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ABSTRACT

Teachers participating in this study were enrolled in one of two courses developed for high school teachers of physical science. The courses were offered as part of the Summer Institute in Science, an Education for Economic Security Act Title II program funded by the Texas Higher Education Coordinating Board. Behavioral intention, attitude toward the behavior (and its determinants, behavioral beliefs and outcome evaluations), subjective norm (and its determinants, normative beliefs and motivations to comply) were determined using the method described by Ajzen and Fishbein (1980). The functional dependence of behavioral intention on attitude and subjective norm was examined. The purpose of this study was to explore the utility of the Theory of Reasoned Action for understanding and predicting science teaching behavior. In particular, the study investigated the cognitive foundations and social support for the physical science teachers' decision to engage in a specific teaching behavior, using investigative methods to teach physical science in a yearlong, general education, high school course consisting of one semester each of introduction to physics and introduction to chemistry. Intent to use investigative methods to teach physical science appears to be the result of a teacher's personal decision to do so, without regard to social pressures. (CW)

# Determinants of Physical Science Teachers' Intentions to Use Investigative Teaching Methods:

## A Test of the Theory of Reasoned Action



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Determinants of Physical Science Teachers' Intentions to Use Investigative Teaching Methods:

A Test of the Theory of Reasoned Action

## Purpose

The purpose of this study was to explore the utility of the Theory of Reasoned Action for understanding and predicting science teaching behavior. In particular, the study investigated the cognitive foundations and social support for physical science teachers' decision to engage in a specific teaching behavior, using investigative methods to teach physical science.

## Theoretical Base

The Theory of Reasoned Action was developed by social psychologists to better understand and predict human behavior. Proposed by Fishbein and Ajzen (1975) the Theory has been found to be successful in explaining such diverse human behaviors as drinking, dieting, choosing a career, planning a family, voting, and consumer purchasing behavior (Ajzen and Fishbein, 1980). In education, the Theory has been used successfully to understand and predict grade 8 students' intentions to enroll in a high school science course and girls' intentions to enroll in at least one physical science course in high school (Koballa, Crawley, & Shrigley, 1987).

Four constructs are central to the Theory of Reasoned Action: behavior, behavioral intention, attitude toward the behavior, and subjective norm. The best predictor of behavior (B), according to the Theory, is intention to engage in the behavior. In turn, behavioral intention (I) is determined by two variables, one personal and the other social. Attitude toward the behavior (AB), the personal component, represents the extent to which an individual believes that performing the behavior will lead to desirable consequences. Subjective norm (SN), on the other hand, represents the social component, a measure of the extent to which an individual believes that important "others" think the behavior should be performed. Intention, attitude, and subjective norm, are linked to behavior through the equation,

$$B \sim I \sim (AB + SN) = w_1 AB + w_2 SN$$

where $w_1$ and $w_2$ are respectively the relative weights or contributions attitude and subjective norm make to the prediction of behavioral intention and subsequently behavior.

Attitude and subjective norm each are composed of two distinct components. Attitude toward the behavior (AB) for any individual depends on the person's perceived consequences of performing the behavior ($b_i$) and on the person's evaluation of each of the consequences ($e_i$). Attitude, behavioral beliefs, and outcome evaluations are related through the equation (Fishbein and Ajzen, 1975, p 223),

$$AB = \Sigma_i b_i e_i$$

The strength of each belief linking a consequence to performing a behavior ($b_i$) is weighted by the individual's evaluation of the consequence ($e_i$) and summed over all salient beliefs to determine a person's attitude toward performing a specific behavior (AB).

Subjective norm (SN) is the social component of behavioral intention. Its contribution to behavioral intention is determined by what the individual perceives to be the expectations of others, called normative beliefs ($n_k$), and the individual's motivation to comply ($m_k$) with others' expectations. Normative beliefs and motivations to comply are related to subjective norm through the equation,

$$SN = \Sigma_k n_k m_k$$

The strength of each belief linking a behavior to the expectation of another person, the normative belief ($n_k$), is weighted by an individual's motivation to comply with the other person's expectations ($m_k$), summed over all referents, to arrive at subjective norm (SN).

Design and Procedures

Sixty-seven elementary and secondary school teachers participated in the Summer Institute in Science, an Education for Economic Security Act, Title II, program funded by the Texas Higher Education Coordinating Board. The objectives of the EESA, Title II, program are to: (1) improve the skills of teachers and instruction in math, science, foreign languages, and computer learning and (2) to improve instruction in the Essential Elements in the appropriate subject at a particular grade level as designated by the State Board of Education. The Essential Elements in science represent process skills appropriate for a particular grade level and subject.

Two courses (Concepts in Chemistry and Concepts in Physics) were developed specifically for teachers of physical science in Texas, a year long course consisting of one semester each of introduction to chemistry and introduction to physics. Twenty-three teachers were enrolled in Concepts in Chemistry and twenty-four in Concepts in Physics. Classes met daily, three hours per day for three weeks.

Investigations developed for use in each course followed identical formats for the chemistry and physics courses and stressed the teaching of physical science concepts through active use of the Essential Elements. Inexpensive, commonly available equipment and materials were utilized in each investigation.

Toward the end of the first week of class teachers responded to an open-ended questionnaire, following the method described by Ajzen and Fishbein (1980, p 261). On this questionnaire teachers identified their salient beliefs and referents, what they perceived to be the consequences and personal support for engaging in a specific teaching behavior—use of the activities and investigations completed in the Summer Institute in Science Course(s) with students I teach this school year. The behavioral criterion contains four elements: the action (use of), the target of the action (the activities and investigations), the context in which the action occurs (with students I teach), and the time at which the action is to be performed (this next school year). Next, beliefs and referents information was content analyzed to arrive at modal salient beliefs and referents, accounting for 90% of the beliefs and referents mentioned on the open-ended questionnaire. Normative and behavioral beliefs formed the basis of a subsequent questionnaire designed to determine behavioral intention, attitude toward the behavior (including behavioral belief strength and outcome evaluation), and subjective norm (including normative belief strength and motivation to comply).

Regression analyses were used to determine the relative contributions of attitude and subjective norm to the prediction of behavioral intention—the best predictor of subsequent behavior—for nineteen teachers enrolled in Concepts in Chemistry and twenty-three teachers enrolled in Concepts in Physics. Data were deleted from the analyses for four teachers enrolled in the chemistry course and one teacher enrolled in the physics course, persons who were either elementary or middle school teachers who would not teach physical science during the coming school year.

Results

Fifteen salient beliefs and six personal referents were identified from responses to the open-ended questionnaire. Teachers believed that use of the investigations would lead to increased student interest in science, development of higher level thinking skills, active involvement of students in science lessons, acquisition of language skills, to name but a few. Administrators (the superintendent and principal), other teachers, the department chairperson, parents, and students provided the external support for using investigations in physical science classes. The final questionnaire elicited information from teachers regarding their behavioral intention, attitude toward the behavior (including behavioral beliefs and outcome evaluations), and subjective norm (including normative beliefs and motivation to comply).

Results of seperate multiple regression analyses for teachers enrolled in chemistry and physics approached significance ($p$ values of .0577 and .0773, respectively) using the "Full Model", i.e., attitude and subjective norm. Regression effects accounted for 23% of the variance in intention among teachers enrolled in chemistry and 15% of the variance in intention among teachers enrolled in physics. Table 1 contains the results of significance tests using the "Full Model". Correlation coefficients were computed between attitude and intention and subjective norm and intention for teachers enrolled in each course using the full model. Attitude, but not subjective norm, was found to be related to intention for teachers in each course ($p \leq .05$). The beta coefficients were also found to be significant ($p \leq .05$) for the contribution of attitude, but not subjective norm, to the prediction of intention in the regression equations (see Table 2).

Subjective norm was removed from the regression equations. Simple regression equations using attitude as the sole predictor of intention were constructed and their significance tested.

Table 1

Significance Test of Regression Effects—Full Model (Attitude & Subjective Norm)

| Course | Source | SS | df | MS | F | p | $R^2$(adj) |
|---|---|---|---|---|---|---|---|
| Chemistry | Regression | 1.41 | 2 | 0.70 | 3.47 | .0577 | .32 |
| | Residual | 3.04 | 15 | 0.20 | | | |
| Physics | Regression | 2.20 | 2 | 1.10 | 2.92 | .0773 | .23 |
| | Residual | 7.54 | 20 | 0.38 | | | |

Table 2

Correlation and Regression Coefficients—Full Model (Attitude & Subjective Norm)

| | | Correlation Coefficients | | Regression Coefficients | |
|---|---|---|---|---|---|
| Course | Outcome | $r_{AB \cdot I}$ | $r_{SN \cdot I}$ | $w_{AB}$ | $w_{SN}$ |
| Chemistry | Intention (I) | .46* | .22 | .12* | -.39 |
| Physics | Intention (I) | .47* | .16 | .17* | -.03 |

*$p \leq .05$.

Results of significance tests of simple regression effects using a "reduced model" proved to be significant ($p$ = .046 for teachers enrolled in chemistry and $p$ = .022 for teachers enrolled in physics). Attitude was found to account for 17% and 19% of the variance in intention for teachers enrolled in chemistry and physics, respectively. Results of tests for significance of the regression effects are found in Table 3.

Table 3

Significance Test of Regression Effects—Reduced Model (Attitude Only)

| Course | Source | SS | df | MS | F | p | $R^2$(adj) |
|---|---|---|---|---|---|---|---|
| Chemistry | Regression | 1.02 | 1 | 1.02 | 4.64 | .046 | .17 |
| | Residual | 3.72 | 17 | 0.22 | | | |
| Physics | Regression | 2.20 | 1 | 2.20 | 6.10 | .022 | .19 |
| | Residual | 7.55 | 21 | 0.36 | | | |

Attitude toward the behavior and subjective norm are determined by their respective beliefs, behavioral and normative. According to the theory of reasoned action, the set of salient behavioral beliefs determines the attitude toward the behavior, and the set of normative beliefs determines the subjective norm. The separate relationships between direct and indirect measures of attitude and subjective norm were tested for significance by computing separate correlation coefficients between attitude toward the behavior (the direct measure of attitude) and the set of salient beliefs (the indirect measure, i.e., $AB_i = \Sigma_i b_i e_i$) and between subjective norm (the direct measure of the influence of the social environment) and the set of salient referents (the indirect measure, i.e., $SN = \Sigma_k n_k m_k$). For teachers enrolled in the chemistry course, the set of salient beliefs was found to be significantly related to attitude ($p = .0010$); the set of salient referents was not found to be related to subjective norm ($p = .1402$). On the other hand, for teachers enrolled in the physics course the set of salient beliefs and salient referents were found to be related to attitude and subjective norm ($p = .0120$ and $p = .0003$, respectively). Results of tests of significance between direct and indirect measures of attitude and subjective norm are presented in Table 4.

Table 4

Correlation Between Direct (AB/SN) and Indirect (Σ) Measures of Attitude and Subjective Norm

| | Attitude Toward Behavior $[AB_i \cdot (\Sigma b_i \times e_i)]$ | | Subjective Norm $[SN \cdot (\Sigma n_k \times m_k)]$ | |
|---|---|---|---|---|
| Course | r | p | r | p |
| Chemistry | .69 | .0010 | .36 | .1402 |
| Physics | .51 | .0120 | .69 | .0003 |

The contribution of each set of fifteen salient behavioral belief (Full Model) to the prediction of attitude toward the behavior (i.e., use of the activities and investigations completed in the Summer Institute in Science Course(s) with students I teach this school year) was tested for significance for teachers enrolled in the chemistry and physics courses. The Full Model, consisting of the complete set of fifteen salient behavioral beliefs, was found to be predictive of attitude for teachers enrolled in chemistry ($p = .0485$) but not for teachers enrolled in physics ($p = .2063$). Under the Full Model for teachers enrolled in chemistry, the set of salient beliefs accounted for 87% of the variance in attitude. Only 37% of the attitude variance was accounted for under the Full Model for teachers enrolled in physics. Results of significance tests for regression of salient beliefs on attitude are presented in Table 5.

The fifteen behavioral determinants of attitude were further examined for teachers enrolled in physics in using the following procedure. The least significant attitude determinant, based on the level of significance of the determinant's beta value, was first identified and removed from the regression equation. The contribution of the remaining determinants was then computed. If the effects of the regression remained insignificant (i.e., $p > .05$), the next least significant

Table 5

Significance Test of Regression Effects--Behavioral Determinants of Attitude (Full Model)

| Course | Source | SS | df | MS | F | p | $R^2$(adj) |
|---|---|---|---|---|---|---|---|
| Chemistry | Regression | 90.39 | 15 | 6.03 | 8.90 | .0485 | .87 |
| | Residual | 2.03 | 3 | 0.68 | | | |
| Physics | Regression | 63.34 | 15 | 4.22 | 1.86 | .2063 | .37 |
| | Residual | 15.87 | 7 | 2.27 | | | |

*Note*. Full model employs 15 salient behavioral beliefs.

determinant was then identified and removed. This procedure was continued until significance was reached for the overall regression effects ($p \leq .05$). The resultant set of attitude determinants, salient beliefs, constituted the "p Model". Using the foregoing procedure three beliefs were removed from the regression equation, leaving a reduced set of attitude determinants consisting of twelve beliefs which accounted for 54% of the variance in attitude. Results of the test of the regression effects under the "p Model" are presented in Table 6.

Table 6

Significance Test of Regression Effects—Behavioral Determinants of Attitude (p Model)

| Course | Source | SS | df | MS | F | p | $R^2$(adj) |
|---|---|---|---|---|---|---|---|
| Physics | Regression | 62.67 | 12 | 5.22 | 3.16 | .039 | .54 |
| | Residual | 16.54 | 10 | 1.65 | | | |

*Note*. In "p model" least significant determinants are stepwise removed until overall significance is reached.

Significant regression effects were achieved for the determinants of attitude, for teachers enrolled in chemistry, using the "Full Model", and teachers enrolled in physics, using the "p Model". The resultant regression equations contained beta weights, some of which were significant and some of which were not. To arrive at the smallest set of attitude determinants with significant beta weights for teachers enrolled in chemistry and teachers enrolled in physics, the set of behavioral beliefs was further reduced. The procedure followed to produce the "Beta Model" was similar to that used to produce the "p Model", namely the least significant determinant was first removed from the regression equation, beta weights of the remaining determinants in the regression equation were re-computed, and the level of significance of each beta weight was checked for significance (i.e., $p \leq .05$). Once significance was reached for all beta weights, the stepwise deletion process was halted. Under the "Beta Model" ten determinants of attitude were each found to be significant for teachers enrolled in chemistry, but only one attitude determinant survived the stepwise deletion procedure. Table 7 contains the results of tests for significance of the regression effects under the "Beta Model".

Table 7

Significance Test of Regression Effects—Behavioral Determinants on Attitude (ß Model)

| Course | Source | SS | df | MS | F | p | $R^2$(adj) |
|---|---|---|---|---|---|---|---|
| Chemistry | Regression | 87.06 | 10 | 8.71 | 12.99 | .0007 | .87 |
| | Residual | 5.36 | 8 | 0.67 | | | |
| Physics | Regression | 38.73 | 1 | 38.73 | 20.09 | .0004 | .47 |
| | Residual | 40.49 | 21 | 1.93 | | | |

Note. In "ß model" least significant determinants are stepwise removed until significance of all remaining ß-values is reached.

For teachers enrolled in chemistry all fifteen salient beliefs were found to be significant predictors of attitude using the "p Model", and ten beliefs proved to be significant using the "Beta Model". Beliefs deleted from the regression equation included beliefs that use of the activities and investigations would allow teachers to cover all course topics, show students applications of concepts, get students actively involved in learning science, clarify concepts and principles, and make science class more interesting and fun. Beliefs making the greatest contribution to the prediction of attitude under the "Beta Model" included using the activities and investigations to create more interest in science (negative contribution), help students to understand science, boost other teachers' interest in teaching science, and promote student/student/teacher interaction (negative contribution). Results of regression analyses of attitude determinants under the "p Model" and "Beta Model" for teachers enrolled in chemistry are presented in Table 8.

The set of attitude determinants for teachers enrolled in physics was reduced from fifteen beliefs using the "Full Model" to twelve beliefs using the "p Model". Determinants deleted from the prediction of attitude under the "p Model" included beliefs that use of the activities and investigations would boost other teachers' interest in teaching science, would depend upon the availability of materials and equipment, and would clarify concepts and principles studied. Making the greatest contributions to the determination of attitude were the beliefs that use of the activities and investigations would create more interest in science, make science class more interesting and fun (negative contribution), give students experience using science equipment, and allow the teacher to cover all the course topics (negative contribution). The only belief to survive under the "Beta Model" was the belief that use of the activities and investigations would likely create more interest in science. Results of regression analyses of attitude determinants under the "Full Model", the "p Model" and the "Beta Model" for teachers enrolled in physics are presented in Table 9.

Table 8

Regression of Behavioral Beliefs On Attitude Toward Behavior (Chemistry)

| Use of the activities and investigations with students I teach this coming year will ... | p Model | | ß Model | |
|---|---|---|---|---|
| | ß | p | ß | p |
| create more interest in science. | -2.40 | .0257 | -1.44 | .0036 |
| depend on the time available. | 0.86 | .0377 | 0.59 | .0011 |
| help students to understand science. | 2.25 | .0112 | 1.77 | .0004 |
| allow me to cover all the course topics. | -0.19 | .3460 | — | ns |
| boost other teachers' interest in teaching science. | 1.16 | .0544 | 0.85 | .0095 |
| show students applications of concepts. | 0.55 | .2140 | — | ns |
| get students actively involved in learning science. | 0.21 | .4413 | — | ns |
| give students experience using science equipment. | 0.38 | .1026 | 0.39 | .0126 |
| develop in students the ability to use vocabulary. | 1.33 | .0480 | 0.75 | .0382 |
| help develop thinking/problem solving skills. | 0.49 | .0914 | 0.42 | .0097 |
| depend on the availability of materials/equipment. | 0.48 | .0551 | 0.23 | .0467 |
| appeal to differing ages/abilities/interests. | -1.23 | .0523 | -0.56 | .0441 |
| clarify concepts and principles students study. | -0.03 | .9150 | — | ns |
| promote student/student/teacher interaction | -1.30 | .0280 | -0.89 | .0031 |
| make science class more interesting and fun. | 0.10 | .5884 | — | ns |

Table 9

Regression of Behavioral Beliefs On Attitude Toward Behavior (Physics)

| Use of the activities and investigations with students I teach this coming year will ... | Full Model | | p Model | |
|---|---|---|---|---|
| | ß | p | ß | p |
| create more interest in science.[a] | 0.99 | .0317 | 1.09 | .0027 |
| depend on the time available. | 0.24 | .2413 | 0.24 | .0988 |
| help students to understand science. | 0.49 | .2262 | 0.43 | .1123 |
| allow me to cover all the course topics. | -0.67 | .0908 | -0.65 | .0480 |
| boost other teachers' interest in teaching science. | 0.16 | .6496 | — | ns |
| show students applications of concepts. | -0.55 | .3772 | -0.49 | .3250 |
| get students actively involved in learning science. | 0.36 | .4503 | 0.45 | .1839 |
| give students experience using science equipment. | 0.80 | .1652 | 0.85 | .0284 |
| develop in students the ability to use vocabulary. | 0.14 | .6995 | 0.15 | .5098 |
| help develop thinking/problem solving skills. | -0.19 | .5277 | -0.17 | .4840 |
| depend on the availability of materials/equipment. | -0.02 | .9534 | — | ns |
| appeal to differing ages/abilities/interests. | 0.40 | .3160 | 0.44 | .0950 |
| clarify concepts and principles students study. | 0.06 | .8912 | — | ns |
| promote student/student/teacher interaction | -0.26 | .3520 | -0.23 | .2949 |
| make science class more interesting and fun. | -1.09 | .0658 | -1.52 | .0179 |

[a] Sole belief determined to be significant under "ß Model" ($ß = 0.70$, $p = .0002$).

Removal of subjective norm was shown to increase the significance of the contribution of attitude to the prediction of teachers' intention to use the activities and investigations with students they would teach during the next school year. The levels of significance of the regression effects improved for teachers enrolled in chemistry (from $p = .0577$ to $p = .046$) and teachers enrolled in physics ($p = .0773$ to $p = .022$). The indirect measure of subjective norm ($\Sigma_k n_k m_k$) was found to be significantly related to the direct measure for teachers enrolled in physics but not for teachers enrolled in chemistry (see Table 4). Under the "p Model" the complete set of normative determinants was shown to be significantly predictive of subjective norm. Using the "Beta Model" the superintendent and other teachers were the sole determinants of subjective norm. The contribution of the principal, parents, students, and the department chairperson were deleted under the "Beta Model". Presented in Table 11 are the results of the regression of normative beliefs on subjective norm for teachers enrolled in physics using the "p Model" and the "Beta Model".

Table 11

Regression of Normative Beliefs On Subjective Norm (Physics)

| Salient | p Model | | ß Model | |
|---|---|---|---|---|
| Referents | ß | p | ß | p |
| Superintendent | 0.07 | .0577 | 0.08 | .0070 |
| Parents | 0.00 | .9972 | — | ns |
| Principal | 0.05 | .2702 | — | ns |
| Students | -0.01 | .7275 | — | ns |
| Other Science Teachers | 0.08 | .1015 | 0.08 | .0036 |
| Department Chairperson | -0.02 | .2936 | — | ns |

Conclusions

Results of this study indicate attitude toward the behavior to be the sole determinant of teachers' intentions to engage in the behavior, i.e., use of the activities and investigations with students enrolled in their classes during the upcoming school year. Teachers' personal beliefs concerning the consequences of using investigative methods to teach physical science strongly influence their attitude toward doing so. On the other hand, the social environment, consisting of the superintendent, the principal, departmental chairperson, students, colleagues, and parents (i.e., salient referents) exert little influence on teachers' decision to use investigative teaching methods. Intent to use investigative teaching methods appears to result from personal decisions reached by teachers without regard to social influence. This finding may indicate that the decision to use one teaching method or another is an intensely personal one, unaffected by the expectations of personal referents. On the other hand, the insignificant contribution of subjective norm to the prediction of behavioral intention may result from a lack of social support rather than from teachers' abilities to withstand social pressures.

The reason for examining the determinants of attitude and subjective norm is to gain greater understanding of the beliefs teachers hold about use of investigative teaching methods with the students they teach. According to the Theory of Reasoned Action, behavior change is ultimately the result of changes in beliefs. Research has shown that use of hands-on activities by science teachers in grades 10-12 has declined from 1977 to 1985-86, yet 4 out of 5 teachers and principals believe laboratory-based activities to be more effective than traditional teaching methods (Weiss, 1987). If science educators are to work with science teachers to improve the access of all students to laboratory-based instruction they must understand teachers personal beliefs and the social influences they face in the classroom.

How can behavior change be brought about? At least two approaches (in isolation or combination) seem promising based on the results of the present study. First, researchers can plan attitude change experiments to strengthen teacher's beliefs about the consequences of using investigative teaching methods or improve their evaluation of the consequences of using these methods or both. For example, a persuasive communication might be developed in which teachers were provided with research evidence concerning the link between the use of investigative teaching methods and improved student understanding of science concepts (a salient belief among teachers included in the present study) and with additional information designed to improve their evaluation of the outcome, namely improved understanding of science concepts. A second route to strengthening teachers' intent to use investigative teaching methods involves providing increased social support for doing so. Using this route to change intentions (and subsequently changing behavior) investigators might, for example, design an experiment in which the school principal and/or department chairperson regularly observes and encourages teachers to use investigative teaching methods. Changing teachers' intentions can be accomplished either by changing their attitude toward use of investigative teaching methods or their perceptions of the social support for doing so.

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