RESEARCH AND TEACHING

An Examination of Constructivism, Active Learning, and Reflexive Journaling and Their Independent and Combined Effects on Student Acceptance of Biological Evolution

By Clinton Thomas Laidlaw, Seth M. Bybee, Steven Shumway, Thomas Heath Ogden, Steven Peck, and Jamie L. Jensen

Instruction that increases acceptance of evolution is essential to effective biology instruction, but instruction about evolution is not consistently correlated with increased levels of acceptance. Does the pedagogical approach utilized make the difference? Using a curriculum that demonstrably increases evolution acceptance, we compare multiple pedagogical styles (behaviorist vs. constructivist, active vs. less active, and journaling vs. not journaling) in a full-factorial design to test the hypotheses that pedagogy designed for constructivism, active learning, and reflexive journaling will increase the probability that students' acceptance of evolution increases. Though we observed statistically significant acceptance gains, no treatments were statistically different from the other treatments regarding those acceptance gains. Evolution acceptance is possible despite the use of constructivist-designed or behaviorist-designed pedagogy, active learning or less active learning, or maintaining a reflexive journal or not. There is no indication that any combination of these instructional approaches has a greater effect than any other on evolution acceptance.

Biology is an essential part of a general education (American Association for the Advancement of Science, 1993; Brewer & Smith, 2011; Bybee, 1997; Kagan, 1992; National Association of Biology Teachers, 2010; National Research Council, 1996). Learning is easier when new information is unified and fits into existing schema (Piaget, 1967). The field of biology is unified by the theory of evolution (Dobzhansky, 1973; American Association for the Advancement of Science, 1993; Brewer & Smith, 2011; Bybee, 1997; Kagan, 1992; National Association of Biology Teachers, 2010; National Research Council, 1996). Despite being accepted overwhelmingly by the scientific community (Pew Research Center, 2015; Alters & Alters, 2001), biological evolution is frequently rejected by the general public (Miller et al., 2006). In many cases, because it is viewed as a source of controversy or rejected by the instructors, evolution is omitted from a biology curriculum (Lerner, 2001; Farber, 2003; Oliveira et al., 2011; Verhey, 2005; Goldston & Kyzer, 2009), leaving biology as a disconnected grouping of facts to be memorized, repeated, and then forgotten (Nehm & Schonfeld, 2007; Nehm & Reilly, 2007; Catley & Novick, 2009). Students who do not accept evolution generally do not apply it outside the classroom (Lerner, 2001; Farber, 2003; Oliveira et al., 2011; Verhey, 2005; Goldston & Kyzer, 2009).

Taken together, the literature indicates that there should be a positive relationship between evolution instruction and acceptance (Anderson et al., 2002; Bishop & Anderson, 1990; Demastes et al., 1995; Lord & Marino, 1993; Nehm & Schonfeld, 2008, Sinatra et al., 2003). Some studies have supported this hypothesis (Robbins & Roy, 2007; Akyol et al., 2010; Kim & Nehm, 2011; Ha et al., 2012), and some have not (Bishop & Anderson, 1990; Demastes et al., 1995; Jensen & Finley, 1996; Asterhan & Schwarz, 2007; Stover & Mabry, 2007; Rutledge & Sadler, 2011; Deniz & Donnelly, 2011; Lawson & Worsnop, 1992; Crawford et al., 2005; Cavallo & McCall, 2008; Sinatra et al., 2003; Brem et al., 2003; Shtulman, 2006; Cavallo et al., 2011). What is the difference between instruction that increases evolution acceptance and instruction that does not? Among the possible explanations...
is pedagogical style (Tanner & Allen, 2004)—for example, that informed by constructivist learning theory such as active learning (Nehm & Reilly, 2007; Alters & Nelson, 2002).

Constructivism assumes that conceptual understanding is constructed from the interaction of new and old experiences within the mind of the individual (Piaget, 1967; Airasian & Walsh, 1997; Vrasidas, 2000). This concept contrasts with behaviorism, a learning theory based principally on the increase or decrease in the number of behaviors, based on their relationship to rewards and punishments (Ertmer & Newby 1993). Constructivists assume that when using techniques designed to provide experience for students, the students will show an elevated level of ownership for that understanding compared to alternative instruction methods (Alters & Nelson, 2002).

Freeman and colleagues (2014) found that using active learning of any kind increased exam performance in STEM classes. Active learning was also suggested to increase knowledge and acceptance of evolution (Alters & Nelson, 2002) since active learning could increase learning about concepts correlated with evolution acceptance, such as the nature of science and evolution (Deng et al., 2011; Farber, 2003; Dunk et al., 2017; Nehm & Reilly, 2007).

Constructivist pedagogy and active learning, however, may be more time consuming than traditional instruction (Oliver-Hoyo et al., 2004). Changing to a constructivist pedagogy may also require altering entire courses (Airasian & Walsh, 1997). Reflexive journaling (Clark & Rossiter, 2008) could increase the rate of acceptance without requiring such imposing levels of restructuring.

Journaling encourages students to reflect, particularly regarding material that introduces doubt or perplexity (such as evolution), and to address such doubt (Spalding et al., 2002). Reflection is the “active, persistent, and careful consideration of any belief or supposed form of knowledge in the light of the grounds that support it and the further conclusions to which it tends” (Dewey, 1933, p. 9). Boud and colleagues (1985) further define reflection as “an important human activity in which people recapture their experience, think about it, mull it over and evaluate it” (p. 19). Given that self-reflection is one of the most important aspects of learning according to constructivism (Vrasidas, 2000), instructors should encourage students to reconsider their experiences and take the time to evaluate them. Journaling can provide this opportunity for students (Scharmann & Butler, 2015; Chirema, 2007; Fosnot, 1996; Munday et al., 2014; Reynolds, 2013; Makaiau et al., 2015; Blake, 2005; Wald & Reis, 2010; Kuiper & Pesut, 2004). Students report that journaling increases the clarity of their thoughts (Pinkstaff, 1985) and reflective journals assist them in reviewing and critically assessing the importance of class material (Maypole & Davies, 2001; Fritson et al., 2013).

Scharmann & Butler (2015) found that journaling about evolution increases the number of correct ideas regarding evolution. Though promising, this study included only the journaling treatment, making it impossible to determine the actual effect that the act of journaling played. There was also no outside measurement of acceptance except for the statements made in the journals themselves. Akkaraju & Wolf (2016) conducted a similar study in which students engaged in online blogging. They also observed improvement during the course. Again, there was no control group, and measurements of knowledge and acceptance were obtained exclusively from the blog entries.

This study is focused on answering three questions regarding instruction and acceptance of evolution. First, are students taught using pedagogy designed for constructivism more likely to accept evolution than those who are taught using pedagogy designed for behaviorism? Second, are students taught in an active classroom more likely to accept evolution than those taught in a minimally active classroom? And third, are students who keep reflective journals about the relationship between what they are learning and evolution more likely to accept evolution than those who do not? These questions were tested in a full factorial, quasi-experimental design to determine if any combination of the three strategies led to differential increases in acceptance of evolution compared to other combinations.

**Methods**

**Study population**

Our study population consisted of 351 students enrolled in 10 sections of an entry-level, non-majors biology class at a large (approximately 37,000 students), open-enrollment, 4-year, public university in the western United States that used evolution as an organizing principle.

**Course overview**

The course consisted of four units that each comprised approximately one quarter of the semester:

- **Unit 1:** natural selection, nature of science, cell structure and function
- **Unit 2:** genetics, mechanisms of evolution
- **Unit 3:** phylogenetic tree thinking, non-vertebrate diversity and
evolution
• Unit 4: vertebrate diversity and evolution, hominid evolution

The diversity of organisms was presented in a phylogenetic context.

Questions
Question 1: Are students taught using pedagogy designed for constructivism more likely to accept evolution than those who are taught using pedagogy designed for behaviorism?

We randomly assigned entire classes of introductory biology to one of two treatments: constructivist and behaviorist. Constructivist classrooms were taught using pedagogy that facilitated the personal construction of conceptual understanding by posing questions and providing experiences to the students, giving them time and opportunity to build their own understanding of the content, and verifying afterward that correct constructs had been built. Grades were still assigned based on exam and other classroom performance, so this design did still have some behaviorist aspects as well.

Constructivist treatment
1. The instructor presents a somewhat puzzling example.
2. Students are then asked questions regarding possible explanations for the puzzling phenomenon. They are asked to consider the question, then discuss it with the person sitting next to them.
3. Following introspection and conversation, we discuss their answers as a class, which will likely leave us with multiple possible hypotheses.
4. We then present more information that can inform students’ perception regarding the previous questions.
5. Students are then asked to re-evaluate their understanding of the initial observation considering what was just observed, then they would discuss it in pairs.
6. Following introspection and conversation, we discuss their answers as a class to ensure that the class has come to a reasonable consensus.

The behaviorist treatment was similarly student centered in nature to the constructivist treatment. The behaviorist treatment presents conclusions upfront and then rewards the students through affirmation and praise whenever those conclusions are appropriately repeated (Scheurman, 1998; Bohgossian, 2006; Bichelmeyer, & Hsu 1999). To ensure we are testing the style of teaching and not the activities being used, we used the same activities in both treatments. Behaviorist classes were told at the onset what their constructs should be, and the examples (the same examples used in the constructivist classrooms) were used to illustrate what had been explained. Thus, the fundamental difference was in the order of the presentation and the emphasis placed on contemplation and discussion (Table 1). Both classes were in all other ways as similar to one another as possible. Because constructivism is a theory of learning, it is impossible to ensure a classroom is wholly nonconstructivist.

Behaviorist treatment
1. Begin by explaining a puzzling phenomenon, thus dispelling any questions the students might have.
2. Show the class the example used as the puzzling example in the constructivist treatment.
3. To ensure that students are participating in the activity, have them regurgitate the explanation for

<table>
<thead>
<tr>
<th>TABLE 1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Basic differences between the instruction in the constructivist and behaviorist treatments with their respective sample sizes.</td>
</tr>
<tr>
<td>Constructivist classroom (n = 188)</td>
</tr>
<tr>
<td>• Experiences precede conclusions</td>
</tr>
<tr>
<td>• Conclusions generated by students</td>
</tr>
<tr>
<td>• Reflection strongly encouraged</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>TABLE 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Representation of the four treatment groups created in the full factorial of the active vs. less-active and the constructivist vs. behaviorist treatments (with their respective sample sizes).</td>
</tr>
<tr>
<td>Constructivist</td>
</tr>
<tr>
<td>Active/Constructivist (n = 111)</td>
</tr>
<tr>
<td>Less active/Constructivist (n = 77)</td>
</tr>
</tbody>
</table>
the example given in the previous step (reinforcement).

4. Present the further evidence presented in Step 4 of the constructivist treatment (this time to reinforce the conclusions you provided).

5. Again, discuss as a class how this example illustrates the explanation given at the beginning of the discussion, and confirm correct responses (reinforcement).

Question 2: Are students taught in an active classroom more likely to accept evolution than those taught in a minimally active classroom?

To test the effect of active learning, we prepared a full-factorial design in which both the constructivist and behaviorist treatments were conducted as both active and less active (Table 2). The fundamental difference between the active and less-active designs was that the students in the less-active classes were not asked to discuss the material with neighbors or the class, and all activities were performed by the instructor and only observed by the students. In the active class, on the other hand, the activities were performed by the students, who were encouraged to discuss the material. We do not call the less-active treatment “not active,” because even listening and taking notes can be considered active participation (Bonwell & Eison, 1991).

Question 3: Are students who keep reflexive journals about the relationship of what they are learning and evolution more likely to accept evolution than those who do not?

We randomly selected students from our existing constructivist and non-constructivist sections, assigning half of the students following each treatment to complete a weekly journal entry (Table 3). Students were informed that their grade on the journaling assignment would be based on the thought and consideration they put into their journal entries, not the opinions expressed. Journals were to be about 1 page submitted weekly and were to address each of these three topics:

- what the student learned about biology that week
- how the things the student learned relate to the concept of biological evolution
- how the student’s perception of evolution had changed as a result of what they had learned

Data collection

Data were collected at the beginning of the semester (before instruction) and at the end of the semester (after instruction). Both surveys were administered using Qualtrics software. These surveys included the Knowledge of Evolution Exam (KEE) composed of “10 basic, discriminating questions about evolutionary topics,” resulting in scores between 0 and 10, to measure evolution knowledge (Moore et al., 2009, p. 6). The Measure of Acceptance of the Theory of Evolution (MATE; Rutledge & Sadler, 2007), which consists of 20 items scored on a six-option Likert scale (points were given from 0 to 5, with possible total scores ranging from 0 to 100 and higher scores indicating greater acceptance), was used to quantify change in acceptance. The pre-instruction survey also included the Lawson’s Classroom Test of Scientific Reasoning (LCTSR; Lawson, 1978, 2000), which measures scientific reasoning ability on a scale of 0 to 24. Five questions regarding the frequency of students’ religious practices from a religiosity instrument (Manwaring et al., 2015) were included to ensure equivalence in terms of student religiosity. Students were also asked if they believed in God. These were used because scientific reasoning and religiosity can be significant predictors of acceptance (Glaze et al., 2015). These were included as covariates, as were demographic questions (e.g., gender, age, STEM or non-STEM major).

### Table 3

<table>
<thead>
<tr>
<th>Constructivist</th>
<th>Behaviorist</th>
</tr>
</thead>
<tbody>
<tr>
<td>Active constructivist with journaling ($n = 36$)</td>
<td>Active behaviorist with journaling ($n = 29$)</td>
</tr>
<tr>
<td>Active constructivist without journaling ($n = 75$)</td>
<td>Active behaviorist without journaling ($n = 57$)</td>
</tr>
<tr>
<td>Less-active constructivist with journaling ($n = 40$)</td>
<td>Less-active behaviorist with journaling ($n = 34$)</td>
</tr>
<tr>
<td>Less-active constructivist without journaling ($n = 37$)</td>
<td>Less-active behaviorist without journaling ($n = 43$)</td>
</tr>
</tbody>
</table>

Note. The active constructivist without journaling and the active behaviorist without journaling consisted of two sections assigned to the same treatment condition.
Data analysis

Data were analyzed using multiple regression to determine which factors were statistically correlated with acceptance gains over the semester for all students who completed both the pre- and post-instruction instruments.

Results

Our study population had an average age of 22, with 52.41% male and 47.59% female, 52.69% STEM majors and 47.61% non-STEM majors, an average LCTSR score of 13.86 out of 24, and religiosity of 47.35 out of 75, with 94.33% reporting a belief in God (Table 4).

Across treatments, MATE (acceptance) scores increased 15.29 points on a 100-point scale ($t = -17.48, p < .001$), with a high effects size ($d = 1.13$) from a pre-instruction mean score of 60.68 out of 100. KEE (knowledge) scores increased by 1.22 points on a 10-point scale ($t = -9.75, p < .001$), with a medium effects size ($d = 0.63$) from a mean pre-instruction score of 5.56 out of 10.

Question 1 results: Are students taught using pedagogy designed for constructivism more likely to accept evolution than those who are taught using pedagogy designed for behaviorism?

There was no statistically significant difference in increase in MATE scores between behaviorist and constructivist treatments with the interactions between the treatments included ($p = .605$) or without the interactions between treatments ($p = .247$) in the presence of the other variables: KEE score before instruction, MATE score before instruction, change in KEE, if the class was taught in an active- or less-active manner, if students keeping a reflexive journal or not, students’ declared sex, LCTSR score, whether or not students were a STEM major, religiosity score, whether or not students believed in God, and age (Tables 5 and 6).

There was also no statistically significant difference in increase in KEE scores between behaviorist and less-active treatments, with the interactions between the treatments included ($p = .982$) or without the interactions included ($p = .980$) in the presence of the other variables.

Question 2 results: Are students taught in an active classroom more likely to accept evolution than those taught in a minimally active classroom?

There was no statistically significant difference in increase in MATE scores between active and less-active treatments, with the interactions between the treatments included ($p = .434$) or without the interactions included ($p = .434$) in the presence of the other variables (Tables 5 and 6).

No interactions of treatments were statistically significant (Table 6).

There was no statistically significant difference in increase in KEE scores between journaling and not-journaling treatments, with the interactions between the treatments included ($p = .241$) or without the interactions included ($p = .241$) in the presence of the other variables.

Question 3 results: Are students who keep reflexive journals about the relationship of what they are learning and evolution more likely to accept evolution than those who do not?

There was no statistically significant difference in increase in MATE scores between active and less-active treatments, with the interactions between the treatments included ($p = .434$) or without the interactions included ($p = .434$) in the presence of the other variables (Tables 5 and 6).

There was no statistically significant difference in increase in KEE scores between active and less-active treatments, with the interactions between the treatments included ($p = .241$) or without the interactions included ($p = .241$) in the presence of the other variables.

Table 4

<table>
<thead>
<tr>
<th>Factor</th>
<th>Active (%)</th>
<th>Less active (%)</th>
<th>Constructivist (%)</th>
<th>Behaviorist (%)</th>
<th>Journaling (%)</th>
<th>Not journaling (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Religiosity</td>
<td>46.90</td>
<td>47.93</td>
<td>48.14</td>
<td>46.42</td>
<td>47.75</td>
<td>47.07</td>
</tr>
<tr>
<td>LCTSR</td>
<td>13.99</td>
<td>13.68</td>
<td>13.65</td>
<td>14.10</td>
<td>14.00</td>
<td>13.76</td>
</tr>
<tr>
<td>KEE (Pre-instruction)</td>
<td>5.55</td>
<td>5.57</td>
<td>5.76</td>
<td>5.53</td>
<td>5.66</td>
<td>5.49</td>
</tr>
<tr>
<td>MATE (Pre-instruction)</td>
<td>60.96</td>
<td>60.30</td>
<td>59.75</td>
<td>61.75</td>
<td>60.39</td>
<td>60.87</td>
</tr>
<tr>
<td>STEM</td>
<td>57.21</td>
<td>46.71</td>
<td>52.63</td>
<td>52.76</td>
<td>56.34</td>
<td>50.24</td>
</tr>
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</table>
included \((p = .252)\) in the presence of the other variables.

The only statistically significant predictors of MATE score change were students’ pre-instruction KEE (knowledge) score \((p < .001)\), which was directly correlated with MATE change; their change in KEE score from before instruction to after instruction \((p < .001)\), which was also directly correlated with MATE change; and their pre-instruction MATE score \((p < .001)\), which was inversely related to their change in MATE (see Tables 5 and 6).

The only statistically significant predictors of KEE score change were students’ pre-instruction MATE score \((p = .001)\), which was directly correlated with KEE change; their change in MATE score from before instruction to after instruction \((p < .001)\), which was also directly correlated with MATE change; their pre-instruction KEE score \((p < .001)\), which was inversely related to their change in MATE; and their LCTSR (scientific reasoning) score \((p < .001)\).

**Discussion and future directions**

Though it has frequently been hypothesized that pedagogical styles designed for constructivism, active learning, and reflexive journaling would increase evolution acceptance, our results do not support these hypotheses in any combination. We found statistically significant acceptance increases in terms of MATE score, but this change was observed irrespective of the treatment or combination of treatments employed in the classroom. The same is true for increases in knowledge as measured by the KEE.

The only statistically significant predictors of MATE change were the student’ initial KEE scores (how much they knew about evolution entering the course), their KEE change (how much they learned about evolution during the course), and their initial MATE score (how much they accepted evolution at the beginning of the course). Knowledge of evolution was related to acceptance of evolution. Initial MATE score was inversely related to their change in MATE score, indicating a ceiling effect. One of the leading criticisms of the MATE is that it may conflate

### TABLE 5

<table>
<thead>
<tr>
<th>Model</th>
<th>B</th>
<th>Std. Error</th>
<th>(\beta)</th>
<th>t</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Constant)</td>
<td>12.1590</td>
<td>3.5860</td>
<td></td>
<td>3.3900</td>
<td>.001</td>
</tr>
<tr>
<td>KEE (Pre-instruction)</td>
<td>1.790</td>
<td>.470</td>
<td>.237</td>
<td>3.808</td>
<td>.000</td>
</tr>
<tr>
<td>MATE (Pre-instruction)</td>
<td>-1.498</td>
<td>.470</td>
<td>.591</td>
<td>-10.614</td>
<td>.000</td>
</tr>
<tr>
<td>KEE change</td>
<td>1.842</td>
<td>.367</td>
<td>.275</td>
<td>5.017</td>
<td>.000</td>
</tr>
<tr>
<td>Journaling</td>
<td>.266</td>
<td>1.310</td>
<td>.009</td>
<td>.203</td>
<td>.839</td>
</tr>
<tr>
<td>Active</td>
<td>.711</td>
<td>1.303</td>
<td>.025</td>
<td>.545</td>
<td>.586</td>
</tr>
<tr>
<td>Constructivist</td>
<td>-1.484</td>
<td>1.280</td>
<td>.053</td>
<td>-1.159</td>
<td>.247</td>
</tr>
<tr>
<td>Female</td>
<td>.059</td>
<td>1.374</td>
<td>.002</td>
<td>.043</td>
<td>.966</td>
</tr>
<tr>
<td>STEM</td>
<td>-.328</td>
<td>1.279</td>
<td>-.012</td>
<td>-.256</td>
<td>.798</td>
</tr>
<tr>
<td>LCTSR</td>
<td>.028</td>
<td>.152</td>
<td>.010</td>
<td>.181</td>
<td>.856</td>
</tr>
<tr>
<td>Believe in God</td>
<td>3.100</td>
<td>3.301</td>
<td>.051</td>
<td>.939</td>
<td>.348</td>
</tr>
<tr>
<td>Religiosity</td>
<td>-.099</td>
<td>.052</td>
<td>-.112</td>
<td>-1.899</td>
<td>.058</td>
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<tr>
<td>Age</td>
<td>-1.020</td>
<td>.198</td>
<td>-.025</td>
<td>-.516</td>
<td>.606</td>
</tr>
</tbody>
</table>

*Note. B = unstandardized regression coefficient; \(\beta\) = standardized coefficient.*
knowledge with acceptance (Smith et al., 2016; Smith, 2010); as that may be the case, it could be argued that the correlation between knowledge gains and acceptance gains would be expected when using the MATE. While this is a possibility, the inverse relationship observed between initial MATE scores and change in MATE scores is not observed with initial KEE scores and change in MATE scores where a positive correlation exists. Students with higher initial knowledge scores as measured by the KEE also demonstrated higher, not lower, increases in acceptance as measured by the MATE over the course of the semester.

As has been observed in other studies, knowledge of evolution and increased knowledge of evolution were correlated with an increase in acceptance (Nadelson & Southerland, 2010; Fowler & Zeidler, 2016; Glaze et al., 2015). Thus, factors kept constant may account for the increase in acceptance observed. These factors include the curriculum and specific examples used in this course, the amount of time dedicated to instruction about evolution, the fact that evolution was used as the unifying theme of the course, the single instructor as a possible role model or as a perceived member of the in-group or groups to which students in the class perceive themselves to belong, or the culture of the classroom.

There is the possibility that the amount of time spent on evolution is an important factor in increasing

<table>
<thead>
<tr>
<th>Model</th>
<th>B</th>
<th>Std. Error</th>
<th>ß</th>
<th>t</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Constant)</td>
<td>11.443</td>
<td>3.888</td>
<td>2.944</td>
<td>.003</td>
<td></td>
</tr>
<tr>
<td>KEE (Pre-instruction)</td>
<td>1.733</td>
<td>.473</td>
<td>.229</td>
<td>3.664</td>
<td>.000</td>
</tr>
<tr>
<td>MATE (Pre-instruction)</td>
<td>-5.070</td>
<td>.047</td>
<td>-.602</td>
<td>-10.694</td>
<td>.000</td>
</tr>
<tr>
<td>KEE change</td>
<td>1.811</td>
<td>.369</td>
<td>.271</td>
<td>4.909</td>
<td>.000</td>
</tr>
<tr>
<td>Journaling</td>
<td>3.306</td>
<td>2.758</td>
<td>.116</td>
<td>1.199</td>
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</tr>
<tr>
<td>Active</td>
<td>1.885</td>
<td>2.405</td>
<td>.067</td>
<td>.784</td>
<td>.434</td>
</tr>
<tr>
<td>Constructivist</td>
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<td>-.518</td>
<td>.605</td>
</tr>
<tr>
<td>Female</td>
<td>.135</td>
<td>1.383</td>
<td>.005</td>
<td>.098</td>
<td>.922</td>
</tr>
<tr>
<td>STEM</td>
<td>-2.950</td>
<td>1.280</td>
<td>-.011</td>
<td>-.231</td>
<td>.818</td>
</tr>
<tr>
<td>LCTSR</td>
<td>.056</td>
<td>.154</td>
<td>.020</td>
<td>.365</td>
<td>.715</td>
</tr>
<tr>
<td>Believe in God</td>
<td>3.103</td>
<td>3.311</td>
<td>.051</td>
<td>.937</td>
<td>.349</td>
</tr>
<tr>
<td>Religiosity</td>
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<td>.053</td>
<td>-.120</td>
<td>-2.038</td>
<td>.042</td>
</tr>
<tr>
<td>Age</td>
<td>-.116</td>
<td>.201</td>
<td>-.028</td>
<td>-.579</td>
<td>.563</td>
</tr>
<tr>
<td>Journal x Active</td>
<td>-6.460</td>
<td>3.862</td>
<td>-.183</td>
<td>-1.673</td>
<td>.095</td>
</tr>
<tr>
<td>Journal x Constructivist</td>
<td>-3.296</td>
<td>3.876</td>
<td>-.098</td>
<td>-.850</td>
<td>.396</td>
</tr>
<tr>
<td>Active x Constructivist</td>
<td>-.361</td>
<td>3.366</td>
<td>-.012</td>
<td>-.107</td>
<td>.915</td>
</tr>
<tr>
<td>Journal x Active x Constructivist</td>
<td>7.333</td>
<td>5.216</td>
<td>.166</td>
<td>1.406</td>
<td>.161</td>
</tr>
</tbody>
</table>

Note. B = unstandardized regression coefficient; ß = standardized coefficient.
overall evolution acceptance. However, there is no consistent trend in the literature showing that increasing the amount of instruction about evolution consistently results in higher acceptance rates (Glaze et al., 2015).

Some key factors we observed about the instructor include that they shared the same religious convictions as the majority of the students. This study was performed at the same institution with demographically similar students to those observed by Holt and colleagues (2018), who found that students taught by an instructor who observably shared the students’ religious and cultural convictions were more likely to accept what was being taught than those taught by the same instructor when that instructor concealed this fact.

Social identity and self-categorization theories in social psychology explain intergroup behavior based on the perceived membership of individuals to relevant social groups (Turner & Oakes, 1986; Tajfel & Turner, 1979; Tajfel & Turner, 1986; Haslam, 1997). People are generally critical of ideas coming from individuals perceived as being outside of their group and accepting of ideas coming from individuals perceived as being within their group (Tajfel, 2010). Classes in which the teacher is not viewed as part of the in group could result in reduced credence for what is being presented.

Conclusion

Increased levels of student acceptance of biological evolution can be attained as a result of instruction using a wide diversity of pedagogical styles. Though differences may exist based on other measures, we see no statistically significant difference in acceptance or knowledge gains based on the use of pedagogy designed for constructivism or behaviorism, active or less-active learning, or whether or not the students are asked to keep a journal. Increasing evolution acceptance is possible for instructors who use a broad range of teaching styles.

References


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