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Acceptance, Confidence, and Time: Exploring Dynamics of Middle and Secondary Science Teacher Autonomy in Teaching Evolution in the Southeastern United States

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Abstract: Evolution education represents the greatest challenge to scientific literacy in the United States. Long accepted as the foundational concept of biology, in the public realm evolution elicits controversy. The Southeastern United States is a breeding ground for this, and other, anti-science thinking that has far-reaching implications as seen during the 2020 pandemic and anti-science legislation from the region. One approach to close gaps in understanding evolution is to ensure that it is taught in schools in a way that is robust and accurate, as teachers are the front lines in the fight for scientific literacy. For that to happen, teachers must overcome their own barriers and concerns about teaching this so-called "controversial" topic. This quantitative study found that despite experience, certification, confidence in teaching evolution, and high levels of acceptance, teachers spent minimal time (less than three days) teaching evolution but there are factors that impact time and confidence that can be used to combat the problem. Identifying these fundamental interactions builds a starting point for targeted preparation and support to ensure that teachers have the tools, confidence, and content needed to teach evolution adequately.

Keywords: *Evolution education, nature of science, secondary science.*

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Introduction

Evolution education is a high focus area in research due to the critical role of evolution as the unifying theory in all of life science. Teachers represent a front-line when it comes to impacting public perceptions and understanding of evolution. Yet, they frequently avoid or inaccurately teach the subject due to their struggles with the concept. It is essential to understand what teachers bring to the table to impact the approach and time they dedicate to evolution instruction. From their demographics and religiosity to their formal training, complex interactions play a role in the autonomous decision-making that occurs in each classroom. Evolution teaching and learning is lamented as a critical failing in science education (Smith & Siegel, 2016). While the scientific community stands unanimously in favor of evolution as the best explanation of diversity and unity of life, the public stands in contrast, seeing controversy and conflict between scientific ways of knowing and deeply seeded worldviews (Plutzer & Berkman, 2008, Wiles, 2008). In K-12 settings, understanding evolution for scientific literacy is our goal (Borgerding et al., 2015). However, teachers still struggle with evolution, often spending limited time on the subject or avoiding it altogether (Banilower et al., 2018; Friedrichsen et al., 2016; Hermann et al., 2020).

Teachers are front-line connections to the public, as most people attend K-12 schools, but not all will go on to post-secondary training (Beardsley et al., 2012; Berkman & Plutzer, 2015). In essence, K-12 education represents a critical crossroad for science and worldviews—the social, cultural, and experiential lenses through which we view the world—where students and teachers face a great variety of conflicting elements as they navigate their classrooms (Bertka et al., 2019; Hermann, 2013). Therefore, understanding teacher content knowledge, understanding of the nature of science, acceptance of evolution, and background experiences of the groups we wish to impact is a critical first step in approaches to overcome barriers to the teaching of evolution in the United States and around the globe.

There is an abundance of issues and concerns teachers face regarding the teaching of evolution in their classrooms (Glaze & Goldston, 2015; Nadelson & Hardy, 2015). Some are unaware of the legal precedent that frames what can and cannot be taught (Hermann et al., 2020; Moore, 2004a, 2004b), some are fearful that they will face reprisal from administrators, parents, and students (Moore & Kraemer, 2005); and still, others report they are not confident enough

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to teach something that is seen as controversial, resulting in teaching that is inaccurate or inconsistent (Bowman, 2008; Moore, 2008). Despite inclusion in national standards (NGSS), and many state-level standards, there is still measurable push-back in classrooms as some teachers limit the time spent on the topic, elect to supplement the scientific topics with non-scientific alternatives, or simply refuse to teach the concept (Banilower et al., 2018; Hermann et al., 2020).

Research of teacher perception and outcomes suggests several factors that might impact teacher choices relative to what and how to teach evolution. Studies have focused on preservice perceptions, acceptance, and understanding of evolution (Glaze et al., 2015); understandings of the nature of science in students and teachers (Akyol et al., 2010; Ha et al., 2012); how teachers' personas in the classroom change when they teach the topic (Goldston & Kyzer, 2009); and how they cope with conflict they might perceive whether or not it is realized (Griffith & Brem, 2004). Researchers have uncovered complex relationships between religiosity and acceptance of evolution (Nehm & Schonfeld, 2007; Nehm et al., 2009), varying relationships between knowledge and acceptance (Deniz & Donnelly, 2011; Glaze & Goldston, 2019; Glaze et al., 2015; Nehm & Schonfeld, 2007), and shifting impacts of demographics on things like acceptance and religiosity based on locations and levels of instruction (Rutledge & Mitchell, 2002; Trani, 2004).

We expect relationships between things like confidence levels, acceptance of a subject, and willingness to spend more time teaching that subject based on everyday logical observations we see with many other topics (Sinatra et al., 2003). Expectations lead to assumptions in practice about the impact of years of teaching experience or the level of degree attained and how that might impact perceptions or acceptance of evolution. Still, teachers approach evolution as novices, not experts (Oliveira et al., 2011).

Methodology

This exploratory quantitative study details the characteristics of teachers and evolution-related thinking and practices of middle and secondary science teachers in Georgia, a state located in the Southeastern United States. The research questions that guide this study are:

1. What are the characteristics of middle and secondary science teachers in Georgia in terms of their teaching demographics, evolution thinking, and classroom practices?
2. What factors impact the key measures shown to affect performance in evolution education (time spent teaching evolution, confidence in evolution, and acceptance of evolution)?

Setting and Population

This study took place in Georgia, a state in the Southeastern United States, with a population of 10.62 million people. According to state data, teachers serve approximately 1,717,887 students in public schools, of which 409,253 are in middle school, and 521,741 are secondary. Those students attend 2,303 schools representing 21 city systems and 159 county systems. The state has the third-largest rural student population in the United States, and 60% of students in the state are eligible for free/reduced lunch. According to the State Department of Education, the state had 118,124 full-time teachers in 2019. Approximately 9,235 were certified in secondary sciences; however, only 8.3% of science certified teachers were considered to be certified in-field rather than broad field (Georgia Department of Education, 2020).

Sample

The sample for this study is convenient because it is based upon voluntary participation, not specific alignment to larger population demographics. Teachers were recruited by email or newsletter through the Georgia Science Teachers' Association. All science teacher members of GSTA in the middle-secondary range (grades 4-8 are middle grades, grades 6-12 are secondary) were included in the recruitment email providing they held a valid state teaching certificate, and teach courses that contain evolution as a standard (life science, biology). Following removal of participants with missing data points, a sample of 79 remained for the study. While this is less than what would be considered a representative sample based on the population, it is three times the minimum sample required for Pearson r (David, 1938; Bonnett & Wright, 2000).

Instrumentation

The Measure of Acceptance of Theories of Evolution (MATE) instrument is a 20 question Likert-style survey in which participants respond to both positively and negatively worded prompts to identify the extent to which they accept evolution (Rutledge & Warden, 2000). The MATE measure was utilized for its generalization to other reported studies that employed the MATE as a measure within and outside of the region (Glaze et al., 2015; Rutledge & Mitchell, 2002). The MATE was validated by a panel of experts before its wide-spread usage (Rutledge & Warden, 2000) and has reported reliability measures in a range from .77 (Johnson, 1986) to .94 (Johnson, 1986; Rutledge & Warden, 2000; Rutledge & Sadler, 2007) among populations of students in science and secondary teachers. Reliability was conducted on this study sample, resulting in a Cronbach alpha value of 0.97, noticeably higher than that reported by Rutledge and

Warden (2000) among in-service teachers. It was similar in alignment with students in biological fields where an alpha of .94 was reported (Rutledge & Sadler, 2007).

The Nature of Science measure is a 17 question Likert-style survey adapted from Johnson (1986) by Rutledge and Warden (2000) used to provide a snapshot of participant understanding of science as a field of study. The NOS survey was reviewed by a panel to determine the validity and has reported reliability of .94 with in-service science teachers (Rutledge & Warden, 2000). Reliability conducted on this sample for the measure resulted in a Cronbach alpha value of 0.65, lower than expected, yet still within the lower range of consideration as reliable. Common method bias was controlled in this study by ensuring distance and time between the two measures for acceptance (MATE) and nature of science (NOS) measures in the survey itself (Podsakoff et al, 2003).

Analysis

Data were recorded in Qualtrics and exported to SPSS for exploration. Demographic frequencies were calculated to describe the sample. Demographic variables of interest for correlation were gender, years of teaching experience, areas of certification, and the level of training (certification) completed by teachers. Additional variables included teacher religiosity, acceptance of evolution (MATE), time spent teaching evolution, and generalized understandings of the nature of science (NOS). An added measure was teachers' self-reported confidence in teaching evolution, both human and non-human. Descriptive and frequency analysis describe the sample characteristics and explore variability among the teachers. For relationships, variables were dichotomized where necessary before running Pearson correlations for continuous variables and Spearman's rho to explore whether relationships existed among non-continuous variables of interest. Data were examined and plotted to ensure they met all assumptions for testing using each analysis. Further analysis was limited by the sample size in relation to the number of variables considered.

Results

Teacher Characteristics

Table 1. Sample Demographics

Gender of Study Participants

	n	***%***	***State %***
Gender			
Male	17	21.5	21
Female	62	78.5	79
Non-binary	0	0	0

Note. N =79

Background of study participants

	n	***%***
Background		
Rural (<20,000)	28	35.4
Non-rural (>20,000)	51	64.6

Note. N =79

Professional Training, Certification Areas, & Years of Teaching Experience

	n	***%***
Area of Certification		
Biology	11	13.9
Physical Sciences	4	5.1
General Science	46	58.2
Other	18	22.8
Level of Certification		
Induction	19	24.1
Standard/Performance Professional	45	57
Advanced/Lead Professional	15	19
Years of Experience		
0-5 years	29	36.7
6-10 years	10	12.7
11-15 years	12	15.2
16+ years	28	35.4

Note. N =79

Participants in this study represented each of the regional districts of education in the state and were somewhat representative of the larger population in terms of gender although they are not truly representative of the state teacher population as a whole. Table 1 demonstrates the background of participants in terms of gender, teaching setting, and experiential demographics. While non-binary options were provided in the survey, none of the participants identified with those options, so they were condensed for reporting purposes. This sample is parallel with gender to the population of teachers in the state, with 78.5% female and 21.5% male (the state report shows 79% female and 21% male). Missing racial data is noted as a limitation of the study and an area for future exploration and was not available for inclusion. Two-thirds of their backgrounds came from urban or metropolitan areas, described as towns or cities with a population greater than 20,000. Of the 619 recognized cities in the state, only 53 (approximately 8.5%) are identified as non-rural--having populations higher than 20,000 (Georgia Cities by Population, n.d.). Participants were mostly representative of non-rural areas (64.6%), with the remaining 35.4% coming from rural backgrounds.

Among the 79 participants, there was a wide range of levels of experience, levels of professional certification attained, and areas of certification. Among those polled, there were teachers whose certification area was biology (11, 13.9%), physical science (physics or chemistry, 4, 5.1%), general science (46, 58.2%), or other (18, 22.8%). In terms of levels of training, participants represented every level of state certification from induction certification (19, 24.1%--initial certification for the first years of teaching--i.e., probationary in a sense) to professional (45, 57%), through advanced professional certificates (15, 19%). There was also representation in the sample across a range of levels of years of teaching experience. In an interesting twist, a majority (72%) of the sample represented either novice teachers (0-5 years, 29, 36.7%) or very experienced teachers (16+ years, 28, 35.4%), with the remaining quarter falling almost equally between the two middle categories (6-10 years, 10, 12.7%; 11-15 years, 12, 15.2%).

Evolution Confidence

Table 2. Self-reported confidence in teaching evolution (human & non-human)

	Non-Human Evolution		***Human Evolution***	
	n	***%***	***n***	***%***
Not Confident	16	20.3	21	26.6
Moderately Confident	24	30.4	26	32.9
Very Confident	39	49.4	32	40.5

Note: N=79

As shown in Table 2, participants were asked to self-report their confidence in teaching both non-human and human evolution in separate questions. A majority of participants had at least some confidence in their ability to teach evolution when not discussing humans. However, there was a downward shift in confidence when asked about confidence in teaching human evolution.

Time Spent Teaching Evolution

Table 3. Time Spent Teaching Evolution

	Frequency	**Percent**
Less than 3 days	32	40.5%
3-5 days	8	10.1%
6-10 days	15	19%
More than 11 days	14	17.7%
All year as a theme	10	12.7%

Note. N =79

Table 3 highlights the self-reported frequency of time each academic year spent on the teaching of evolution Participants were at the low end of coverage, with half reporting that they spent a week or less addressing evolution concepts. 40.5% of all participants noted spending fewer than three days on the topic. An additional 29 participants spent between one and two weeks of curricular time on evolution, but only ten (12.7%) approached evolution as a unifying theme. In addition to time spent on evolution, two questions addressed alternatives to evolution, specifically whether teachers include alternatives to evolution (yes/no) and, if so, to indicate which alternatives they include. Among the 79 participants, 17 acknowledged the inclusion of alternatives to evolution, specifying the addition of Christian creation stories (6), non-Christian creation stories (2), or intelligent design specifically (6). Just over half affirmed that they only include scientific concepts in their evolution instruction. Of the participants, 32.9% did not explicitly teach evolution in their classes. When provided with space to expand on "other," participants noted adjacent topics such as adaptation, speciation, and biodiversity as well as references to faith but not explicitly teaching creationism.

Evolution Acceptance & Understanding of Nature of Science

Acceptance of evolution, as measured by the MATE for this sample, was determined to be high, with a mean value of 84.19. In this sample, the standard deviation was 16.71, indicating a greater spread among the scores, which ranged from 25 to 100 points (the lowest score is 20 points). For the NOS instrument, the participants scored a 61.14 point average, situating them in the low understanding grouping. The standard deviation of that measure indicated less distance between scores at 7.03. However, the range of scores was also more condensed, with the lowest score being 41 and the highest at only 78 (of 100 possible points).

Both the MATE and NOS have levels that correspond to specific ranges of scores from very low to very high acceptance (See Appendix A). In this sample, the most populous level for the MATE was "very high," which represented 50% of the scores. Collectively the low and very low levels were only around 11%, and 16% were at moderate, which is the middle ground. The remaining 21% fell in the high acceptance score range. For the NOS measure, only one participant rated a score above the moderate range, and only nine were very low (11.3%). The majority of participants, for this measure, scored in the low range (46%), with another 30% falling in the moderate level.

Correlation Analysis

For the correlation analysis both Pearson's r (Appendix B) and Spearman's rho (Appendix C) were applied to explore relationships among variables of interest since the variables included continuous and non-continuous variables (See appendices for Pearson and Spearman tables). In terms of gender, there existed significant weak associations only with secondary or middle level instruction (-.337, .337 respectively) but none with other variables of interest. However, with so few males in the sample, any generalization about those relationships would be highly speculative. As expected, years of experience did positively relate to level of certification (.623, $p < .001$), as higher certification generally requires advancing degree attainment but not all persons seek certification above a master's degree. Also, the area of certification impacted teaching level, as middle grades teachers were more likely to have general science certifications compared to the more specific areas of content specificity required at secondary levels. There were also patterns visible relative to confidence, specifically that acceptance (.608, $p < .001$) and time spent teaching evolution (.338, $p < .001$) are positively related to teacher confidence in teaching evolution. As seen in other studies, acceptance was negatively impacted by religiosity (-.401), meaning that greater self-reported religiosity is tied with lower acceptance levels and higher acceptance with lower reported religiosity.

Along that same line, as nature of science understanding increases, so does the level of acceptance (.551). Furthermore, the nature of science demonstrated the strongest relationship with acceptance compared with all other variables. One area of additional interest in acceptance was that it is positively related to secondary (.513) and negatively related among middle grades teachers (-.513) suggesting higher acceptance among secondary teachers compared to their middle-level counterparts. The same inverse relationships also showed up in the nature of science understanding (.525, -.525), evolution confidence (.480, -.480), and time spent on evolution (.464, -.464). Time spent on evolution had weak positive correlations to the area of certification held by the teachers, with those certified in physical sciences having a negative weak relationship to teaching time (-.248, $p = .027$) compared to those with biology certification (.363, $p = .001$), or other certifications—those teaching out of field (-.271, $p = .016$). Confidence, however, did not demonstrate any significant relationships to the areas of certification held by teachers, suggesting that factors impacting confidence may not be connected with content training and are of interest for additional exploration. Most importantly, time spent teaching evolution was positively impacted by acceptance of evolution (.410, $p < .001$), nature of science understanding (.352, $p = .001$), and confidence in evolution teaching, both human (.388, $p < .001$) and non-human (.558, $p < .001$).

Partial Correlations

In light of the circuitous loop represented by time spent teaching evolution and confidence in teaching, partial correlations were conducted controlling for time (Appendix D) and confidence (Appendix E) to determine whether there was an impact on other relations. Controlling for time and then confidence did present a slight impact on correlations present among variables of interest, however, the remaining relationships persisted with only minute value or no value adjustment and thus minor adjustment to strength level. With time controlled, acceptance became correlated to rural (-.240) and urban (.240) background as an impacting factor, with urban teachers having a weak positive relationship to acceptance and rural teachers having a negative weak relationship. With confidence controlled, acceptance correlated negatively to certification level (-.222) and had a weaker interaction with religiosity (-.370).

Discussion

The purpose of this study was to explore the complex nature of the teaching of evolution in Georgia, a state in the Southeastern United States where there is a history of controversy surround a topic deemed critical to scientific literacy (Ayala, 2016). Two questions were asked in an effort to explore the characteristics of teachers in the state as well as factors that might impact their confidence in teaching evolution and the time, they elect to spend teaching evolution.

Teacher Characteristics (Question One)

Since teachers are the foremost advocates of evolution to the public (Plutzer & Berkman, 2008), it is critical that they teach evolution and that evolution instruction is accurate and in depth (Ayala, 2016). Participants represented a spectrum of levels of training, certification, and years of experience. Overall, the sample was very much in line with the state-level demographics for gender and other teaching demographics--noting the absence of racial/ethnic data (Quick-Facts-on-Georgia-Education, 2019). While the information aligned with state data, it was surprising that fewer than 10% of teachers are considered to be teaching in their field of certification, which could explain why there were so many who identified other fields as their primary field of certification. According to Nixon et al. (2017), the percentage of teachers operating in their specific field is only 36%; however, this state shows only a third of that number in field. Similarly, the percentage of teachers with life science/biology focus in this sample was much lower than the 63% presented by Banilower et al. (2018), affirming the position of Hermann et al. (2020) that coursework could be an important issue for address. It is not uncommon for teachers to test into new certification areas or teach a wide variety of courses in areas where fewer teachers present to cover the range of courses offered.

When looking at confidence in teaching evolution, a majority of participants had at least some confidence in their ability to teach evolution. Still, it varied based on whether it was confidence in human or non-human evolution. Griffith and Brem (2004) highlighted the roles of intimidation and uncertainty among teachers regarding how they will handle teaching evolution. That uncertainty was highlighted in the strong disconnect between acceptance, confidence, and time spent teaching. While there was still majority agreement on confidence, the shift from higher confidence to less confidence when moving from general evolution to human evolution highlights the change in perceptions and comfort shown to occur when specific topics in evolution are broached. The shifts shown in this sample fits with what we know about teacher personas shifting when teaching evolution (Goldston & Kyzer, 2009) and the range of approaches undertaken to cope with conflict areas (Griffith & Brem, 2004.

While research has shown that time teaching evolution varies greatly from group to group, time spent in this sample was much lower than expected for a group with a mean high acceptance of evolution. The number of participants in this sample teaching evolution three days or less was 30% greater than the 33% found by Rutledge and Mitchell (2002) with a lower rate of acceptance. Similarly, Berkman et al. (2008) showed that nationally 23% of teachers approached evolution as a theme a decade ago, and recently, Hermann et al. (2020) reported even higher at 48.3% taking a thematic approach. However, in this sample, only 12.7% approached evolution thematically with an additional 17.7% approaching it as a unit of instruction, compared to the 31.8% presented by Hermann et al. (2020). Specifically addressing the noted differences between secondary and middle-level teacher participants, it was not surprising to confirm that there is greater confidence, acceptance, nature of science understanding, and time spent teaching among secondary teachers than middle grades. Existing studies have suggested that secondary teachers have higher levels in these and other areas related to evolution (Nadelson & Nadelson, 2010) and that content coursework in preparation has some positive impact on time spend teaching evolution (Berkman & Plutzer, 2011; Friedrichsen et al., 2016).

Religiosity and the pressures surrounding cultures and beliefs embedded in some regions have long been discussed as barriers to science literacy and evolution education (Ayala, 2016; Barnes et al., 2017; Glaze et al., 2015; Laats & Siegel, 2021; Taber, 2017). Similar to studies by Moore (2008) and Berkman et al. (2008), teachers in this sample felt inclined or pressured to include non-scientific alternatives in their teaching, including creationism and intelligent design. However, some pointed to student inquiry as a reason to address these in class. Trani (2004) suggested that religious pressures against acceptance of evolution were overcome when participants had high understandings of the nature of science and content knowledge of evolution. In this sample, those interactions do not have noticeable outcomes on the amount of time teachers spend on the topic in their classrooms. According to Bowman (2008), five of ten students are receiving creationism or intelligent design instruction in their science classes. While this study cannot account for a student-by-student comparison, the percentage of teachers who are adding alternatives represents nearly one-fourth of the sample, and another 33% are not teaching evolution explicitly. Therefore, it is safe to say that a similar half are likely not receiving scientifically accurate instruction in evolution and that instruction is still inadequate (Bowman, 2008; Moore, 2004a, 2004b, 2008; Rutledge & Warden, 2000; Rutledge & Mitchell 2002).

There was little surprise in the results regarding acceptance and understanding of the nature of science as they have been of particular interest in evolution education as predictors of teaching (Binns & Bloom, 2017; Glaze & Goldston, 2015, 2019). This sample demonstrated a higher average acceptance than many other explored groups (Akyol et al., 2010; Glaze & Goldston, 2019; Glaze et al., 2015; Rutledge & Warden, 2000) but understandings of the nature of science were still low (Glaze & Goldston, 2019; Glaze et al., 2015; Ha et al., 2012; Kim & Nehm, 2011). One possible reason for the high acceptance could be that the sample was derived from a professional science teaching organization's membership, suggesting a vested interest among participants in continued learning and growth in the field of science education. It is encouraging to see increasing numbers in the understanding of the nature of science in this group, however, with the strong focus on the nature and process of science as a key to science literacy, there is much room for improvement (Deniz et al., 2011; Rutledge & Warden, 2000;).

Relationships (Question Two)

The correlation models presented several patterns that were of interest. Each of the correlations for middle grades trended to the negative, suggesting that middle-grade teachers felt less confident, had lower acceptance, less understanding of the nature of science, and spent less time teaching evolution than their peers in secondary education. There are several possible reasons for these trends, but there is relatively little research differentiating between middle grades education (grades 4-8) and secondary (9-12) or elementary (K-5) teacher education (Hermann, 2018; Vaughn & Robbins, 2017). Nadelson and Nadelson (2010) suggest that preparation content has something to do with elementary teachers' discomfort with evolution. The lower middle grades (4-8) may have similar struggles.

Acceptance continues to demonstrate a negative correlation to religiosity and a positive correlation to understanding the nature of science (Glaze et al., 2015; Glaze & Goldston, 2019; Wiles, 2008). Similarly, the time spent teaching evolution did have some positive correlation to confidence levels; however, the overall amount of time spent on evolution was discouraging (Goldston & Kyzer, 2009). Interestingly, there was not a correlation found between religiosity and the inclusion of non-scientific alternatives in the classroom as found by Nehm et al. (2009); however, there was no consideration made for external pressures relative to the religiosity of students being considered and how teacher perceptions of possible conflict might weigh on the matter (Goldston & Kyzer, 2009).

The key interactions were still present but slightly differed in intensity when looking through a controlled lens for time and confidence. However, little study has been done to explore the complex relationships between confidence, acceptance, understandings (NOS and content knowledge), and their roles in teacher classroom autonomy (Borgerding et al., 2015). Some anticipated relationships were not present, such as experience and certification level correlating to time spent or confidence when it comes to evolution, aligning with Goldston and Kyzer's (2009) findings that even seasoned teachers struggle with teaching evolution due to external pressures.

Conclusion

While teachers may be more willing to teach that which aligns with their beliefs, acceptance alone is not enough to move teachers beyond their concerns to spend adequate time teaching evolution. Improving evolution teaching represents a historical challenge that is persistent and resistant to one-size-fits-all approaches. We should reach out to teachers where they are, recognizing that many factors come into play to impact what and how they teach evolution. Assumptions are broad regarding roles of certification, background, and experience when it comes to teaching. However, there are complex intersecting interactions that cannot be ignored in approaches to improving evolution education.

When a group of teachers has a higher level of acceptance, more targeted exposure to content such as biology coursework and professional learning opportunities could increase confidence and thus increase the time spent on teaching evolution. Conflicting interactions among low, moderate, and high acceptance samples suggest the best approach for science teachers and preservice training is diverse—taking into consideration where those participants are situated (knowledge, acceptance levels, worldviews, certification, and backgrounds), applying a wide range of strategies for coping and teaching, bridging gaps between worldview/culture and science (understanding/acceptance), increasing understandings of the nature of science (nature of science), incorporating pedagogy for difficult conversations (confidence), and supporting a deeper understanding of relevant scientific concepts (content).

Recommendations

It is recommended that further study be conducted to explore the factors that can positively impact time spent teaching evolution as well as the loop that exists between time spent teaching evolution and confidence in teaching evolution. Ideally a similar study could be carried out to expand on the size of the sample to determine whether this loop is a function of sample size and location or is a broader consideration in further explaining the complex relationships that exist amongst the teaching of evolution and the factors that contribute to teachers' decision-making as it pertains to contentious topics in the science classroom.

Limitations

The findings of this study are limited in generalization due to several factors. The singular location and lack of true representation of the science teacher population nationally or in the state means that the results may not hold true to other sample groups. Similarly, the small sample size and specific targeting of teachers involved in professional organizations limit representation of all science teachers in the sample. Similarly, representation in the sample was predominantly from non-rural settings, an unusual case in a state that is third in the nation for the percent of students in rural school settings. It is possible this is because (1) there are more teachers in non-rural areas than in rural, making it appear off balance, (2) rural teachers may have less funding to access state associations and be reached, or (3) rural teachers have been shown to have more resistance to teaching evolution and therefore did not respond. Furthermore, it is possible that, due to the contentious nature of the topic of evolution in the Southeastern United States among some cultural and religious groups, teachers who are not comfortable with evolution would refuse to participate in the study, resulting in a shift of perceptions.

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Appendix A

Frequency of Levels of Acceptance and Understanding of the Nature of Science (N=79)

	n	*%*
MATE		
Very low (20-52)	4	5.06
Low (53-64)	5	6.33
Moderate (65-76)	13	16.46
High (77-88)	17	21.52
Very High (89-100)	40	50.63
NOS		
Very low (20-52)	9	11.39
Low (53-64)	46	58.23
Moderate (65-76)	23	29.11
High (77-88)	1	1.27
Very High (89-100)	0	0

Note. N =79

Appendix B

*Open Correlation Analysis of Continuous Variables of Interest **(N=79)***

Variables	**1**	**2**	**3**	**4**	**5**	**6**
1. Gender	-					
2. Certification Level	-.056	-				
3. Area of Certification	-.161	.117	-			
4. Religiosity	.206	.069	.033	-		
5. Urban	.102	-.094	.109	-.157	-	
6. Rural	-.102	.094	-.109	.157	-1	-
7. Secondary	-.337*	-.011	.249*	-.190	-.047	.047
8. Middle Grades	.337*	.011	-.249*	.190	.047	-.047
9. Alternatives to evolution	-.156	-.057	.191	.216	-.192	.192
10. MATE	-.195	-.188	.205	-.401**	.201	-.201
11. NOS	-.110	-.052	.104	-.153	-.008	.008

*Not*e. Cells contain zero-order (Pearson) correlations.

Open correlation analysis (continued)

Variables	**7**	**8**	**9**	**10**	**11**
7. Secondary	-				
8. Middle Grades	-1	-			
9. Alternatives to evolution	-.059	.059	-		
10. MATE	.513**	-.513**	-.165	-	
11. NOS	.525**	-.525**	-.015	.551**	-

Appendix C

Open Correlation Analysis of Non-Continuous Variables of Interest (N=79)

Variables	Spearman's rho	Significance (2-tailed)	95% Confidence Intervals (2-tailed)[a,b]	
			Lower	Upper
Female gender - Years Exp	-.117	.304	-.330	.107
Female gender - Evo Conf	-.263	.019*	-.461	-.041
Female gender - Human Evo Conf	-.277	.013*	-.473	-.056
Female gender - Evo Time	-.116	.309	-.329	.109
Male gender - Years Exp	.104	.361	-.120	.318
Male gender - Evo Conf	.289	.010*	.068	.483
Male gender - Human Evo Conf	.308	.006*	.088	.499
Male gender - Evo Time	.150	.188	-.075	.360
Certification Level - Years Exp	.623	<.001*	.450	.751
Certification Level - Evo Conf	.070	.538	-.153	.287
Certification Level - Human Evo Conf	.035	.760	-.188	.254
Certification Level - Evo Time	-.044	.701	-.263	.179
Area Other - Years Exp	-.234	.038*	-.435	-.011
Area Other - Evo Conf	-.215	.057	-.419	.009
Area Other - Human Evo Conf	-.167	.141	-.376	.057
Area Other - Evo Time	-.271	.016*	-.468	-.049
Area PS - Years Exp	-.185	.102	-.392	.039
Area PS - Evo Conf	-.150	.186	-.361	.075
Area PS - Human Evo Conf	-.045	.697	-.263	.178
Area PS - Evo Time	-.248	.027*	-.448	-.025
Area Bio - Years Exp	.012	.918	-.210	.232
Area Bio - Evo Conf	.239	.034*	.016	.440
Area Bio - Human Evo Conf	.213	.060	-.011	.417
Area Bio - Evo Time	.363	.001*	.147	.546
Area Gen Sci - Years Exp	.273	.015	.051	.470
Area Gen Sci - Evo Conf	.082	.472	-.142	.298
Area Gen Sci - Human Evo Conf	.013	.912	-.209	.233
Area Gen Sci - Evo Time	.086	.449	-.138	.302
Religiosity - Years Exp	.159	.161	-.066	.369
Religiosity - Evo Conf	-.130	.255	-.342	.095
Religiosity - Human Evo Conf	-.169	.138	-.377	.056
Religiosity - Evo Time	-.042	.711	-.261	.180
Urban BG - Years Exp	.032	.781	-.191	.251
Urban BG - Evo Conf	-.028	.808	-.247	.195
Urban BG - Human Evo Conf	.015	.897	-.207	.235
Urban BG - Evo Time	-.075	.511	-.292	.149
Rural BG - Years Exp	-.032	.781	-.251	.191
Rural BG - Evo Conf	.028	.808	-.195	.247
Rural BG - Human Evo Conf	-.015	.897	-.235	.207
Rural BG - Evo Time	.075	.511	-.149	.292
Years Exp - Evo Conf	.143	.208	-.082	.354
Years Exp - Human Evo Conf	.147	.196	-.078	.358
Years Exp - Evo Time	.082	.474	-.142	.298
Years Exp - Mate Acceptance	.111	.329	-.113	.325
Years Exp - NOS	.042	.713	-.181	.261
Secondary - Evo Conf	.480	<.001*	.278	.642
Secondary - Human Evo Conf	.432	<.001*	.223	.603
Secondary - Evo Time	.464	<.001*	.260	.629
Middle - Evo Conf	-.480	<.001*	-.642	-.278
Middle - Human Evo Conf	-.432	<.001*	-.603	-.223
Middle - Evo Time	-.464	<.001*	-.629	-.260
Evo Conf - Human Evo Conf	.757	<.001*	.625	.846
Evo Conf - Evo Time	.558	<.001*	.370	.702
Evo Conf - Mate Acceptance	.500	<.001*	.301	.657
Evo Conf - NOS	.374	<.001*	.159	.555
Human Evo Conf - Evo Time	.388	<.001*	.175	.567
Human Evo Conf - Mate Acceptance	.608	<.001*	.430	.740
Human Evo Conf - NOS	.393	<.001*	.180	.571
Evo Time - Mate Acceptance	.410	<.001*	.199	.585
Evo Time - NOS	.352	.001*	.135	.536

a. Estimation is based on Fisher's r-to-z transformation.
b. Estimation of standard error is based on the formula proposed by Bonett and Wright.
c. Confidence Interval cannot be computed for this variable pair because the correlation is 1 or -1.

Appendix D

Partial correlation controlling for time (N = 79)

Variables	1	2	3	4	5	6	7
1. Gender							
2. Certification Level	-.064						
3. Certification Area	-.137	.138					
4. Religiosity	.203	.067	.046				
5. Urban	.096	-.098	.131	-.160			
6. Rural	-.096	.098	-.131	.160	-1		
7. Years of Experience	-.109	.584**	.278*	.166	.043	-.043	
8. Secondary	-.321**	.019	.154	-.192	-.022	.022	.189
9. Middle Grades	.321**	-.019	-.154	.192	.022	-.022	-.189
10. Alternatives	-.159	-.058	.203	.215	-.193	.193	-.055
11. MATE	-.166	-.178	.122	-.414**	.240*	-.240*	.093
12. NOS	-.078	-.035	.023	-.148	.012	-.012	.016
13. Confidence	-.237*	.053	.074	-.174	.045	-.045	.100

Note. Cells contain partial correlations of all variables when controlling for time.

Partial correlation controlling for time (continued)

Variables	8	9	10	11	12	13
8. Secondary	-1					
9. Middle Grades	-.058	.058				
10. Alternatives to evolution	.423**	-.423**	-			
11. MATE	.454**	-.454**	-.171	-		
12. NOS	.299**	-.299**	-.010	.494**	-	
13. Confidence	-1		-.080	.371**	.167	-

Appendix E

Partial correlation controlling for confidence (N = 79)

Variables	1	2	3	4	5	6	7
1 Gender	-						
2 Certification Level	-.055	-					
3 Certification Area	-.116	.117	-				
4 Religiosity	.171	.073	.069	-			
5 Urban	.107	-.094	.111	-.158	-		
6 Rural	-.107	.094	-.111	.158	-1	-	
7 Years of Experience	-.088	.578**	.272*	.188	.037	-.037	-
8 Secondary	-.253*	-.018	.181	-.128	-.056	.056	.168
9 Middle Grades	.253*	.018	-.181	.128	.056	-.056	-.168
10 Alternatives	-.183	-.056	.212	.206	-.192	.192	-.047
11 MATE	-.082	-.222*	.126	-.370**	.227*	-.227*	.063
12 NOS	-.034	-.059	.047	-.109	-.010	.010	.004
13 Time Spent	.027	-.080	.189	.057	-.076	.076	.025

Note. Cells contain partial correlations of all variables when controlling for confidence.

Partial correlation controlling for confidence (continued)

Variables	8	9	10	11	12	13
8. Secondary	-					
9. Middle Grades	-1	-				
10. Alternatives to evolution	-.027	.027	-			
11. MATE	.373**	-.373**	-.147	-		
12. NOS	.457**	-.457**	.009	.486**	-	
13. Time Spent	.266*	-.266*	.028	.141	.193	-