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ABSTRACT

The Views About Sciences Survey (VASS) is a survey of student views about knowing and learning science for the purpose of assessing the relation of these views to achievement in science courses. This paper discusses the survey's design, development, results, and implications for science education. The survey assesses student views along two broad dimensions, scientific and cognitive, with a novel Contrasting Alternatives Design. It was administered to 326 college students enrolled in various introductory physics courses. Results indicate the following: college physics students have views about physics that often diverge from physicists' views; students do not [illegible] consistent tendency towards one type of view or another on all VASS items, student views can be classified into three distinct profiles: expert, transitional, and folk, with the majority of students evincing a transitional profile; and the closer students are to expert views on individual items or to an expert profile on the entire VASS, the better their performance in college physics courses. Appendix includes the VASS instrument. Contains 71 references. (Author/JRH)

Views About Science and Physics Achievement
The VASS Story

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Abstract

The Views About Sciences Survey (VASS) is a paper-and-pencil instrument to characterize student views about knowing and learning science and assess the relation of these views to achievement in science courses. VASS shows that: (a) college physics students have views about physics that often diverge from physicists' views, (b) student views can be classified in three distinct profiles, expert, transitional, and folk, with the majority of students evincing a transitional profile, and (c) students with an expert profile are the most likely to earn an "A" in their physics courses, while those with a folk profile are the most likely to do poorly or fail in these courses.

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Educational researchers have observed that students at all levels are encumbered with *folk* views about the nature of science and science education that are incompatible with the views of scientists and educators. Introductory science courses do little to change student folk views and, more often than not, the changes are negative. Furthermore, students' achievement in science courses may be negatively affected by their folk views (Aikenhead et al., 1987, 1988; Baker & Piburn, 1991; Cobern, 1993; Edmonson & Novak, 1993; Meichtry, 1993; Redish & Saul, 1995; Schibeci & Riley, 1986; Songer & Linn, 1991).

We have developed the *Views About Sciences Survey* (VASS) to explore and systematize such observations, and we have administered it to thousands of high school and college students across the USA. This paper discusses major features of VASS and its outcomes in college physics courses.

Views About Sciences Survey (VASS)

Objectives

VASS has been developed to survey student views about *knowing* and *learning* science and to assess their *relation to student understanding* of science. More specifically, VASS is designed to meet the following objectives:

1. To ascertain significant *differences* between the views of students, teachers and scientists.
2. To identify patterns in student views and classify them in general *profiles*.
3. To measure the *effectiveness of instruction* in *changing* student views and profiles.
4. To compare student views/profiles at various grade levels (8-16).
5. To assess the relation between student views/profiles and achievement.
6. To ascertain differences in the views/profiles of students in the various sciences (physics, chemistry, biology,...).
7. To compare student views/profiles across various demographic strata.

Taxonomy

To identify major issues that should be addressed by VASS, we reviewed related works in the relevant literature, including the following:

1. Scholarly views on the epistemology of science (e.g., Bernard, 1865; Bunge, 1973; Giere, 1988; Harre, 1959; Johnson-Laird, 1983; Kuhn, 1970; Lakatos & Musgrave, 1974; Lakoff, 1986; Lecourt, 1974; Popper, 1983; Tobin, 1993; Ullmo, 1969).
2. Major works in cognition (e.g., Changeux, 1983; Dewey, 1933; Ericsson & Charness, 1994; Gardner, 1985; Gilovich, 1991; Ginsburg & Opper, 1979; Glass, Holyoak & Santa, 1979; Grossberg, 1982; Jones, 1986; Klahr, 1976; Lochhead & Clement, 1979; Margolis, 1987; Newell & Simon, 1972; Perry, 1970; Piaget, 1972; Resnick, 1989; Simon, 1979; Squire, 1986; Stewart, 1985; Tobin, 1993)
3. National science standards (AAAS, 1990 & 1993; NCEE, 1983; NRC, 1996; NSTA, 1993 & 1995).
4. Research on student views about science (e.g., Aikenhead et al., 1987, 1988; Baker & Piburn, 1991; Barrington & Hendricks, 1988; Cobern, 1993; Cooley & Klopfer, 1961; Ebenezer & Zoller, 1993; Edmonson & Novak, 1993; Germann, 1988; Gilbert, 1991; Kimball, 1968; Klopfer, 1969; Lederman & O'Malley, 1990; Mackay, 1971; Meichtry, 1993; Redish & Saul, 1995; Roth & Rychoudhury, 1993; Rubba & Andersen, 1978;

Schibeci & Riley, 1986; Schmidt, 1967; Simpson & Oliver, 1985; Songer & Linn, 1991; Welch & Pella, 1967).

In constructing a taxonomy of the targeted issues, we sought to avoid: (a) arcane and problematic questions about science, and (b) bias toward our own position (Halloun, in press & 1996; Hestenes, 1992). We then devised one VASS instrument after another to assess student views on the targeted issues, and, in three years, we administered the various VASS forms to over 10,000 high school and college students nationwide. We kept refining our taxonomy and the VASS items based on:

1. Peer review.
2. Students' answers on VASS items (as well as teachers'), and their relation to course achievement and performance on content-based conceptual surveys like the Force Concept Inventory (Hestenes et al., 1992).
3. Interviews with respondents.

We finally settled on two broad dimensions. One pertains to the epistemology and methodology of science, the other to cognitive aspects of science education. Each dimension comprises three subdomains. The first dimension, referred to hereafter as *scientific dimension*, pertains to the structure and validity of scientific knowledge, and to scientific methodology. The second dimension, referred to hereafter as *cognitive dimension,* pertains to learnability of science, critical thinking, and personal relevance of science. To assess variability in student views in different disciplines, we constructed parallel forms of VASS along these dimensions for physics, chemistry and biology, as well as a VAMS form for mathematics. Each form consists of 33 items, 16 of which comprise the scientific dimension, and 17, the cognitive one.

Each of the six subdomains is framed below in the form of pairs of contrasting views about science or science education that our analysis revealed to be the most prevalent. The primary view is the one we found to be most common among scientists and educators. The opposing view is often held by the lay community and science students at all grade levels.

Scientific dimension

1. ***Structure:*** Science is a *coherent body of knowledge* about *patterns* in nature revealed by *careful investigation*
   — rather than a loose collection of directly perceived facts.
2. ***Methodology:*** The methods of science are *systematic* and *generic*
   — rather than idiosyncratic and situation specific.

   Mathematics is a *tool* used by scientists for describing and analyzing ideas
   — rather than a source of factual knowledge.

   Mathematical modeling for problem solving involves *more*
   — than selecting mathematical formulas for number crunching.
3. ***Validity:*** Scientific knowledge is *approximate, tentative,* and *refutable*
   — rather than exact, absolute and final.

Cognitive dimension

4. ***Learnability:*** Science is *learnable by anyone* willing to make the effort
   — not just by a few talented people.

   Achievement depends more on *personal effort*
   — than on the influence of teacher or textbook.
5. ***Critical Thinking:*** For meaningful understanding of science, one needs to:

   (a) concentrate more on the *systematic use of principles*
   — than on memorizing facts;

(b) examine situations in *many ways*
— instead of following a single approach from an authoritative source;

(c) look for *discrepancies in one's own knowledge*
— instead of just accumulating new information;

(d) *reconstruct* new subject knowledge in one's own way
— instead of memorizing it as given.

6. ***Personal relevance:*** Science is *relevant to everyone's life.*
— It is not of exclusive concern to scientists.

Science should be studied more for *personal benefit*
— than for just fulfilling curriculum requirements.

Contrasting Alternatives Design

Traditional assessment instruments present items in one of two formats: (a) open– (or constructed–) response, or (b) objective– (or selected–) response. Open formats like interviews and essays can be valuable and informative means of assessment for purposes like ours. However, they are not feasible for large populations. Objective formats like multiple-choice and Likert scale are more practical and cost-efficient. However, research indicates that they encounter insuperable validity and reliability problems when used in surveying students' views about science (Halloun, 1994; Krynowsky, 1988; Munby, 1983; Rennie & Parker, 1987; Symington & Spurling, 1990).

For VASS, we needed a valid and reliable testing format that could be used to survey large populations efficiently. Since no traditional format meets all three criteria: validity, reliability and feasibility, we set out to devise a new item format for VASS.

I: Describe what you normally do when solving a physics problem. List all steps you often follow, in order.

S: *First step in any problem would be to read the problem and list what's given and what you need, variables or what not. And the next step would be to find formulas that include these variables. And then, the third would be to solve for the unknowns. That's basically it.*

I: So this would be an algorithm you would work through in any kind of problem?

S: *Basically, I would agree. It's a basic general, general outline of how to solve a problem.*

I: Do you ever consider drawing some kind of a diagram?

S: *Uh-huh... I'd consider that helpful, yeah, I'd probably include that in step one. Draw, label, find out what you have and don't have.*

I: So that becomes then, your first step.

S: *Uh-huh.*

I: Would that be true for any kind of problem?

S: *Visualization helps a lot. I would say it would be a good step to try in any problem. If you can't visualize it, I wouldn't try to draw it. Yeah, I would agree that would have to be helpful for any kind of problem.*

I: Do you usually do it?

S: *Do I do it? Usually yes. It's almost asked of us in physics class: force diagrams, free body diagrams. I would say they're probably most helpful. I would say, yeah.*

Figure 1: Excerpt from an interview with a university physics student.

Figure 1 shows part of an interview protocol that reflects the rationale behind our drive for a novel testing format. VASS was first administered in essay format. Students were then asked in one of the questions to state the first thing they do in solving a physics problem. The student in Figure 1 replied that he starts by looking for the appropriate *formula*. When interviewed, it became evident that the first thing this student actually does in solving a physics problem is *draw diagrams*. However, this procedure seemed so trivial for him that he thought it was not worth mentioning in his written response.

Had the question been asked alternatively in a Likert format:

> *The first thing I do when solving a physics problem is to search for formulas that relate givens to unknowns,*

this student would have undoubtedly agreed with the statement. Had the same question been asked differently in the same format, such as

> *The first thing I do when solving a physics problem is to represent the situation with sketches and drawings,*

the same student would have also agreed with the statement. Thus, contradictory results would be obtained with two Likert items that are supposedly intended to measure the same thing. One may then argue that the problem could be solved by presenting the question in a multiple choice (MC) format:

> *The first thing I do when solving a physics problem is:*
>
> *(a) represent the situation with sketches and drawings.*
>
> *(b) search for formulas that relate givens to unknowns.*

However, the MC format often does not allow more than one choice, and when it does, it does not reflect whether the many chosen alternatives are favored to the same degree or not. For instance, if one is allowed to choose either or both alternatives above, the MC format does not reflect whether one does (a) as frequently as (b) or not.

To solve this problem, we devised the Contrasting Alternatives Design (CAD) whereby a given item consists of a statement followed by two contrasting alternatives which respondents are asked to balance on an eight-point scale. They can pick either alternative exclusively (options 1 or 7), a weighted combination of the two (options 2, 3, 4, 5, or 6), or neither one (option 8). Figure 2 shows how the item above is asked in VASS. Details about the development and validation of this new format and various VASS forms are presented elsewhere (Halloun & Hestenes, 1996; Halloun, Carlson, & Hestenes, 1996).

The first thing I do when solving a physics problem is:
(a) represent the situation with sketches and drawings.
(b) search for formulas that relate givens to unknowns.

Answer Options

① Only (a), Never (b); ② Mostly (a), Rarely (b); ③ More (a) Than (b);
④ Equally (a) & (b);
⑤ More (b) Than (a); ⑥ Mostly (b), Rarely (a); ⑦ Only (b), Never (a);
⑧ Neither (a) Nor (b)

Figure 2: A CAD item from VASS Form P11.

Results

This section offers a broad characterization of college student views about knowing and learning physics and the relation of these views to course achievement. The discussion is based on results obtained in the 1995 fall semester following the administration of VASS Form P11 as a pretest to 326 college students enrolled in various introductory physics courses.

In reporting and discussing data, we will refer to one of the two alternatives in any given VASS item as the *expert* alternative, and the other as the *folk* alternative (Figure 2). The expert alternative is the one that we believe is shared by scientists and educators at large and that was favored by our VASS reviewers and a majority of 50 high school teachers and 27 university professors who took VASS.

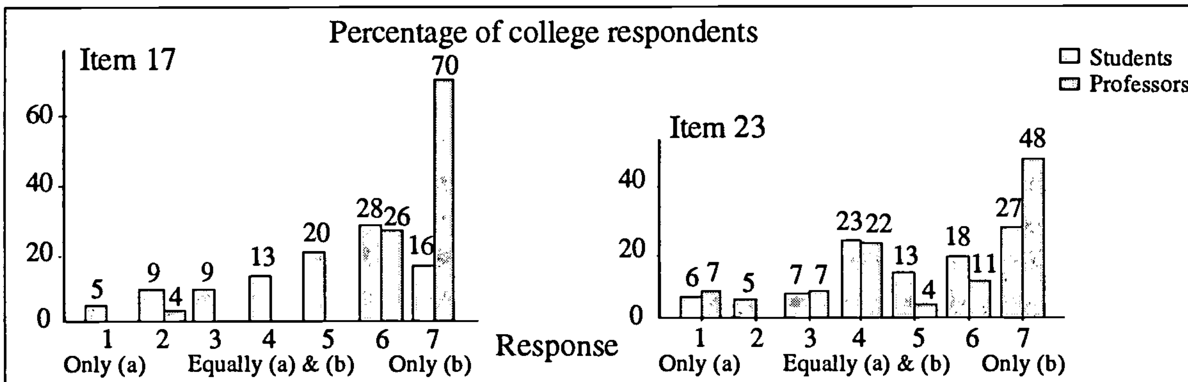
Student and Professor Views on Individual Items

VASS was given to high school and college teachers in order to: (a) establish baseline data for experts, and (b) compare students' views to their teachers'. Figure 3 shows how participating college physics professors and students answered questions 17 and 23 in VASS Form P11.

Figure 3 shows that, when a student fails to solve a problem correctly (Item 17), 96% of participating college physics professors prefer that students try more often than not to figure out how their method of solution differs from the one presented by the teacher (options 6 and 7), rather than to memorize the latter by rote. In contrast, 64% of participating college physics students share this position that physics should be learned *dialectically and not by rote from authority*.

Similar discrepancies between professors and students are observed in item 23 wherein the expert view that *scientific knowledge is not necessarily about directly perceived facts in the real world* is shared by 48% of professors and 27% of students (option 7). Incidentally, this item is one of four VASS items which showed that even professors are not immune to misconceptions about the nature of physics knowledge (or to misinterpreting a related VASS question).

Overall, the percentage of college professors who were inclined more toward the expert alternative than the folk alternative ranged from 63% to 100% on the various items (except



17. After the teacher solves a physics problem for which I got a wrong solution on my own:
    (a) I discard my solution and learn the one presented by the teacher.
    (b) I try to figure out how the teacher's solution differs from mine.

23. Physicists say that electrons and protons exist in an atom because:
    (a) they have seen these particles in their actual form with some instruments.
    (b) they have made observations that can be explained by such particles.

Figure 3: Response distributions of 326 college students and 27 college physics professors on a *cognitive* item (No. 17) and a *scientific* item (No. 23) in VASS Form P11.

for four items whereby only about half of the professors agreed with what we maintain should be the expert position). In contrast, the percentage of students who expressed an inclination toward expert alternatives on the various VASS items ranged from 14% to 78%. Only on 16 items out of 33, did more than 50% of participating college students favored the expert over the folk alternative.

Figure 4 shows boxplots comparing responses of college professors and students on all 33 items of VASS Form P11. As can be seen in this figure:

1. Students' responses often show a larger spread on both sides of the median than professors' responses.
2. Except on items 21, 24 and 26, professors' responses are far more polarized than students' responses. Response option 4 (equally both alternatives) occupies the median for only two items (21 and 26) in professors' responses, whereas it does the same for 13 items in students' responses. More than 25% of college students chose option 4 on each one of these 13 items.

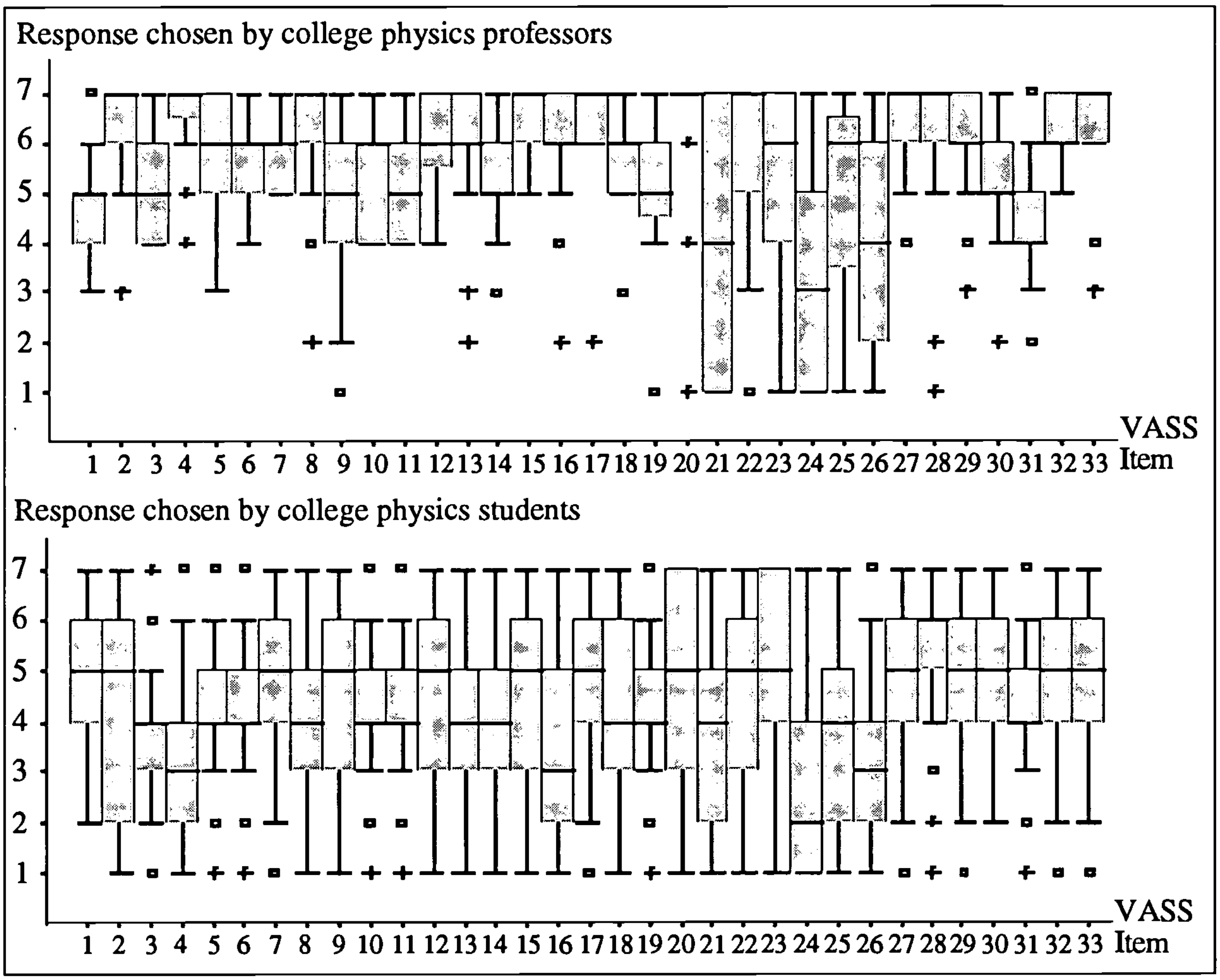


Figure 4: Boxplots showing response distributions of college physics professors (top) and students (bottom) on all items of VASS Form P11. All items are recoded so that option 7 corresponds exclusively to the expert alternative.

Each box stretches from the 25th percentile to the 75th percentile of respondents on a given item, with the median shown by a thick horizontal line inside the box. When the line is closer to one end of a box than another, the data are skewed in the direction of the far end. Lines drawn from the ends of a box (often called *whiskers*) stretch out to the smallest or largest values that are not outliers. *Outliers*, shown by squares, correspond to responses given by small proportions of respondents and stretching out over 1.5 box-lengths from the 25th or 75th percentiles. *Extreme* and rarest cases, shown by crosses, stretch out over 3 box-lengths from these percentiles. For a better understanding of boxplots, please compare items 17 and 23 in this figure and Figure 3.

Student Profiles

In addition to analyzing students' positions on individual items, we looked for patterns in their responses on all VASS items, in order to: (a) identify general profiles according to which students can be classified in distinct groups, and (b) assess how these profiles relate to students' performance in physics courses.

Item response classification

A careful exploratory analysis of the answers of participating professors and students led us to the following considerations with regard to *individual items*:

1. Professors' answers were not evenly polarized on all items. On some items, all professors or the overwhelming majority of them chose exclusively the expert alternative (response option 1 or 7). On others, the majority of professors was divided among the three options that favor the expert alternative over the folk alternative (options 1 through 3, or 5 through 7).

   A student is then considered to hold an *expert view* on a given item if her/his answer falls within the range of answers given by the majority of professors on this particular item.

2. Except on a few items with insignificant *outliers* and *extremes* (Figure 4), the few professors who were not more inclined towards the expert alternative chose either response option 4 (equally both alternatives) or were divided between this option and the adjacent one (option 3 or 5).

   A student is then considered to hold a *mixed view* on a given item if s/he shares the middle position with those professors who did not express an expert view on this particular item.

3. Following the above, a student is considered to hold a *folk view* on a given item if her/his answer is shared by virtually no professor, and is closer to the folk alternative than the expert one.

For example, on items like item 17 (Figure 3), the *expert view* corresponds to options (6) and (7), the *mixed view*, to options (4) and (5), and *the folk view*, to options (1), (2), and (3). Had alternative (a) not been actually *false* in item 23, the expert view in this item would have corresponded to options (5), (6) and (7) (as it actually did in other items with similar response distribution), and the mixed view to option (4), or to options (3) and (4). However, given the nature of the alternatives in item 23, the cutoffs between the three view types are the same in this item as in item 17.

General profile classification

As a consequence of the above classification of student views on individual items, we explored the possibility of classifying students in three broad groups of distinct profiles that we will refer to as *expert*, *transitional* (or *mixed*), and *folk* profiles respectively.

The following are some of the primary criteria that were set to establish the demarcation lines between the three groups:

1. A student should belong to one, and *only one*, group.
2. A profile should consist of relatively *coherent views*. This is especially critical for the expert profile. A student with an expert profile should express more expert views than mixed and folk views combined, within each of the scientific and cognitive dimensions.
3. The threshold for the *expert profile* should be such that virtually no student can be counted as expert if s/he expresses expert views on less items (or folk views on more items) than a physics professor or a high school teacher with a BS in physics who expresses the least number of expert views on the entire VASS Form P11.
4. Any student who expresses expert views and folk views on equal number of items

should be considered to have a *transitional profile*.

5. Any student who expresses folk views on about half the items should be considered to have a *folk profile.*
6. It is preferred that the profiles have some *predictive validity* with respect to student achievement in physics courses.
7. The profiles should be characterized in the most *tangible, feasible* and *advantageous* ways possible.

Consequently, we decided to distinguish the three profiles by the *number* of views of a specific type, and to use only 25 items in VASS-Form P11 for this purpose. The remaining eight items were discarded in the current study because the cutoffs between the three respective view types could not be defined as sharply on these items as on the other 25 items. (These eight items are now being revised). The characteristics of the three profiles are presented in Table 1. Table 2 shows how these characteristics were matched in our sample of 326 college physics students.

The *expert profile (EP)* is characterized by at least 15 items out of 25 with expert views (Table 1).

In our sample, 36 students (11%) fall in this category (Table 2). No student expressed expert views on all 25 items. One student expressed such views on 24 items. 30 EP students (83% of all EP students) expressed folk views on no more than 5 items. 4 EP students (11%) expressed folk views on 6 items, and one student (3%) on 7 items and another on 8 items.

The *transitional profile (TP)* is characterized by: (a) 10 to 14 items with expert views ***and*** equal or less number of folk views, or (b) no more than 9 items with expert views ***but*** no more than 9 items with folk views (Table 1).

237 participating college students (73%) fall in this category (Table 2). Only 2 of these TP students (less than 1%) expressed folk views on 10 items. All other expressed folk views on no more than 9 items (category (b) in the transitional profile). 123 TP students (52%) expressed expert views on 10 to 14 items. 62 TP students (26%) expressed mixed views on at least 12 items.

The *folk profile (FP)* is characterized by at least 10 items out of 25 with folk views ***and*** no more than 12 items with expert views, provided that the numbers of folk views and expert views are not equal (Table 1).

Table 1

General profile characteristics

Profile	Number of Items out of 25	
	Expert views	Folk views
Expert	15 or more	—
Transitional	13 – 14	—
	12	12 or less
	11	11 or less
	10	10 or less
	9 or less	9 or less
Folk	12	13
	11	12 or more
	10	11 or more
	9 or less	10 or more

Table 2

Characteristics of the three profiles in the sample of 326 college physics students

Profile	% of students	Number* of Items out of 25 with		
		Expert views	Mixed views	Folk views
Expert	11	15 – 24 ***16***	0 – 8 ***4***	1 – 8 ***4***
Transitional	73	2 – 14 ***10***	2 – 20 ***9***	0 – 10 ***6***
Folk	16	2 – 11 ***7***	1 – 13 ***6***	10 – 17 ***12***
All three	100	2 – 24 ***9***	0 – 20 ***8***	0 – 17 ***6***

* Ranges are given in the top row of each profile, and medians in the bottom row. As integers, medians are all equal to the corresponding means , except for the overall mean of expert views that is 10 instead of 9.

53 participating college students (16%) fall in this category (Table 2). Only one student of the FP group (2%) expressed expert views on 11 items, and two (4%) on 10 items. All other FP students (94%) expressed expert views on no more than 9 items.

Other important results should be noted at this point in our sample (Table 2):

1. The threshold for the *expert* profile (15 items with expert views) falls just more than one standard deviation (4 items with expert views) above the overall mean of expert views (10 items).
2. The threshold for the *folk* profile (10 items with folk views) also falls just more than one standard deviation (3 items with folk views) above the overall mean of folk views (6 items).
3. The mean (and median) of *expert* views *decreases* considerably from EP to TP and then FP. FP's mean of expert views (7 items) is exactly 2.52 standard deviations below the EP's mean of expert views (16 items).
4. The mean (and median) of *folk* views *increases* considerably from EP to TP and then FP. FP's mean of folk views (12 items) is exactly 2.46 standard deviations above the EP's mean of folk views (4 items).
5. The mean (and median) of *mixed* views *increases* gradually from EP to FP and then TP. TP's mean of mixed views (9 items) is exactly 1.30 standard deviations above the EP's mean of mixed views (4 items).

Student Profiles across Various College Courses

Participating college students were enrolled in introductory physics courses of three different levels. 128 students (39%) were enrolled in a calculus-based course, 77 students (24%), in an algebra-based course, and the remaining 121 (37%), in two lower-level, elementary courses designed for non-science majors. Figure 5 compares the profile distribution of students in the three course categories.

As can be seen in Figure 5, about three quarters of students in each group have a transitional profile (TP), and more students have a folk profile (FP) than an expert profile (EP). The situation is slightly but not significantly better for the calculus-based course than the other courses. There are 2% to 3% less FP and TP students in this course than in the other courses, and 5% more EP students.

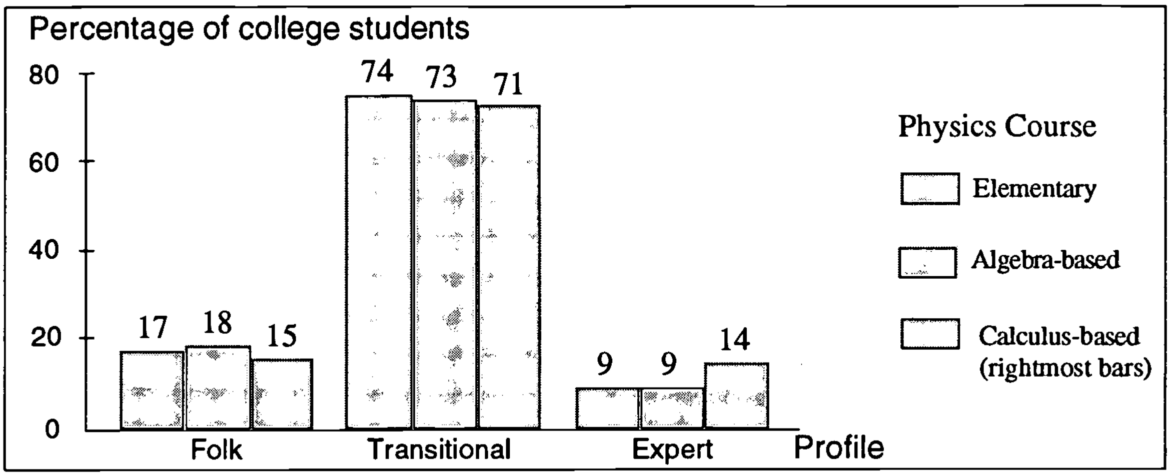


Figure 5: Profile distribution among the three groups of college physics students.

A student is assigned a "profile weight" of 1, 2, or 3, depending on whether s/he has a folk, transitional, or expert profile respectively. Because there are more students with folk than with expert profile, the overall mean of profile weights was *below the transitional profile weight* of 2.0 in each of three student groups. The profile mean weight was 1.99, 1.91 and 1.93 in the calculus-based, algebra-based and elementary courses respectively.

Student Views and Achievement

Educational researchers have often speculated that students' views about knowing and learning science affect their understanding of what they are taught in science courses. In order to test this speculation, we assessed the relationship between students' performance on VASS and their final grades in their courses of enrollment (among other things).

Figure 6 shows the distribution of the 326 college physics students' grades in their respective physics courses across the seven response options on items 17 and 23. In this figure, grades B and C are lumped together, and so are grades D and F. The figure shows a clear relationship between students' answers on individual items and their course grades. In both items, although more so in item 17 than in item 23, the expert view (options 6 and 7) is picked overwhelmingly by "A" students, and to a significantly lesser extent by the rest of participating students. Furthermore, there is a higher proportion of high risk students (grades D and F) than any others showing an inclination towards the folk view. Students in the middle category (with B and C grades) are spread out across both ends of the spectrum, with a little more inclination toward the expert view than the folk view.

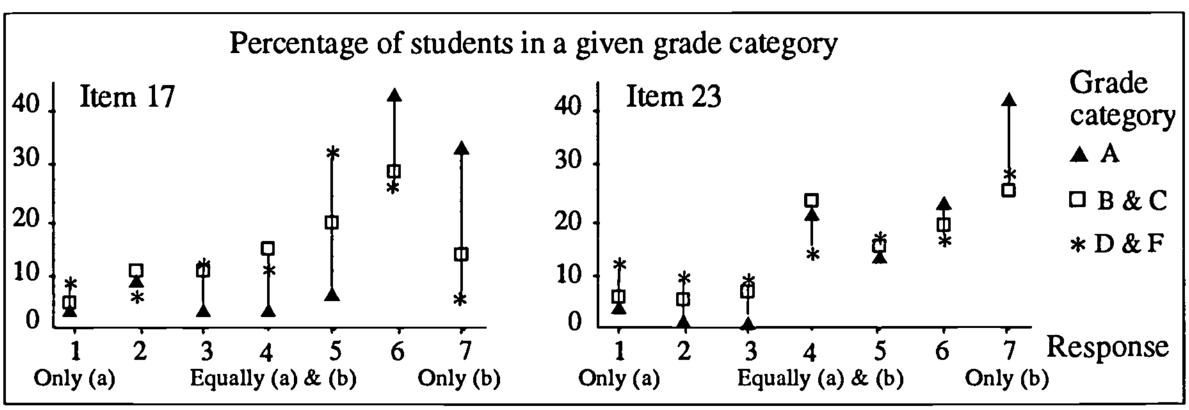


Figure 6: Distribution of student course grades across response options on items 17 and 23 in VASS Form P11.

Similar patterns were observed throughout all 25 VASS items used for defining the three profiles. Figures 7 and 8 show how student performance in college physics courses is related to their overall profiles.

Figure 7 shows the distribution of students' final grades across the three profiles. 33% of A students in our college physics sample had an expert profile (EP), and the remaining 67% of these students, a transitional profile (TP). No A student had a folk profile (FP). In contrast, the trend is reversed for D and F students of whom 26% had an FP, 68% a TP, and only 5% an EP.

Figure 8 shows the distribution of students' profiles across their final grades. About 95% of students with an expert profile completed their college physics courses with a grade of "C" or better. 87% of TP students and 77% of FP students did the same. However, 30% of EP students ended up with an "A", while only 11% of TP students and no FP student did the same. Moreover, only 9% of FP students ended up with a "B".

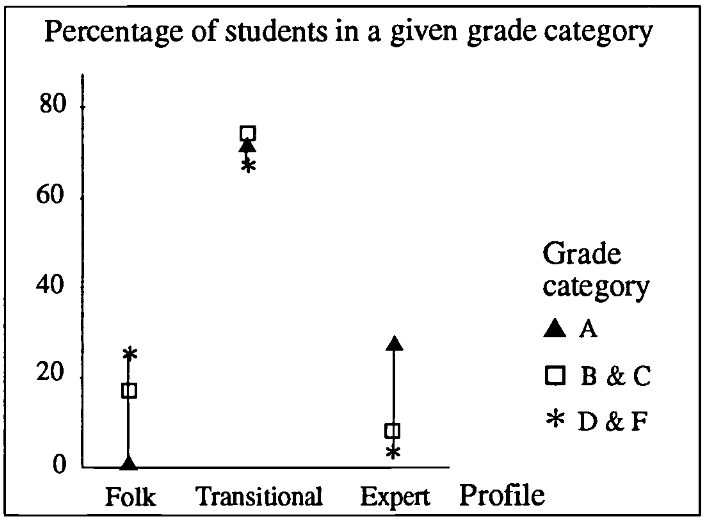


Figure 7: Distribution of student course grades across the three profiles.

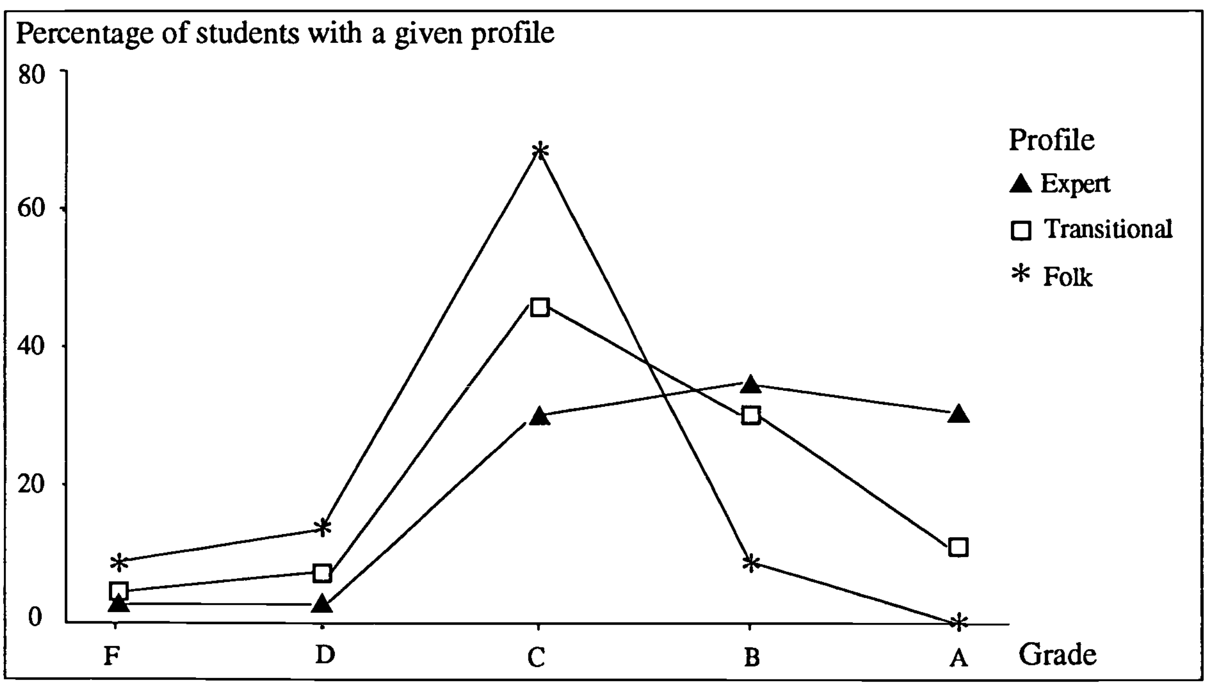


Figure 8: Distribution of student profiles across final grades in college physics courses.

Conclusion

VASS shows that:

1. College students hold folk views about knowing and learning physics that are often incompatible with views commonly held by physicists.
2. Students do not show a consistent tendency towards one type of view or another on all VASS items. Every college student holds a mixture of folk, mixed and expert views about any of the scientific and cognitive dimensions assessed in VASS.
3. Based on their views on various issues, students can still be classified in three broad groups of distinct profiles. These are the expert, the transitional, and the folk profiles. About three quarters of participating college students exhibit a transitional profile, and more students exhibit a folk profile than an expert profile.
4. The closer students are to expert views on individual items, or to an expert profile on the entire VASS, the better their performance in college physics courses; and the closer they are to a folk view/profile, the worse their performance. More specifically, and based on our sample results:
   (a) Students with an expert profile are by far the most likely to earn an "A" in a college physics course.
   It is extremely unlikely that a student with a folk profile earns an "A" in such a course.
   In fact, among students with a folk profile in our sample, no one ended up with an "A" in any physics course, and only 9% ended up with a "B".
   (b) Students with a folk profile are the most likely to fail a college physics course or complete it with a "D" or a "C".
   It is extremely unlikely that a student with an expert profile does poorly in such a course.
   In fact, fewer than 6% of students with an expert profile in our sample ended up with a "D" or an "F".
   (c) It is far more likely for students with a transitional profile to complete their college physics course with a "B" or a "C" than any other grade.

What is reported in this paper represents only a small sample of what went into the development of VASS and of subsequent outcomes. Interested readers are invited to refer to our related publications listed in the references, and to watch for upcoming articles in major science and mathematics education journals, in order to learn more about our work in physics, as well as in biology, chemistry and mathematics.

Our work with VASS is by no means exhausted. Data are still being analyzed in many respects. Profiles reported in this paper will be refined based on incoming data from many colleges and high schools. Cutoffs between the different view types on individual items as well as between the different profiles will be refined. The transitional profile may still be divided into distinctive profiles. Each profile will then be characterized qualitatively along the six VASS subdomains. All this and more will be used in the development of new curricula at all levels.

Acknowledgment

This work is part of the *Modeling Instruction* project headed by David Hestenes at ASU and supported by the National Science Foundation.

Many schools and universities have graciously volunteered to administer VASS to their students. About one hundred colleagues have gratefully made valuable contributions to this work. Dale Baker, James Birk, David Halliday, Jane Jackson, Anton Lawson and Michael Politano were especially helpful in reviewing the various VASS versions. The assistance of Sharon Osborn Popp was instrumental in the statistical analysis of the data.

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Appendix

VASS – Form P12

The following is VASS Form P12 for physics. This form supersedes Form P11 referred to in this article. Form P12 differs from Form P11 in the following respects:

1. Three of the eight items in Form P11 that were left out of the profile analysis have been discarded. The remaining five items have undergone major revision for clarity.
2. Some of the other twenty five items in Form P11 have undergone minor revision for clarity.
3. Item 31 in Form P12 is added for scrutiny purposes. It should not be included in any item or profile analysis.

Interested teachers are hereby granted the right to use VASS Form P12 at will in their classrooms. It is advised that the *VASS Answer Sheet* be used for paper-and-pencil administration of any VASS form. VASS answer sheets can be requested from the author at his ASU address.

Views About Sciences Survey

Form P12

This survey is designed by the Modeling Instruction research team at Arizona State University. It is intended to identify factors that affect people's understanding of physics, and to assist in the design of instructional material.

*Your participation is **voluntary**. The results will not affect your grade, even if you choose not to participate. All data are **confidential**. Your identity will not be disclosed to any party. Return of the survey materials will be considered your consent to participate.*

If you have any question about this survey, please call Dr. I. Halloun at (602) 965-8528.

Please:

*Do **not** write anything on this questionnaire.*
Mark your answers on the computer sheet.
*Use a **No. 2 pencil** only, and follow marking instructions on the computer sheet.*
*Make **only one** mark per item.*
*Do **not** skip any question.*
*Avoid guessing. Your answers should reflect what **you** actually and honestly think.*
Plan to finish the survey in 30 minutes.

---

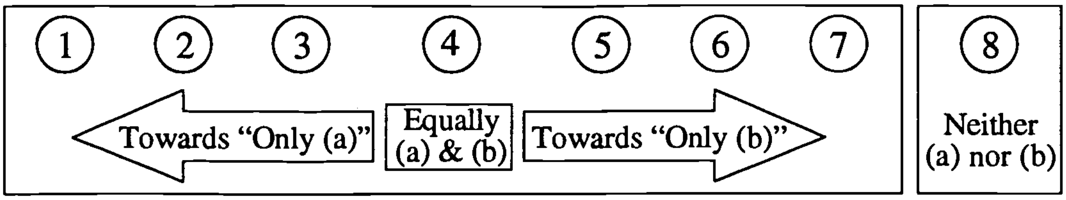
*The example below illustrates the eight choices that you have for answering the following 31 questions. Please mark your answers to these questions in section **III** of the VASS Answer Sheet.*

Example

Learning physics requires:
(a) a serious effort.
(b) a special talent.

What would each one of the eight choices mean?

① Only (a), Never (b):	Learning physics requires ***only*** *a serious effort* and ***no*** special talent *at all.*
② Mostly (a), Rarely (b):	Learning physics requires ***far more*** *a serious effort* than a special talent.
③ More (a) Than (b):	Learning physics requires ***somewhat more*** *a serious effort* than a special talent.
④ Equally (a) & (b):	Learning physics ***equally*** requires ***both*** a serious effort and a special talent.
⑤ More (b) Than (a):	Learning physics requires ***somewhat more*** a *special talent* than a serious effort.
⑥ Mostly (b), Rarely (a):	Learning physics requires ***far more*** a *special talent* than a serious effort.
⑦ Only (b), Never (a):	Learning physics requires ***only*** a *special talent* and ***no*** serious effort *at all.*
⑧ Neither (a) Nor (b):	Learning physics requires ***neither*** a *special talent* ***nor*** *a serious effort.*



1. Learning physics requires:
   (a) a serious effort.
   (b) a special talent.

2. If I had a choice:
   (a) I would never take any physics course.
   (b) I would still take physics for my own benefit.

3. Reasoning skills that are taught in physics courses can be helpful to me:
   (a) in my everyday life.
   (b) if I were to become a scientist.

4. I study physics:
   (a) to satisfy course requirements.
   (b) to learn useful knowledge.

5. My score on physics exams is a measure of how well:
   (a) I understand the covered material.
   (b) I can do things the way they are done by the teacher or in some course materials.

6. For me, doing well in physics courses depends on:
   (a) how much effort I put into studying.
   (b) how well the teacher explains things in class.

7. When I come across a difficulty while studying physics:
   (a) I immediately seek help, or give up trying.
   (b) I try hard to figure it out on my own.

8. When studying physics in a textbook or in course materials:
   (a) I find the important information and memorize it the way it is presented.
   (b) I organize the material in my own way so that I can understand it.

9. For me, how information in physics courses relates to everyday life is usually:
   (a) easy to recognize.
   (b) hard to recognize.

10. In physics, it is important for me to:
    (a) memorize technical terms and mathematical formulas.
    (b) learn ways to organize information and use it.

1	2	3	4	5	6	7	8
Towards "Only (a)"			Equally (a) & (b)	Towards "Only (b)"			Neither (a) nor (b)

11. In physics, mathematical formulas:
    (a) express meaningful relationships among variables.
    (b) provide ways to get numerical answers to problems.

12. After I go through a physics text or course materials and feel that I understand them:
    (a) I can solve related problems on my own.
    (b) I have difficulty solving related problems.

13. The first thing I do when solving a physics problem is:
    (a) represent the situation with sketches and drawings.
    (b) search for formulas that relate givens to unknowns.

14. In order to solve a physics problem, I need to:
    (a) have seen the solution to a similar problem before.
    (b) know how to apply general problem solving techniques.

15. For me, solving a physics problem more than one way:
    (a) is a waste of time.
    (b) helps develop my reasoning skills.

16. After I have answered all questions in a homework physics problem:
    (a) I stop working on the problem.
    (b) I check my answers and the way I obtained them.

17. After the teacher solves a physics problem for which I got a wrong solution:
    (a) I discard my solution and learn the one presented by the teacher.
    (b) I try to figure out how the teacher's solution differs from mine.

18. How well I do on physics exams depends on how well I can:
    (a) recall material in the way it was presented in class.
    (b) solve problems that are somewhat different from ones I have seen before.

19. To me, physics is important as a source of:
    (a) factual information about the natural world.
    (b) ways of thinking about the natural world.

20. As they are currently used, Newton's laws of motion:
    (a) are the same throughout the universe.
    (b) change depending on where you are in the universe.

1	2	3	4	5	6	7	8
Towards "Only (a)"			Equally (a) & (b)	Towards "Only (b)"			Neither (a) nor (b)

21. The laws of physics are:
    (a) inherent in the nature of things and independent of how humans think.
    (b) invented by physicists to organize their knowledge about the natural world.

22. The laws of physics portray the real world:
    (a) exactly the way it is.
    (b) by approximation.

23. Physicists say that electrons and protons exist in an atom because:
    (a) they have seen these particles in their actual form with some instruments.
    (b) they have made observations that can be explained by such particles.

24. Where they are currently used, Newton's laws of motion:
    (a) will always be used as they are.
    (b) could eventually be replaced by other laws.

25. Physicists' current ideas about the particles making up the atom:
    (a) will always be maintained as they are.
    (b) could eventually be replaced by other ideas.

26. If we want to apply a method used for solving one physics problem to another problem, the objects involved in the two problems must be:
    (a) identical in all respects.
    (b) similar in some respects.

27. Different branches of physics, like mechanics and electricity:
    (a) are interrelated by common principles.
    (b) are separate and independent of each other.

28. Physicists use mathematics as:
    (a) a tool for analyzing and communicating their ideas.
    (b) a source of factual knowledge about the natural world.

29. Scientific findings about the natural world are:
    (a) dependent on current scientific knowledge.
    (b) accidental, depending on scientists' luck.

30. Knowledge in chemistry is:
    (a) related to knowledge in physics.
    (b) independent of knowledge in physics.

31. I answered all the questions in this survey:
    (a) to the best of my ability.
    (b) without thinking seriously about them.

VASS ANSWER SHEET

PLEASE:
Use a #2 pencil only.
Make all marks completely dark
Erase completely any mark you wish to change

ARIZONA STATE UNIVERSITY

INCORRECT MARKS ⊘ ⊗ ◒ ⊙ CORRECT MARK ●

SURVEY FORM

A B C E G H M O P S

0 1 2 3 4 5 6 7 8 9 (two columns)

IDENTIFICATION NUMBER (OR SSN)

0 1 2 3 4 5 6 7 8 9 (nine columns)

COURSE

CODE: blank, A–Z (four columns)

NUMBER: 0 1 2 3 4 5 6 7 8 9 (four columns)

INSTITUTION

NAME: blank, A–Z (seven columns)

STATE: blank, A–Z (two columns)

UNIVERSITY MAJOR

blank, A–Z (seven columns)

DATE THIS FORM WAS FILLED OUT

MONTH	YEAR
JAN	95
FEB	96
MAR	97
APR	98
MAY	99
JUN	00
JUL	
AUG	
SEP	
OCT	
NOV	
DEC	

EDUCATION LEVEL

HIGH SCHOOL	COLLEGE
8	Freshman
9	Sophomore
10	Junior
11	Senior
12	Graduate

RACE/ NATIONAL ORIGIN

- American Indian or Alaskan Native
- Asian or Pacific Islander
- Black, not of Hispanic origin
- Hispanic
- White, not of Hispanic origin
- Other

GENDER

- Female
- Male

BIRTH YEAR

0 1 2 3 4 5 6 7 8 9 (two columns)

II.

Item	A (T)	B (F)	C (U)	D	E	F
1	5	4	3	2	1	0
2	5	4	3	2	1	0
3	5	4	3	2	1	0
4	5	4	3	2	1	0
5	5	4	3	2	1	0
6	5	4	3	2	1	0
7	5	4	3	2	1	0
8	5	4	3	2	1	0
9	5	4	3	2	1	0
10	5	4	3	2	1	0
11	5	4	3	2	1	0
12	5	4	3	2	1	0
13	5	4	3	2	1	0
14	5	4	3	2	1	0
15	5	4	3	2	1	0
16	5	4	3	2	1	0
17	5	4	3	2	1	0
18	5	4	3	2	1	0
19	5	4	3	2	1	0
20	5	4	3	2	1	0
21	5	4	3	2	1	0
22	5	4	3	2	1	0
23	5	4	3	2	1	0
24	5	4	3	2	1	0
25	5	4	3	2	1	0
26	5	4	3	2	1	0
27	5	4	3	2	1	0
28	5	4	3	2	1	0
29	5	4	3	2	1	0
30	5	4	3	2	1	0
31	5	4	3	2	1	0
32	5	4	3	2	1	0
33	5	4	3	2	1	0
34	5	4	3	2	1	0
35	5	4	3	2	1	0

University Testing Services Form #UTSDE1

Item	T A	F B	U C	D	E	F
36	5	4	3	2	1	0
37	5	4	3	2	1	0
38	5	4	3	2	1	0
39	5	4	3	2	1	0
40	5	4	3	2	1	0
41	5	4	3	2	1	0
42	5	4	3	2	1	0
43	5	4	3	2	1	0
44	5	4	3	2	1	0
45	5	4	3	2	1	0
46	5	4	3	2	1	0
47	5	4	3	2	1	0
48	5	4	3	2	1	0
49	5	4	3	2	1	0
50	5	4	3	2	1	0
51	5	4	3	2	1	0
52	5	4	3	2	1	0
53	5	4	3	2	1	0
54	5	4	3	2	1	0
55	5	4	3	2	1	0
56	5	4	3	2	1	0
57	5	4	3	2	1	0
58	5	4	3	2	1	0
59	5	4	3	2	1	0
60	5	4	3	2	1	0
61	5	4	3	2	1	0
62	5	4	3	2	1	0
63	5	4	3	2	1	0
64	5	4	3	2	1	0
65	5	4	3	2	1	0
66	5	4	3	2	1	0
67	5	4	3	2	1	0
68	5	4	3	2	1	0
69	5	4	3	2	1	0
70	5	4	3	2	1	0

III.

Item	Only (a), Never (b)	Mostly (a), Rarely (b)	More (a) Than (b)	Equally (a) & (b)	More (b) Than (a)	Mostly (b), Rarely (a)	Only (b), Never (a)	Neither (a) Nor (b)
1	1	2	3	4	5	6	7	8
2	1	2	3	4	5	6	7	8
3	1	2	3	4	5	6	7	8
4	1	2	3	4	5	6	7	8
5	1	2	3	4	5	6	7	8
6	1	2	3	4	5	6	7	8
7	1	2	3	4	5	6	7	8
8	1	2	3	4	5	6	7	8
9	1	2	3	4	5	6	7	8
10	1	2	3	4	5	6	7	8
11	1	2	3	4	5	6	7	8
12	1	2	3	4	5	6	7	8
13	1	2	3	4	5	6	7	8
14	1	2	3	4	5	6	7	8
15	1	2	3	4	5	6	7	8
16	1	2	3	4	5	6	7	8
17	1	2	3	4	5	6	7	8
18	1	2	3	4	5	6	7	8
19	1	2	3	4	5	6	7	8
20	1	2	3	4	5	6	7	8
21	1	2	3	4	5	6	7	8
22	1	2	3	4	5	6	7	8
23	1	2	3	4	5	6	7	8
24	1	2	3	4	5	6	7	8
25	1	2	3	4	5	6	7	8
26	1	2	3	4	5	6	7	8
27	1	2	3	4	5	6	7	8
28	1	2	3	4	5	6	7	8
29	1	2	3	4	5	6	7	8
30	1	2	3	4	5	6	7	8
31	1	2	3	4	5	6	7	8
32	1	2	3	4	5	6	7	8
33	1	2	3	4	5	6	7	8
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