

The Development and Validation of the Measure of Acceptance of the Theory of Evolution Instrument

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A biology teacher's acceptance or rejection of evolutionary theory as a scientifically valid explanation is potentially important to the role that evolution takes in the high school biology curriculum. Due to the nature of available instrumentation, our understanding of teacher acceptance of this complex over-reaching biological theory may be incomplete or confounded. This paper describes the development and validation of the Measure of Acceptance of the Theory of Evolution (MATE)—a 20-item Likert-scaled instrument that assesses teachers' overall acceptance of evolutionary theory. Chronbach alpha reliability of the MATE is also reported.

Evolutionary theory is the central and unifying theme of the discipline of biology. Its broad explanatory power allows for the investigation of a wide range of intriguing biological questions and provides an underlying framework to the discipline, bringing meaning to the tremendous array of life's traits and behaviors. Because of its explanatory and unifying powers, scientific and educational organizations have formally recognized evolutionary theory as the ultimate organizational framework of the discipline and have called for instruction in evolution to be commensurate with its station in biology (American Association for the Advancement of Science, 1989; National Association of Biology Teachers, 1997; National Research Council, 1985; National Science Teachers Association, 1997). Results from several studies, however, suggest that instruction in evolutionary biology at the high school level has been absent, cursory, or fraught with misinformation (Eglin, 1983; Johnson, 1986; Roelfs, 1987; Shankar & Skoog, 1993).

The factors contributing to the current state of instruction in evolutionary biology have proven to be manifold. Historically, restrictive board of education policies; opposition from religious groups, school administrators, and community members; and inadequate textbook coverage have contributed to the deemphasis of evolution in the high school biology curriculum (Eglin, 1983; Roelfs, 1987; Shankar, 1990; Skoog, 1970; Tatina, 1989; Troost, 1967; Zimmerman, 1987). Yet, there may be additional, perhaps more fundamental, factors that impact the teaching of this important concept.

Research has revealed that teachers' attitudes and views about subject matter can impact their curricular and instructional decisions (Carlesen, 1991; Grossman, 1989; Hashweh, 1987; Shulman, 1986; Wilson, Shulman, & Richert, 1987). Thus, a biology teacher's acceptance or rejection of evolutionary theory as a scientifically valid explanation is potentially important to the place that evolution takes in the biology curriculum. While several studies have documented teacher opinions and attitudes concerning the evolution-creation controversy (Affannato, 1987; Eglin, 1983; Ellis, 1983; Osif, 1997; Roelfs, 1987; Van Koevering & Stiehl, 1989), few studies have explored the status of biology teachers' acceptance of evolutionary theory. Studies addressing this variable are characterized by instruments that either utilize only a few items to assess teacher acceptance of evolutionary theory (Tatina, 1989; Zimmerman, 1987) or that serve as a combined measure of teacher acceptance and teacher understanding of evolutionary theory (Shankar, 1990). Thus, our understanding of teacher acceptance of this complex and over-reaching biological theory may be incomplete or confounded.

The stimulus for the present work was the need for a valid and reliable, homogenous, multi-item instrument to assess teacher acceptance of evolutionary theory. The work described in this paper details the development and validation of the Measure of Acceptance of the Theory of Evolution (MATE) instrument. The MATE was designed to measure teachers' overall acceptance of evolutionary theory by assessing their perceptions of evolutionary theory's scientific validity, ability to

explain phenomena, and acceptance within the scientific community.

Methodology and Results

MATE Development

First, concepts to be addressed by MATE items were developed. Because informed decisions of acceptance or rejection of a scientific theory are based on evaluations of substantive and syntactical elements of a domain (Schwabb, 1968), fundamental concepts of evolutionary theory and the nature of science were selected to be addressed by the MATE: the processes of evolution, the available evidence of evolutionary change, the ability of evolutionary theory to explain phenomena, the evolution of humans, the age of the earth, the independent validity of science as a way of knowing, and the current status of evolutionary theory within the scientific community.

Twenty Likert-scaled items containing statements that addressed the selected concepts were composed. During item construction, efforts were made to maintain a balance of positively and negatively stated items, as suggested by Likert (1932), and to promote the clarity of items by keeping items to an optimum length and by avoiding double-barreled statements. The five points of the Likert scale were *strongly agree*, *agree*, *undecided*, *disagree*, and *strongly disagree*. Thus, each MATE item forces a response indicating the strength of an individual's agreement or disagreement with a statement concerning evolutionary theory.

Validation

To establish the content-validity of the instrument, MATE items were critically analyzed by a jury of five university professors who have expertise in the fields of evolutionary biology, science education, and the philosophy of science. Each member of the jury rated the items on a scale of 1 to 5. A rating of 1 indicated that the reviewer found the item to be invalid and did not contribute to the measure of the intended concept. A rating of 5 indicated that the reviewer had high confidence that the item contributed to the measurement of the intended concept.

As a result of the item analysis by jury members, several items were modified from their original form to maximize the accuracy and clarity of the items. No item was included on the final instrument that had a composite rating from the jury of less than 3.5. The average rating of the items on the instrument was 4.7. It was the consensus of the jury that the individual MATE items assessed the intended concepts, and that

the MATE instrument as a whole was a valid measure of teacher acceptance of evolutionary theory.

To assess the construct validity of the MATE, the statistical technique of factor analysis was utilized. Factor analysis can verify the underlying structure of a test, revealing the number of traits being measured. Thus, if a test is designed to measure one particular trait, a factor analysis should reveal a single factor (Sax, 1979). A principal factors analysis revealed one factor with an eigenvalue greater than 1, suggesting the presence of a single factor (Table 1). All items achieved factor loading values of greater than .65, suggesting that each item contributed significantly to the assessment of the single factor (Table 2). The single factor model accounted for 71% of the variation among the items (Table 1).

Table 1
Eigenvalue and Percent Variance of the First Four Factors (n = 552)

Factor Number	Eigenvalue	Percent of Variance
1	14.31	71.6
2	.50	2.5
3	.23	1.2
4	.18	.9

Table 2
Factor Loadings of Items in the Single Factor Model

Item	Factor Loading
1	93
2	91
3	86
4	90
5	91
6	77
7	70
8	81
9	86
10	83
11	85
12	91
13	84
14	90
15	67
16	90
17	70
18	89
19	78
20	87

Note: n = 552

Reliability

To establish the reliability of the MATE, the instrument was administered to public high school biology teachers in the state of Indiana. For the 1994-1995 academic year, Indiana's public high schools employed 1,039 biology teachers. Fifty teachers were utilized in the initial field-testing of the MATE and were, therefore, unavailable for participation in the study itself. The MATE was mailed to the remaining 989 teachers at the school where they taught in May 1995. A total of 552 completed instruments were returned—a response rate of 53%. From these responses, a reliability coefficient was calculated using the internal consistency method proposed by Cronbach (1951). Scales for reliability coefficients, like the Cronbach alpha, range from 0 (indicating no reliability) to 1.00 (indicating perfect reliability). Reliability of the MATE was found to be .98 (alpha; see Table 3). Item analysis revealed each of the 20 items to have a corrected item total correlation of greater than $r = .65$, suggesting that each item contributed to the overall reliability of the instrument (Table 3). One of the desirable aspects of the Cronbach alpha technique of determining reliability is that it has proven to be a conservative measure, yielding lower reliability coef-

ficients than would be obtained by using other methods (Borg, Gall, & Gall, 1993). Thus, it can be thought of as providing a minimum estimate of overall reliability.

A copy of the MATE is presented as Appendix A. Items 1, 3, 5, 8, 11, 12, 13, 16, 18, and 20 contain positively phrased statements concerning evolutionary theory, while items 2, 4, 6, 7, 9, 10, 14, 15, 17, and 19 contain negatively phrased statements. Scoring for the items is performed by Likert-scaling of responses. Answers indicative of a low acceptance of evolutionary theory receive a score of 1 while answers indicative of a high acceptance of evolutionary theory receive a score of 5. Scoring instructions for the MATE are provided in Appendix B. Possible scores for the MATE range from a high of 100 to a low of 20, indicating high and low levels of acceptance, respectively.

Conclusions

The results of this study indicate that the MATE is a valid and reliable instrument, ready to facilitate the assessment of high school biology teacher acceptance of evolutionary theory. The instrument is composed of multiple items addressing fundamental evolutionary concepts, which enhance its ability to reliably and

Table 3

Internal Consistency Reliability Statistics (Chronbach alpha) for the MATE (n = 552)

Item	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Alpha if Item Deleted
1	73.71	346.01	.92	.88	.978
2	73.67	346.84	.90	.86	.978
3	73.72	352.18	.85	.75	.978
4	73.91	344.58	.89	.85	.978
5	73.75	349.92	.90	.82	.978
6	73.68	363.76	.76	.65	.980
7	74.06	358.95	.69	.56	.980
8	73.70	352.66	.80	.69	.979
9	73.77	349.17	.85	.79	.979
10	73.53	351.36	.82	.78	.979
11	73.72	354.87	.84	.73	.979
12	74.08	357.59	.78	.68	.979
13	73.70	352.42	.83	.73	.979
14	73.68	348.85	.89	.82	.978
15	73.68	365.74	.66	.52	.980
16	73.90	351.20	.88	.85	.980
17	73.91	350.62	.89	.86	.978
18	73.90	345.92	.88	.83	.979
19	73.91	355.16	.77	.67	.979
20	74.02	351.08	.86	.76	.979

Note: Alpha = .98; Standardized Item Alpha = .98

validly assess teacher acceptance of the complex and over-reaching biological theory of evolutionary change of living forms. Further, the instrument is homogeneous, assessing a single construct, which allows for clear interpretation of the results generated from its administration.

The MATE provides a mechanism for establishing the status of teacher acceptance of evolutionary theory. Use of the MATE with additional instrumentation will allow researchers to explore the potential relationship between teachers' acceptance of evolutionary theory and their teaching of the topic of evolution. Pertinent research that could be conducted utilizing the MATE in conjunction with additional, existing instrumentation includes exploring relationships between teacher acceptance of evolutionary theory and the role of evolution in the curriculum; teacher understanding of evolutionary theory; teacher understanding of the nature of science; and teacher academic background. Studies of this nature may serve to inform efforts to enhance the state of evolutionary biology instruction.

Because the MATE was designed to assess the acceptance of evolutionary theory of public high school biology teachers, it may not reliably and validly assess acceptance of other populations of interest. As suggested by Nunnally (1967), instrument development should always be considered a work in progress. Broadening the applicability of the MATE to other populations through further assessments of validity and reliability would increase its value as an educational measure. It is hoped that those who utilize the MATE will report their findings to facilitate this process and strengthen the instrument.

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Appendix A

The MATE Instrument

For the following items, please indicate your agreement/disagreement with the given statements using the following scale.

A	B	C	D	E
Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree

1. Organisms existing today are the result of evolutionary processes that have occurred over millions of years.
2. The theory of evolution is incapable of being scientifically tested.
3. Modern humans are the product of evolutionary processes which have occurred over millions of years.
4. The theory of evolution is based on speculation and not valid scientific observation and testing.
5. Most scientists accept evolutionary theory to be a scientifically valid theory.
6. The available data are ambiguous as to whether evolution actually occurs.
7. The age of the earth is less than 20,000 years.
8. There is a significant body of data which supports evolutionary theory.
9. Organisms exist today in essentially the same form in which they always have.

10. Evolution is not a scientifically valid theory.
 11. The age of the earth is at least 4 billion years.
 12. Current evolutionary theory is the result of sound scientific research and methodology.
 13. Evolutionary theory generates testable predictions with respect to the characteristics of life.
 14. The theory of evolution cannot be correct since it disagrees with the Biblical account of creation.
 15. Humans exist today in essentially the same form in which they always have.
 16. Evolutionary theory is supported by factual, historical, and laboratory data.
 17. Much of the scientific community doubts if evolution occurs.
 18. The theory of evolution brings meaning to the diverse characteristics and behaviors observed in living forms.
 19. With few exceptions, organisms on earth came into existence at about the same time.
 20. Evolution is a scientifically valid theory.
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Appendix B

MATE Scoring Instructions

To account for positively and negatively phrased items, the scaling of responses must be appropriately reversed so that responses indicative of a high acceptance of evolutionary theory receive a score of 5 while answers indicative of a low acceptance receive a score of 1. To score the MATE, follow the three steps below:

Step 1. Scoring of items 1, 3, 5, 8, 11, 12, 13, 16, 18, and 20 is as follows:

Strongly Agree = 5
Agree = 4
Undecided = 3
Disagree = 2
Strongly Disagree = 1

Step 2. Scoring of items 2, 4, 6, 7, 9, 10, 14, 15, 17, and 19 is as follows:

Strongly Agree = 1
Agree = 2
Undecided = 3
Disagree = 4
Strongly Disagree = 5

Step 3. An individual's score on the MATE is equal to the sum of the scaled responses of all 20 items.