance and excitement of a rap show. Brinkman's efforts to improve public understanding of evolution have earned him various awards and honors, such as the National Center for Science Education's Friend of Darwin Award (Brinkman, <http://www.bababrinkman.com/bio/>).

In 2013, Brinkman tested the efficacy of his performance as a means of informal education by administering the Evolutionary Attitudes and Literacy Survey (EALS) (Short & Hawley, 2012) around a performance at Thames College in London. Students from five different classes in the Applied Science, Biology, and Nursing tracks attended the performance, spanning a range of ages, ethnic and religious backgrounds, and prior exposure to evolution. Participants were asked to fill out the survey immediately before and after the performance and a month after the event. Given that innovative artistic approaches to science education have been shown to aid long-term retention, we hypothesized that evolution literacy and attitudes would be greater following the performance, particularly at the retention stage.

## METHODS

### Participants

EALS was administered before and after a Baba Brinkman performance at Thames College in September 2013. Including pre-, post-, and retention iterations, at least one survey was submitted from 92 different participants. Demographic information was collected only on the pretest, which many did not complete; thus we can only account for 12 males and 27 females. Among the 53 participants who disclosed their ethnicity, 21 were African, 1 East Asian, 5 Middle Eastern, 6 South Asian, 6 white, and 14 self-reported as "other."

### Procedures

Surveys were administered to Thames College classes in BTEC L2 Applied Science, BTEC L3 Applied Science, A2 Biology, HND Applied Biology, and Access to Nursing by the course instructors. The courses ranged in the amount of evolution taught. Access to Nursing students received no training in evolutionary subjects; BTEC L2 Applied Science class had some evolution taught in the classes with information on natural selection and adaptation; BTEC L3 Applied Science course featured little evolution, but it was maintained that students should have learned about the subject earlier in their university careers; and HND Applied Biology and A2 Biology had considerable evolutionary biology taught within the course. Each student was asked to fill out the survey three times—before Brinkman's performance, directly after, and one month later.

### Materials

EALS is a 104-item multidimensional scale with 16 lower-order constructs (political activity, religious activity, conservative self-identity, attitudes toward life, intelligent design fallacies, young earth creationist beliefs, moral objections, social objections, distrust of the scientific enterprise, relevance of evolutionary theory, genetic literacy, evolutionary knowledge, evolutionary misconceptions, knowledge about the scientific enterprise, self-exposure to evolution, and youth exposure to evolution), which reduce to 6 higher-order variables (Political Activity, Creationist Reasoning, Political/Religious Conservatism, Knowledge/Relevance, Evolution Misconceptions, and Evolution Exposure) (Hawley, Short, McCune, Osman, & Little, 2011). Evolution Exposure includes questions on youth and adult exposure to evolution such as trips to natural history museums, science magazines, and nature television shows. Evolutionary Knowledge gauges how well participants actually understand evolutionary concepts (e.g., “The more recently species share a common ancestor, the more closely related they are”). Creationist Reasoning estimates how much participants lean toward creationism and hold social and moral objections to evolution or Young Earth Creationist beliefs (e.g., “I read my holy book literally”). Political/Religious Conservatism estimates political and religious conservatism. Evolutionary Misconceptions assesses common fallacies about evolution participants believe to be true (e.g., “Natural selection is synonymous with evolution”).

This study used a modification of the 62-item EALS short form (Short & Hawley, 2012). Political Activity items were removed and scales standardized as a seven point Likert scale from 1 (strongly disagree) to 7 (strongly agree) to reduce the burden on participants, and six additional items were included to gauge whether musical tastes and views of rap in particular affect learning (e.g., “I listen to rap or hip-hop music regularly”). This modified EALS-SF elicited excellent reliability in the pre- (0.82) and retention (0.81) tests but not in the posttest (0.49).

Following Hawley et al. (2011), the Openness to Experiences questionnaire from the Five Factors Model (McCrae & John, 1992), 1992) was also administered to query participant openness to new ideas. Openness to experience has been correlated with the willingness to entertain complex subjects, such the theory of evolution. This survey achieved moderately acceptable reliability (0.68).

## Analysis

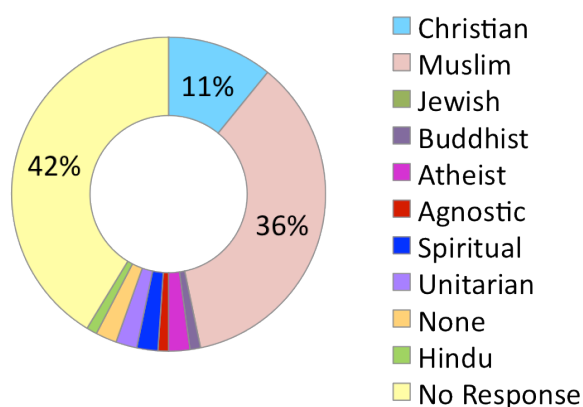
The five retained higher-order variables were calculated using subscale means. Maximum model boundaries were explored using bivariate correlations. Low compliance and reliability for the posttest prevented multivariate regression across the three measures, so we used a paired samples *t*-tests to compare pretest or retention scores to test the study hypothesis. We probed the influences of Creationist Reasoning, Political/Religious Conservatism, and covariates on Evolutionary Knowledge, Evolution Misconceptions, and Evolution Exposure using two-way repeated measures analyses of variance (ANOVA). We considered results significant if  $P < 0.05$ .

## RESULTS

### Demographics

Of 58 respondents to the pretest, 10 self-identified as Christian, 33 as Muslim, 1 as Buddhist, 2 as Atheists, 1 as Agnostic, 2 as Spiritual, 2 as Unitarian, 1 as Hindu, and 2 as none (Fig. 1). An item querying the religion in which they were raised elicited similar results—16 self-reported as Christian, 31 Muslim, 1 Jewish, 1 Buddhist, 1 Atheist, 2 Unitarian, 1 Hindu, and 1 none. A total of eight participants were no longer part of the religion in which they were raised. The 79 participants who provided their ages ranged from 16.7 to 43.9 years old (mean  $\pm$  SD = 21.6  $\pm$  4.93).

**Figure 1:** Current religion of participants



### Correlations

Demographics and the openness to experience data were only collected during administration of the pretest, so we conducted bivariate correlations to analyze relationships among these variables. As Table 1 indicates, there were noteworthy and significant relationships among gender, ethnicity, current religion (but not religion raised in), openness, and various EALS-SF factors. Males had significantly less evolutionary knowledge and exposure. Self-reported whites scored highest in Evolutionary Knowledge and lowest in Creationist Reasoning, and whites and East Asians scored highest in Evolution Exposure, while Africans scored lowest in factors Evolutionary Knowledge and Exposure and highest in Creationist Reasoning. Agnostics had the highest Evolutionary Knowledge, while Muslims had the lowest; and Unitarians and Agnostics had the highest Evolution Exposure, whereas Christians and Muslims had the least. Hindus, Christians, and Muslims all scored similarly high in Creationist Reasoning. As expected, openness was significantly and positively associated with Evolutionary Knowledge and Evolution Exposure, as well as with ethnicity. Whites and self-reported “other” scored highest in openness, whereas East Asians scored lowest.



**Table 1.**  
*Bivariate Correlations of Pretest Variables*

	1	2	3	4	5	6	7	8	9	10	11	12
1 Gender	1.00											
2 Ethnicity	-0.03	1.00										
3 Religion now	-0.24	0.28*	1.00									
4 Religion raised	-0.01	0.15	0.69**	1.00								
5 Openness	-0.27	0.36**	0.20	-0.02	1.00							
6 EALS-SF	-0.33*	0.05	0.02	-0.02	0.37**	1.00						
7 Evolutionary Knowledge	-0.51**	0.34*	0.46**	-0.03	0.34*	0.29*	1.00					
8 Evolution Exposure	-0.44**	0.32*	0.51**	0.25	0.32*	0.44**	0.55*	1.00				
9 Evolution Misconceptions	-0.16	0.17	0.18	0.16	0.22	0.47**	0.22	-0.02	1.00			
10 Creationist Reasoning	-0.18	-0.33*	-0.43**	-0.10	0.01	0.58**	-0.49**	-0.30*	0.20	1.00		
11 Political/Religious Conservatism	-0.10	-0.13	-0.25	-0.10	0.18	0.70**	-0.03	-0.02	0.45**	0.62**	1.00	
12 Rap Attitudes	-0.18	0.12	0.18	-0.04	0.24	0.05	0.23	0.09	0.17	-0.16	0.01	1.00

\* $P < 0.05$ , \*\* $P < 0.01$



### t - Tests

Of the 92 participants, only 5 completed all three surveys. Seventy of the 92 did not complete a posttest. Because of this lack of posttest data, we used paired samples *t*-tests to compare the means of pretest and retention variables only. These variables included Evolution Exposure, Evolutionary Knowledge, Evolution Misconceptions, Political/Religious Conservatism, and Creationist Reasoning.

**Table 2.**  
*Paired samples t-tests of Evolution Attitudes and Literacy Survey factors.*

	N	Pre		Retention		t	P
		Mean	SD	Mean	SD		
Evolutionary Knowledge	25	4.26	0.67	2.95	1.02	1.49	0.15
Evolution Exposure	21	4.00	1.24	4.74	1.18	-2.29	0.03
Evolution Misconceptions	22	4.04	0.87	3.68	1.08	1.58	0.13
Creationist Reasoning	28	3.60	1.01	3.78	1.16	-1.12	0.28
Political/Religious Conservatism	28	4.17	0.65	4.25	0.70	-0.62	0.54
Rap Attitudes	19	4.31	1.00	4.10	1.09	1.02	0.32

Evolution Exposure was the only factor for which participants reported statistically significant change (Table 2), though a non-significant reduction was also observed in Evolution Misconceptions. However, we also that found Evolutionary Knowledge and Rap Attitudes decreased slightly, and Creationist Reasoning and Political/Religious Conservatism increased, though not significantly.

### Repeated Measures Analysis of Variance

To test the relationships among EALS factors, we conducted two-way repeated measures ANOVAs. We constructed six models with an *evolution* and a *disposition* within-subjects factor in each. Models were constructed with Evolutionary Knowledge, Evolution Exposure, and Evolution Misconceptions pretest and retention means as the *evolution* factor. Two separate models were tested for each of these with Creationist Reasoning and Political/Religious Conservatism pretest and retention means as the *disposition* factor. Gender, ethnicity, and current religion were included as between-subjects factors and openness as a covariate for all models.

As Table 3 indicates, the main effect for the decrease in Evolutionary Knowledge from pretest to retention when modeled with Creationist Reasoning was significant with a large effect size. There was also a significant moderating effect by current religion and a borderline significant interaction with ethnicity, both with large effect sizes. Though the Evolutionary Knowledge and Political/Religious Conservatism model's main effect was not significant, there was a significant moderation effect by current religion with a large effect size.

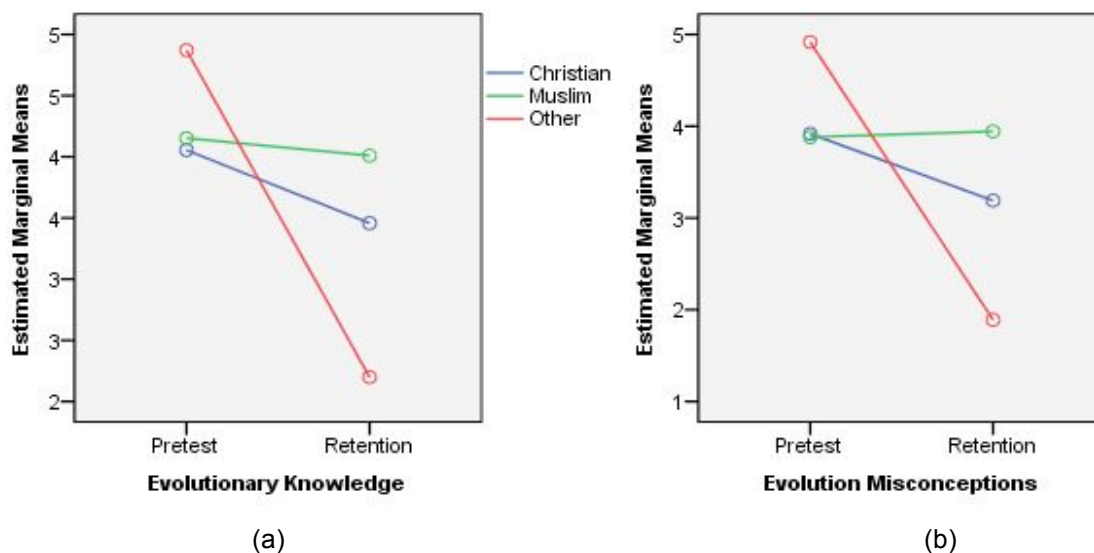
**Table 3.**  
*Two Way Repeated Measures ANOVAs*

	<i>F</i>	<i>df</i>	<i>P</i>	Partial $\eta^2$
Evolutionary Knowledge	6.85	1,8	0.03	0.461
x-Creationist Reasoning	0.16	1,8	0.70	0.019
x-Gender	0.18	1,8	0.68	0.022
x-Ethnicity	3.47	4,8	0.06	0.634
x-Current religion	10.88	2,8	0.01	0.731
x-Openness	2.39	1,8	0.16	0.230
Evolutionary Knowledge	1.18	1,8	0.31	0.129
x-Political/Religious Conservatism	0.67	1,8	0.44	0.077
x-Gender	0.03	1,8	0.87	0.004
x-Ethnicity	1.91	4,8	0.20	0.488
x-Current religion	6.35	2,8	0.02	0.614
x-Openness	0.23	1,8	0.65	0.028
Evolution Exposure	1.17	1,8	0.32	0.163
x-Creationist Reasoning	0.00	1,8	1.00	0.001
x-Gender	0.08	1,8	0.79	0.013
x-Ethnicity	0.25	4,8	0.90	0.145
x-Current religion	2.36	1,8	0.18	0.282
x-Openness	0.32	1,8	0.59	0.510
Evolution Exposure	0.18	1,8	0.69	0.029
x-Political/Religious Conservatism	0.08	1,8	0.78	0.014
x-Gender	0.03	1,8	0.87	0.005
x-Ethnicity	0.05	4,8	0.99	0.035
x-Current religion	0.38	1,8	0.56	0.060
x-Openness	0.04	1,8	0.85	0.006
Evolution Misconceptions	4.99	1,8	0.07	0.454
x-Creationist Reasoning	0.02	1,8	0.89	0.004
x-Gender	0.01	1,8	0.91	0.002
x-Ethnicity	2.18	4,8	0.19	0.592
x-Current religion	9.50	1,8	0.02	0.613
x-Openness	2.40	1,8	0.17	0.286
Evolution Misconceptions	1.62	1,8	0.25	0.213
x-Political/Religious Conservatism	0.05	1,8	0.83	0.009
x-Gender	0.12	1,8	0.74	0.020
x-Ethnicity	0.96	4,8	0.49	0.391
x-Current religion	2.71	1,8	0.15	0.311
x-Openness	1.11	1,8	0.33	0.156

**Note:** Two-way repeated measures ANOVAs with "evolution" (Evolutionary Knowledge, Evolution Exposure, and Evolution Misconceptions) and "disposition" (Creationist Reasoning and Political/Religious Conservatism) as within-subjects factors; gender, ethnicity, and current religion as between-subjects factors; and openness to experience as covariate.

The main effect decrease in Evolution Misconceptions from pretest to retention when modeled with Creationist Reasoning approached significance and had a significant interaction effect for current religion with large effect sizes. These data suggest that current religion had a strong effect on the influence of the RGE performance with regard to Evolutionary Knowledge and Evolution Misconceptions.

To better understand the nature of these interactions, we plotted Evolutionary Knowledge and Evolution Misconceptions against current religion (with all non-Muslim and non-Christian participants were recoded as “other”). As Figure 2 indicates, there was a decrease in knowledge and misconceptions among most religions from pretest to retention—only Muslims increased in misconceptions (Fig. 2b)—with the largest declines among non-Christians and non-Muslims (including Buddhists, Hindu, Spiritualists, Unitarians, and none)



**Figure 2:** Pretest and retention estimated marginal means of Evolutionary Knowledge (a) and Evolution Misconceptions (b) by current religion indicate declines in both among all religious groups except Muslims, whose misconceptions increased slightly.

## DISCUSSION

Consistent with our hypothesis that evolution knowledge and attitudes would improve from before to after the RGE performance, there was a significant increase in exposure to evolution and a significant decrease in misconceptions about evolution when controlling for creationist reasoning, gender, ethnicity, current religion, and openness to experience. However, there was also a significant decrease in knowledge about evolution. There were significant interactions between current religion and knowledge and misconceptions about evolution. We also found that Creationist Reasoning and Political/Religious Conservatism increased, albeit not significantly, leading us to believe that the RGE performance

may have triggered some defensiveness in participants. They were forced to examine their own beliefs and chose to cling more tightly to their religion, which they may have seen as being in direct conflict with evolution.

These mixed results may be a consequence of ethnic or religious bias of the small sample group. Roughly 36% of the participants were Muslim, and since 61% of the sample did not report ethnicity, the rate was likely higher. A study in Beirut, Lebanon found that 47% of Muslim university biology majors oppose evolution and commonly cite the conflicts between evolution and creation as the principal reason for rejecting evolution (Dagher & BouJaoude, 1997). Religious bias may also account for the decline we observed in Evolutionary Knowledge, motivating participants to answer consistent with their religion rather than what they may have learned from other sources, such as the RGE performance.

Since our goal was to enhance evolution literacy and attitudes toward evolution through informal education, the decrease in Evolutionary Misconceptions is promising. Yet, the relevant EALS section does not ask questions that challenge religious beliefs. Questions are based on what the theory states and how well participants understand theory, rather than on the greater implications of evolution. It is possible that the RGE performance taught them about the theory of evolution but failed to change their views on the matter of religion versus science.

Beyond the difficulties of changing worldviews with a roughly 90 minute-long performance, the manner in which the study was conducted rendered our analyses and interpretation problematical. Since so few participants completed pretest, posttest, and retention surveys, we could not develop a comprehensive model of knowledge change and retention. Many of the participants did not fill out a pretest survey at all, which rendered their other surveys unusable. Some participants only filled out one survey, left sections incomplete, or checked the same column for every question, leaving us suspicious about the validity of our analyses. The low rate of compliance may have been due, in part, to creationist leanings even among the biology instructors being relied upon to administer the study, which leaves plenty of room for future improvements in research design and implementation.

Despite these problems, further research of informal efforts to teach evolution can build upon our model. Future research can control for participant and administrator biases by using objective measures of emotional salience during performances and conducting short post-performance follow-up interviews. Obtaining an objective measure of emotional reactions to performances, whether positive or negative, would reduce the influence of outside opinions and peer pressure.

## CONCLUSION

Our findings were mixed, as we found that Baba Brinkman's "Rap Guide to Evolution" performance may have contributed to reduced evolution misconceptions and increased evolution exposure, but we also found a decrease in knowledge.

Despite this, our model highlights directions for future improvements. It will be important to rigorously improve compliance, especially at the posttest survey. Future efforts may also prove more successful if conducted among subjects with low evolutionary literacy but less creationist bias. On the other hand, our study points to several unexplored directions in understanding cultural resistance to evolution. Results were inconclusive due to the lack of completed surveys and the demographics of this particular university, but there appears to be much variation in cultural models about evolution held based on gender, ethnicity, and religiosity. We hope to better understand how to overcome such impediments in teaching evolution through further research using a refined model. Evolution is an incredibly important subject in biology and all other fields of learning because the model can be extended to many other aspects of human existence. Therefore we should find the most effective method of teaching this information.

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