# Views on science and education (VOSE) questionnaire

**Sufen CHEN**

**Graduate School of Technological and Vocational Education**
**National Taiwan University of Science and Technology**
**TAIWAN**

**Email:** sufchen@mail.ntust.edu.tw

Received 17 Nov., 2006
Revised 6 Dec., 2006

## Contents



## Abstract

This article presents the full version of Views on Science and Education (VOSE) in both Chinese and English for assessing college students' and adults' views about nature of science and attitudes toward teaching issues in nature of science. The development of VOSE has been delineated in the September issue of Science Education. The results of the field test are briefly reviewed in this article. Finally, a guideline according to the researcher's views about the test items is provided for coding the data.

Copyright (C) 2006 HKIEd APFSLT. Volume 7, Issue 2, Article 11 (Dec., 2006). All Rights Reserved.

**Keywords:** nature of science, instrument, teaching attitudes

# Introduction

In a recent issue of Science Education, I used VOSE as an example to introduce an innovative approach to developing a questionnaire for assessing views on nature of science (NOS) and the relevant teaching attitudes (Chen, 2006). Many researchers have requested a full copy of VOSE. In response to researchers and educators who would like to apply VOSE, this article presents the instrument, summarizes the quality of the instrument, and clarifies my views about NOS.

# Summary of the Quality of the Instrument

VOSE assesses both the subjects' conceptions of NOS and attitudes toward teaching NOS, as well as their underlying reasons. The conception and attitude parts consist of ten and five questions, respectively. Each question is followed by several items that represent different philosophical positions. Participants are instructed to read all items of a question before ranking each on the five-point scale.

## *Reliability*

The items were empirically derived from the learners' perspectives. On the one hand, VOSE yields reliable results because the items originated from the respondents' viewpoints instead of experts' presumptions of reasonable responses. On the other hand, the test-retest reliability is high. The latest version of VOSE was field tested with 302 college students. Twenty-four of the subjects voluntarily filled out the questionnaire again within 1 to 3 months and achieved a high test-retest correlation coefficient, 0.82.

I explained in the original article that the commonly used internal consistency or Cronbach's alpha is not applicable to empirically-based instruments. Readers may also refer to Aikenhead and Ryan (1992), Rubba, Schoneweg Bradford and Harkness (1996), and Erlandson, Harris, Skipper, and Allen (1993) for more discussion about the reliability of this type of instrument. For VOSE, the Cronbach's alphas of all issues ranged from 0.34 to 0.81 (see the tables in the original article) and were used to

Copyright (C) 2006 HKIEd APFSLT. Volume 7, Issue 2, Article 11 (Dec., 2006). All Rights Reserved.

verify the appropriateness of discarding some items in the pilot test, but not a main criterion for reliability. Some issues involve independent subcategories of views and thus have low alpha values.

### *Validity*

The content and the interpretation of the items were validated by two panels of experts, each consisting of six experts. The 24 subjects who participated in the retest were interviewed for two hours following the retest to establish validity concerning the ambiguity issue. The results showed that on two of the 85 items, item G of question 1 (1G) and item D of question 3 (3D), five interviewees (20.8%) and three interviewees (12.5%) interpreted the items differently from the researcher and the panel of experts. For the remaining 83 items, over 90% of the interviewees interpreted the items consistently with the researcher and experts. The researcher, experts, and respondents attributed similar interpretations to the items. VOSE therefore measures what it purports to measure.

### *Target Subjects*

VOSE is designed for college students and adults, including pre- and inservice teachers. For 10th to 12th graders, VOSE may be appropriate because the language is similar to Views on Science-Technology-Society (VOSTS) (Aikenhead & Ryan, 1992), which was designed for high school students. In addition, a high school student was interviewed to check the clarity of the items in the pilot test. However, for younger students, I would suggest researchers interview some of the students to ensure that the items are comprehensible to them. It should be noted that the NOS and the teaching attitudes parts can be implemented separately. Researchers may use only the NOS part for students below college level.

Moreover, the English version needs to be validated, and, for Chinese users outside Taiwan, the Chinese version may need further revision. Although VOSE was based on multiple sources of empirical data, including Western and Taiwanese learners, only the Chinese version has been field tested, and translation could cause semantic differences. Furthermore, the style of Chinese is based on the tradition in Taiwan. Therefore, the local context and language usage should be taken into consideration for both English and Chinese users.

Copyright (C) 2006 HKIEd APFSLT. Volume 7, Issue 2, Article 11 (Dec., 2006). All Rights Reserved.

Finally, respondents who are not familiar with NOS issues may not have a firm position and may be swayed by the first item they read. To reduce the order effect, researchers should inform the respondents to read all items for a question before answering, and may use forms that switch the order of the items.

## NOS Positions

I addressed a hesitancy in distinguishing between informed and naïve views of NOS in the original article. On the one hand, as a methodology article, I intended to avoid the fallacy that tenets of postpositivism are superior to those of positivism, or that anti-realism overcomes realism. On the other hand, science educators should provide students with opportunities for discussing NOS topics and for justifying beliefs, rather than indoctrinate certain concepts, because all concepts of NOS are tentative. Matthews (1997) noted two mistakes made by James Robinson in his 1968 work "The nature of science and science teaching." First, Robinson considered logical positivism as the only view of NOS. Second, Robinson advocated that one of the educational objectives was to teach students to believe in that one view. Likewise, contemporary science educators may make the same mistakes by equating NOS with a set of beliefs, and expecting students to be transformed to these beliefs. Scientists' and philosophers' views should be made known to students, but not taught in such a way as to stamp "a message from ink-pad on to paper" (Solomon, 1995, p.16). Students should learn to justify their beliefs, not to believe in a certain philosophical position.

Nevertheless, many researchers have requested a detailed guideline for coding the data. I shall clarify my position regarding each test item for researchers' reference. In this text, the item is symbolized by a numerical number, indicating the question, and a letter, indicating the response for the question. For example, items 9A and 9B are the first and second responses for question 9. For data coding, first of all, I would consider the following 16 items as naïve conceptions and reverse their scores:

(1) Items 9A, 9B, and 9F, concerning the universal scientific method.
(2) Items 7A and 7B, which state that laws are more certain than theories.
(3) Items 3C, 3D, and 3E, regarding using no imagination in scientific investigation.

Copyright (C) 2006 HKIEd APFSLT. Volume 7, Issue 2, Article 11 (Dec., 2006). All Rights Reserved.

(4) Items 2C, 2D, and 15F, which stress no influence of socio-culture on scientific investigation.
(5) Items 8C, 15E, and 15I, which highlight no influence of personal beliefs on scientific investigation.
(6) Items 8C and 8D, in which observations are considered to be independent from theories.

Secondly, concerning the epistemological status of theories and laws, my viewpoint is that participants should recognize that scientists create theories and laws to interpret and describe empirical evidence. However, it should be noticed that, while some scientists and philosophers argue that theories and laws are invented, others believe that there is an objective World and scientists try to discover theories and laws. Which view is more desirable for the subjects to possess? This will be the individual researcher's judgment. When I interpret the results of these items, instead of saying that the participants' knowledge is adequate or not, I compare their views about the epistemological statuses of theories and laws. Those who believe that laws are more reliable than theories tend to put laws at the discovery end and theories at the invention end.

For the rest of the NOS items in VOSE, I think they are all acceptable. Participants, whether they are teachers or students, should have a comprehensive view. For example, scientific knowledge is accumulated and evolved, and may have revolutionary change. Theory choice is based on empirical evidence and also influenced by many factors that have nothing to do with objectivity. I would expect the participants to see both sides. In other words, I support a comprehensive view of NOS, which involves multiple viewpoints, instead of a specific philosophy such as positivism or postpositivism. For many NOS issues, an understanding of the participants' beliefs in the multiple viewpoints is more meaningful than a total score or grand means.

Copyright (C) 2006 HKIEd APFSLT. Volume 7, Issue 2, Article 11 (Dec., 2006). All Rights Reserved.

# VOSE in Chinese

## 科學本質與科學教育問卷

### 作答原則：

這份問卷中的每一大題都以一個關於科學本質或科 學教育的敘述爲起頭。大部分的敘述都採用某一極端立場。你可能非常同意、或不同意，也許另有想法。然後，每一大題有數個關於該敘述的回應，**請先讀完該大題所有回應**，然後就你所認爲的實際科學活動或科學家的情形**逐 一在其右側圈選答案**（0,1,2,3,4），答案沒有對或錯。謝謝。

### *I 科學本質*

| 1. **當兩個不同的理論可以同時解釋相同的現象時（例如：潮汐現象），科學家會同時接受兩種理論嗎？** | 非常不同意 | 不同意 | 沒意見 | 同意 | 非常同意 |
|---|---|---|---|---|---|
| A.會，因爲科學家還不能客觀區分兩種理論的優劣，所以暫時都接受。 | 0 | 1 | 2 | 3 | 4 |
| B.會，因爲可能只是理論解釋的方向不同，沒有優劣之分。 | 0 | 1 | 2 | 3 | 4 |
| C.不會，因爲科學家通常比較會接受自己比較熟悉的理論。 | 0 | 1 | 2 | 3 | 4 |
| D.不會，因爲科學家比較會接受簡單明瞭的理論，避免繁瑣的理論。 | 0 | 1 | 2 | 3 | 4 |
| E.不會，科學家會因提出者的學術地位不同，而影響其接受的程度。 | 0 | 1 | 2 | 3 | 4 |
| F.不會，科學家比較會接受不違背核心科學理論的新理論。 | 0 | 1 | 2 | 3 | 4 |
| G.不會，科學家會以直覺判斷。 | 0 | 1 | 2 | 3 | 4 |
| H.不會，因爲真理只有一個，科學家不會在分出優劣之前先接受任何一個理論。 | 0 | 1 | 2 | 3 | 4 |

| **2. 科學活動會受到社會文化（例如：潮流、價值觀）的影響。** | | | | | |
|---|---|---|---|---|---|
| A.會，社會文化影響科學活動的方向/主題。 | 0 | 1 | 2 | 3 | 4 |
| B.會，因爲從事科學活動的科學家受到社會文化影響。 | 0 | 1 | 2 | 3 | 4 |
| C.不會，受過良好訓練的科學家可以使研究活動保持價值中立。 | 0 | 1 | 2 | 3 | 4 |
| D.不會，因爲科學講求客觀，與社會文化的主觀價值不同。 | 0 | 1 | 2 | 3 | 4 |

Copyright (C) 2006 HKIEd APFSLT. Volume 7, Issue 2, Article 11 (Dec., 2006). All Rights Reserved.

| **3. 科學家在進行科學研究時，會應用他們的想像力嗎？** | | | | | |
|---|---|---|---|---|---|
| A.會，因爲想像力是創新的主要來源。 | 0 | 1 | 2 | 3 | 4 |
| B.會，因爲在科學研究中，多多少少會使用到想像力。 | 0 | 1 | 2 | 3 | 4 |
| C.不會，因爲想像力不合科學邏輯。 | 0 | 1 | 2 | 3 | 4 |
| D.不會，因爲想像力可能造成科學家不擇手段來證明自己的論點。 | 0 | 1 | 2 | 3 | 4 |
| E.不會，因爲想像力缺乏公信力。 | 0 | 1 | 2 | 3 | 4 |

| **4. 即使是正確無誤地作科學研究，對其所提出的理論日後一樣有被否定的可能。** | | | | | |
|---|---|---|---|---|---|
| A.科學研究會面臨革命性的改變，舊的理論會被取代。 | 0 | 1 | 2 | 3 | 4 |
| B.因爲科學的進步並非一蹴可幾，而是逐漸累積的過程，所以舊的理論沒有被推翻。 | 0 | 1 | 2 | 3 | 4 |
| C.隨著實驗數據與資料的增多，理論會演化得更精確與完整，並不是被否定。 | 0 | 1 | 2 | 3 | 4 |

| **5. 科學理論/學說（theory）（例如：進化論、原子說）是由科學家從自然界中「發現」或「發明」的。** | 非常不同意 | 不同意 | 沒意見 | 同意 | 非常同意 |
|---|---|---|---|---|---|
| A.發現，因爲概念本來就存在，隨時等著被發現。 | 0 | 1 | 2 | 3 | 4 |
| B.發現，因爲它是根據實驗**事實**。 | 0 | 1 | 2 | 3 | 4 |
| C.有些科學家誤打誤撞地發現了理論，但有些科學家可能從他們已知的事實裡創造發明了理論。 | 0 | 1 | 2 | 3 | 4 |
| D.發明，因爲理論是對實驗**事實**的解釋，而實驗事實是被科學家發現的。 | 0 | 1 | 2 | 3 | 4 |
| E.發明，理論是科學家創造/想出來的。 | 0 | 1 | 2 | 3 | 4 |
| F.發明，因爲理論有被推翻的可能。 | 0 | 1 | 2 | 3 | 4 |

| **6. 科學定律（law）（例如：萬有引力定律）是由科學家從自然界中「發現」或「發明」的。** | | | | | |
|---|---|---|---|---|---|
| A.發現，因爲科學定律本來就存在於自然界中，科學家只是把它找出來而已。 | 0 | 1 | 2 | 3 | 4 |
| B.發現，因爲科學定律是根據實驗**事實**。 | 0 | 1 | 2 | 3 | 4 |
| C.有些科學家誤打誤撞地發現了定律，但有些科學家可能從他們已知的事實裡創造發明了定律。 | 0 | 1 | 2 | 3 | 4 |
| D.發明，科學家**發明**科學定律來解釋所發現的實驗事實。 | 0 | 1 | 2 | 3 | 4 |
| E.發明，因爲自然界中沒有絕對恆常不變的事，所以定律是科學家發明 | 0 | 1 | 2 | 3 | 4 |

Copyright (C) 2006 HKIEd APFSLT. Volume 7, Issue 2, Article 11 (Dec., 2006). All Rights Reserved.

出來的。

| **7. 比起定律，理論有較少的證據支持。** | | | | | |
|---|---|---|---|---|---|
| A.是，理論不如定律一樣確定。 | 0 | 1 | 2 | 3 | 4 |
| B.是，因爲理論經得起考驗就會變成定律，所以定律有較多的證據支持。 | 0 | 1 | 2 | 3 | 4 |
| C.不一定，有些理論比某些定律更有證據支持。 | 0 | 1 | 2 | 3 | 4 |
| D.不是，理論和定律是不同型態的觀念，不能互相比較。 | 0 | 1 | 2 | 3 | 4 |

| **8. 科學家的觀察受個人信念（例如：個人經歷、先入爲主的概念）影響，所以對同一實驗的觀察結果不一定相同。** | | | | | |
|---|---|---|---|---|---|
| A.可能不同，因爲不同的信念導致期待不同的結果，而左右其觀察。 | 0 | 1 | 2 | 3 | 4 |
| B.會相同，因爲同領域的科學家所受的訓練使他們的想法沒有太大的差異。 | 0 | 1 | 2 | 3 | 4 |
| C.會相同，因爲科學訓練使科學家能摒棄個人價值，從事客觀觀察。 | 0 | 1 | 2 | 3 | 4 |
| D.會相同，因爲觀察就是所看見的，不多也不少。事實就是事實。解釋可能因人而異，但觀察到的結果應該相同。 | 0 | 1 | 2 | 3 | 4 |
| E.會相同，雖然觀察難免受主觀因素影響，但科學家會以不同方法驗證以提高客觀性。 | 0 | 1 | 2 | 3 | 4 |

| **9. 大部分的科學家採用標準的科學方法（假設、觀察、實驗、解釋、結論）按部就班地作研究。** | 非常不同意 | 不同意 | 沒意見 | 同意 | 非常同意 |
|---|---|---|---|---|---|
| A.使用標準的科學方法擔保清楚、合邏輯、合理、精確的結果。因此，大部分科學家根據標準的科學方法作研究。 | 0 | 1 | 2 | 3 | 4 |
| B.大部分科學家採用標準科學方法，因爲它的步驟很符合邏輯。 | 0 | 1 | 2 | 3 | 4 |
| C.在大部分的情況下，科學方法很有用，但不保證會有結果，因此科學家創造新的方法。 | 0 | 1 | 2 | 3 | 4 |
| D.沒有所謂的標準方法，科學家會運用各種方法來得到他們想要的結果。 | 0 | 1 | 2 | 3 | 4 |
| E.沒有固定的科學方法，科學可能是意外被發現的。 | 0 | 1 | 2 | 3 | 4 |
| F.不論是用何種方法得到結果，科學家都會用標準科學方法來驗證它。 | 0 | 1 | 2 | 3 | 4 |

## *II 科學教育*

Copyright (C) 2006 HKIEd APFSLT. Volume 7, Issue 2, Article 11 (Dec., 2006). All Rights Reserved.

| **10. 高中以下學生應該學習標準的實驗步驟。** | 非常不同意 | 不同意 | 沒意見 | 同意 | 非常同意 |
|---|---|---|---|---|---|
| A.對，這樣學生才不會無所適從。 | 0 | 1 | 2 | 3 | 4 |
| B.對，因爲學生還沒有能力發明更適合的方法。 | 0 | 1 | 2 | 3 | 4 |
| C.對，應該學習科學家所做的事。 | 0 | 1 | 2 | 3 | 4 |
| D.對，因爲標準的方法是科學家發展出來目前最好的方法。 | 0 | 1 | 2 | 3 | 4 |
| E.對，藉此讓學生學習科學的客觀方法。 | 0 | 1 | 2 | 3 | 4 |
| F.對，可以幫助學生瞭解科學精神。 | 0 | 1 | 2 | 3 | 4 |
| G.不對，不要只教一種實驗方法，應該讓學生有充分思考與發展空間。 | 0 | 1 | 2 | 3 | 4 |
| H.不對，科學沒有所謂的標準方法。 | 0 | 1 | 2 | 3 | 4 |
| I.不對，老師應該與學生一同思考不同的實驗方法。 | 0 | 1 | 2 | 3 | 4 |

| **11. 在國高中課堂中，當學生觀察相同的事物時，一般而言老師應該期望學生要有相同的答案。** | | | | | |
|---|---|---|---|---|---|
| A.是，老師應該指導學生作客觀觀察，以得到一致的答案。 | 0 | 1 | 2 | 3 | 4 |
| B.是，夠細心的話，學生應該會得到相同的答案。 | 0 | 1 | 2 | 3 | 4 |
| C.是，客觀事實是不會因人而異的，無論誰觀察都會是同樣的答案。 | 0 | 1 | 2 | 3 | 4 |
| D.否，因爲學生已有的概念會左右他們觀察的結果。 | 0 | 1 | 2 | 3 | 4 |
| E.否，老師應該帶領學生討論觀察是如何受到先前知識所影響。 | 0 | 1 | 2 | 3 | 4 |

| **12. 學生應該瞭解科學知識可能會改變。** | | | | | |
|---|---|---|---|---|---|
| A.是，瞭解這才是科學的真正本質。 | 0 | 1 | 2 | 3 | 4 |
| B.是，瞭解這是科學會持續進步的原因。 | 0 | 1 | 2 | 3 | 4 |
| C.否，會減低學生學科學的興趣。 | 0 | 1 | 2 | 3 | 4 |
| D.否，會降低學生對科學的接受度。 | 0 | 1 | 2 | 3 | 4 |
| E.否，因爲學生只需要學習科學知識中不會變更的部分。 | 0 | 1 | 2 | 3 | 4 |

| **13. 國高中的自然科課程應探討假設（hypothesis）、理論（theory）和定律（law）的定義與關係。** | | | | | |
|---|---|---|---|---|---|
| A.是，因爲它們是科學知識的架構。 | 0 | 1 | 2 | 3 | 4 |
| B.是，因爲它們是科學探究的核心議題。 | 0 | 1 | 2 | 3 | 4 |
| C.否，知道其定義與關係對學習科學知識沒有太大益處。 | 0 | 1 | 2 | 3 | 4 |
| D.否，因爲假設、理論和定律缺乏明確定義。 | 0 | 1 | 2 | 3 | 4 |

Copyright (C) 2006 HKIEd APFSLT. Volume 7, Issue 2, Article 11 (Dec., 2006). All Rights Reserved.

## *III 科學中的主客觀性*

**請 閱讀下面兩個科學家的故事後作答。**

民國 105 年，甲與乙是同屬一個生物科技中心的教授，共同研究生物基因的篩選與轉植。如果這個計畫成功了，那麼人類將會擺脫先天的限制，除了可以完全預防遺 傳疾病之外，還可以自由的篩選與轉植好的基因，這樣人類世界將不再有先天性遺傳的缺陷。這個計畫已經進入了最後的階段。可是社會大眾開始有反對的聲浪，連 學校方面也有刪減計畫預算的打算。而其實甲自己也開始仔細思索計畫繼續的可能性。他是一個虔誠的基督徒，深信天父會為每個人找到不同的出口，所以儘管人在 出生之時就可能會有種種的疾病與不平等，但人類的多樣性與不可預測性卻是人類創造歷史的根源。他不認為科學的發展應該去改變人類作為一個人的核心條件，所 以覺得當社會文化與科學本質的信念相互衝突時，應該以社會文化作為選擇的依歸，因為科學的價值最終還是必須回歸到「人」。

但 乙不這麼認為。他認為科學的本質本來就是一種絕對客觀性，而社會文化的價值觀就像群眾的喜好一樣，會隨著社會環境的變動而變動，是一種極為主觀的價值展 現。換言之，今日社會文化價值棄之如敝屣的計畫，很可能到了明天卻轉變為眾所追求的價值。所以如果為了一種瞬息萬變的主觀價值去放棄恆常客觀的科學本質， 是非常不值得而且愚蠢的事。為了這件事，乙與甲開始爭吵。甲選擇退出計畫，但是乙則選擇繼續發展。退出計畫的甲，轉向研究植物的基因篩選與轉植，因為覺得 放棄已經發展的研究技術有些可惜，所以試圖選擇了社會文化價值普遍接受的研究方式。最後甲成功的將紅豆杉的抗癌基因轉植到小麥，創造了可以抗癌的小麥。回 首來時路，甲不後悔他當初退出計畫的抉擇，認為科學的本質也許是客觀的，但價值的展現還是必須回到最根本的「人」身上。

而 選擇繼續研究的乙，在動物活體研究成功之後，繼續作人體實驗。乙並不後悔他的選擇，反而更努力的繼續在研究上下功夫。因為乙深信這一個故事還未結束，整個 研究計畫的本質與價值只有在故事結束後才會展現出來。並且一個研究計畫的價值必須要留給歷史來判斷，而不是當代的社會文化價值。

Copyright (C) 2006 HKIEd APFSLT. Volume 7, Issue 2, Article 11 (Dec., 2006). All Rights Reserved.

| **14.從科學教育的觀點來看，我覺得這兩位科學家值得國高中學生學習的精神有哪些？** | 非常不同意 | 不同意 | 沒意見 | 同意 | 非常同意 |
|---|---|---|---|---|---|
| A.甲—瞭解科學家做事應該要憑良心。 | 0 | 1 | 2 | 3 | 4 |
| B.甲—可以兼顧科學研究與社會價值。 | 0 | 1 | 2 | 3 | 4 |
| C.甲—瞭解科學研究無法和社會文化價值完全區隔。 | 0 | 1 | 2 | 3 | 4 |
| D.甲—學習尊重人的多樣性。 | 0 | 1 | 2 | 3 | 4 |
| E.乙—瞭解科學研究應超然不受個人信仰的影響。 | 0 | 1 | 2 | 3 | 4 |
| F.乙—瞭解科學研究應超然不受社會主觀意識的影響。 | 0 | 1 | 2 | 3 | 4 |
| G.都不適合特別學習，因爲在自然課教學中不應該涉及價值選擇。 | 0 | 1 | 2 | 3 | 4 |

| **15.從科學精神的角度出發，我認同甲和乙的哪些地方？** | | | | | |
|---|---|---|---|---|---|
| A.甲—瞭解科學家做事應該要憑良心。 | 0 | 1 | 2 | 3 | 4 |
| B.甲—因爲可以兼顧科學研究與社會價值。 | 0 | 1 | 2 | 3 | 4 |
| C.甲—因爲科學研究無法和社會文化價值完全區隔。 | 0 | 1 | 2 | 3 | 4 |
| D.甲—因爲尊重人的多樣性。 | 0 | 1 | 2 | 3 | 4 |
| E.乙—因爲科學研究應超然不受個人信仰的影響。 | 0 | 1 | 2 | 3 | 4 |
| F.乙—因爲科學研究應超然不受社會主觀意識的影響。 | 0 | 1 | 2 | 3 | 4 |
| G.乙—因爲堅持科學的最高價值--追求真理。 | 0 | 1 | 2 | 3 | 4 |
| H.都很認同，因爲兩個人都很具科學精神，雖然都有受到自身主觀價值的影響。 | 0 | 1 | 2 | 3 | 4 |
| I.都不認同，兩個人都不夠客觀，都有受到自身主觀價值的影響。 | 0 | 1 | 2 | 3 | 4 |

Copyright (C) 2006 HKIEd APFSLT. Volume 7, Issue 2, Article 11 (Dec., 2006). All Rights Reserved.

# Views on Science and Education Questionnaire

## Instructions to participants:

Each question of this questionnaire starts with a statement about the nature of science or science education. Most statements adopt a certain radical stance. You may strongly agree with it, strongly disagree with it, or have other thoughts about it. Each statement is followed by several responses. Please read all of the responses first, then circle your opinion on the right side (SD, D, U, A, SA) of each response according to your knowledge of scientific activities or scientists, or what ought to be taught in science courses. There is no right or wrong answer. Thank you.

SD= Strongly Disagree

D = Disagree

U = Uncertain or No Comment

A = Agree

SA = Strongly Agree

| **1. When two different theories arise to explain the same phenomenon (e.g., fossils of dinosaurs), will scientists accept the two theories at the same time?** | | | | | |
|---|---|---|---|---|---|
| A. Yes, because scientists still cannot objectively tell which one is better; therefore, they will accept both tentatively. | SD | D | U | A | SA |
| B. Yes, because the two theories may provide explanations from different perspectives, there is no right or wrong. | SD | D | U | A | SA |
| C. No, because scientists tend to accept the theory they are more familiar with. | SD | D | U | A | SA |
| D. No, because scientists tend to accept the simpler theories and avoid complex theories. | SD | D | U | A | SA |
| E. No, the academic status of each theory proposer will influence scientists' acceptance of the theory. | SD | D | U | A | SA |
| F. No, scientists tend to accept new theories which deviate less from the contemporary core scientific theory. | SD | D | U | A | SA |
| G. No, scientists use intuition to make judgments. | SD | D | U | A | SA |
| H. No, because there is only one truth, scientists will not accept any theory before distinguishing which is best. | SD | D | U | A | SA |

Copyright (C) 2006 HKIEd APFSLT. Volume 7, Issue 2, Article 11 (Dec., 2006). All Rights Reserved.

| **2. Scientific investigations are influenced by socio-cultural values (e.g., current trends, values).** | |
|---|---|
| A. Yes, socio-cultural values influence the direction and topics of scientific investigations. | SD D U A SA |
| B. Yes, because scientists participating in scientific investigations are influenced by socio-cultural values. | SD D U A SA |
| C. No, scientists with good training will remain value-free when carrying out research. | SD D U A SA |
| D. No, because science requires objectivity, which is contrary to the subjective socio-cultural values. | SD D U A SA |

| **3. When scientists are conducting scientific research, will they use their imagination?** | |
|---|---|
| A. Yes, imagination is the main source of innovation. | SD D U A SA |
| B. Yes, scientists use their imagination more or less in scientific research. | SD D U A SA |
| C. No, imagination is not consistent with the logical principles of science. | SD D U A SA |
| D. No, imagination may become a means for a scientist to prove his point at all costs. | SD D U A SA |
| E. No, imagination lacks reliability. | SD D U A SA |

| **4. Even if the scientific investigations are carried out correctly, the theory proposed can still be disproved in the future.** | |
|---|---|
| A. Scientific research will face revolutionary change, and the old theory will be replaced. | SD D U A SA |
| B. Scientific advances cannot be made in a short time. It is through a cumulative process; therefore, the old theory is preserved. | SD D U A SA |
| C. With the accumulation of research data and information, the theory will evolve more accurately and completely, not being disproved. | SD D U A SA |

| **5. Is scientific theory (e.g., natural selection, atomic theory) "discovered" or "invented" by scientists from the natural world?** | |
|---|---|
| A. Discovered, because the idea was there all the time to be uncovered. | SD D U A SA |
| B. Discovered, because it is based on experimental **facts**. | SD D U A SA |
| C. Some scientists discover a theory accidentally, but other scientists may | SD D U A SA |

Copyright (C) 2006 HKIEd APFSLT. Volume 7, Issue 2, Article 11 (Dec., 2006). All Rights Reserved.

invent a theory from their known facts.

D. Invented, because a theory is an interpretation of experimental **facts**, and experimental facts are discovered by scientists. SD D U A SA

E. Invented, because a theory is created or worked out by scientists. SD D U A SA

F. Invented, because a theory can be disproved. SD D U A SA

**6. Is scientific law (e.g., gravitational law) "discovered" or "invented" by scientists from the natural world?**

A. Discovered, because scientific laws are out there in nature, and scientists just have to find them. SD D U A SA

B. Discovered, because scientific laws are based on **experimental facts**. SD D U A SA

C. Some scientists discover a law accidentally, but other scientists may invent a law from their known facts. SD D U A SA

D. Invented, because scientists invent scientific laws to interpret discovered experimental facts. SD D U A SA

E. Invented, since there are no absolutes in nature, therefore, the law is invented by scientists. SD D U A SA

**7. In comparison to laws, theories have less evidence to support them.**

A. Yes, theories are not as definite as laws. SD D U A SA

B. Yes, if a theory stands up to many tests it will eventually become a law, therefore, a law has more supporting evidence. SD D U A SA

C. Not quite, some theories have more supporting evidence than some laws. SD D U A SA

D. No, theories and laws are different types of ideas. They cannot be compared. SD D U A SA

**8. Scientists' observations are influenced by personal beliefs (e.g., personal experiences, presumptions); therefore, they may not make the same observations for the same experiment.**

A. Observations will be different, because different beliefs lead to different expectations influencing the observation. SD D U A SA

B. Observations will be the same, because the scientists trained in the same field hold similar ideas. SD D U A SA

C. Observations will be the same, because through scientific training scientists can abandon personal values to conduct objective observations. SD D U A SA

D. Observations will be the same, because observations are exactly what we see SD D U A SA

Copyright (C) 2006 HKIEd APFSLT. Volume 7, Issue 2, Article 11 (Dec., 2006). All Rights Reserved.

and nothing more. Facts are facts. Interpretations may be different from one person to another, but observations should be the same.

E. Observations will be the same. Although subjectivity cannot be completely avoided in observation, scientists use different methods to verify the results and improve objectivity. SD D U A SA

**9. Most scientists follow the universal scientific method, step-by-step, to do their research (i.e., state a hypothesis, design an experiment, collect data, and draw conclusions).**

A. The scientific method ensures valid, clear, logical and accurate results. Thus, most scientists follow the universal method in research. SD D U A SA

B. Most scientists use the scientific method because it is a logical procedure. SD D U A SA

C. The scientific method is useful in most instances, but it does not ensure results; therefore, scientists invent new methods. SD D U A SA

D. There is no so-called the scientific method. Scientists use any methods to obtain results. SD D U A SA

E. There is no fixed scientific method; scientific knowledge could be accidentally discovered. SD D U A SA

F. No matter how the results are obtained, scientists use the scientific method to verify it. SD D U A SA

**10. Students in junior and senior high schools should learn the procedure of the scientific method.**

A. Yes, so the students have guidelines to work within. SD D U A SA

B. Yes, because the students are still incapable of coming up with more appropriate methods. SD D U A SA

C. Yes, they should learn what scientists do. SD D U A SA

D. Yes, because the scientific method is the best method that scientists have developed so far. SD D U A SA

E. Yes, it helps the students to learn an objective way of studying science. SD D U A SA

F. Yes, it could help the students to understand the essence of science. SD D U A SA

G. No, we should not only teach one scientific method. Students should be given space to think and develop their own methods. SD D U A SA

H. No, there is no so-called the scientific method. SD D U A SA

I. No, the teachers and the students should brainstorm different research SD D U A SA

Copyright (C) 2006 HKIEd APFSLT. Volume 7, Issue 2, Article 11 (Dec., 2006). All Rights Reserved.

methods together.

**11. In junior and senior high school science classes, when students are observing the same event, the teacher should expect the students to come up with the same findings.**

| | | | | | |
|---|---|---|---|---|---|
| A. Yes, the teacher should advise students to carry out objective observations to get identical findings. | SD | D | U | A | SA |
| B. Yes, if the students are careful enough, they should arrive at the same findings. | SD | D | U | A | SA |
| C. Yes, experimental facts will not differ with the person, thus no matter who makes the observation, the result will always be the same. | SD | D | U | A | SA |
| D. No, the observation will be affected by the students' preconceptions. | SD | D | U | A | SA |
| E. No, the teacher should discuss with the students how observation can be affected by preconceptions. | SD | D | U | A | SA |

**12. Students should understand that scientific knowledge may change.**

| | | | | | |
|---|---|---|---|---|---|
| A. Yes, so they realize the real nature of science. | SD | D | U | A | SA |
| B. Yes, so they realize the reason why science advances. | SD | D | U | A | SA |
| C. No, it will decrease the students' interest in learning science. | SD | D | U | A | SA |
| D. No, it will decrease the students' acceptance of science. | SD | D | U | A | SA |
| E. No, the students only need to learn about the constant fundamentals of scientific knowledge. | SD | D | U | A | SA |

**13. The science course in high school should investigate the definitions of and the relationships between hypothesis, theory, and law.**

| | | | | | |
|---|---|---|---|---|---|
| A. Yes, because they represent the structure of scientific knowledge. | SD | D | U | A | SA |
| B. Yes, because they are the fundamentals of scientific inquiry. | SD | D | U | A | SA |
| C. No, knowing the definition of and relationships between these terms does not help much in learning scientific knowledge. | SD | D | U | A | SA |
| D. No, because hypothesis, theory, and law lack definite meaning. | SD | D | U | A | SA |

Please read carefully the following story about two scientists before answering the last two questions.

Copyright (C) 2006 HKIEd APFSLT. Volume 7, Issue 2, Article 11 (Dec., 2006). All Rights Reserved.

It is the year 2016. A and B are professors at a biotechnology center, and they are researching the selection and transfer of organic genes. If their project succeeds, humans will be free from congenital limitations. In addition to the total prevention of hereditary diseases, people will be free to choose and transfer eugenic genes. The human world will never again have congenital hereditary deficiencies. The research is already into the last step, but the general public opposes it, and even the institution itself has the intention of cutting back the budget. In fact A is already starting to question the continuation of the research. A is a devoted Christian, believing that God will open doors for everyone. Thus, even if people are born with various diseases and deficiencies, the diversity and unpredictability of humankind are what has created history. A doesn't believe that scientific development should change the core essence of a human being. Therefore, when socio-cultural values and beliefs of science are in conflict, choice should be made based on socio-cultural values because the ultimate values of science rely upon the "person" him/herself.

However, B doesn't think this way. B believes that the nature of science is absolutely objective, and that socio-cultural values are just like the public preference, always changing with the social environment, and are a very subjective representation of values. In other words, research that is rejected by today's socio-cultural values could become an aspiration of tomorrow. Therefore, it is unworthy and foolish to abandon the constant objective nature of science just for a fleeting subjective value. B and A start to fight over this matter. Finally, A chooses to withdraw from the research, but B chooses to continue developing it. Since giving up the well-developed research techniques would be very regrettable, A changes research interest to genetic selection and transfer of plants, in an attempt to choose a topic accepted by the dominant socio-cultural values. A eventually successfully transfers the anticancer genes from Taxus mairei to rye, creating anticancer rye. Looking back, A does not regret withdrawing from the project and believes that although the nature of science could be objective, the manifestation of the values should eventually return to the fundamental essence of "human beings."

B, persisting in continuing the original project, has received success on animal live-forms research, continuing on to do research on humans. B does not regret the choice either and even works harder on the project because of the belief that this story does not end here. The entire nature and value of the investigation will unfold in the

Copyright (C) 2006 HKIEd APFSLT. Volume 7, Issue 2, Article 11 (Dec., 2006). All Rights Reserved.

future. It is left for history, rather than the contemporary socio-cultural values, to judge.

| **14. From the perspective of science education, what can junior/senior high school students learn from these two scientists?** | |
|---|---|
| A. A—scientists should have a conscience when doing research. | SD D U A SA |
| B. A—consider both scientific research and social values simultaneously. | SD D U A SA |
| C. A—scientific research cannot be totally divorced from socio-cultural values. | SD D U A SA |
| D. A—respect the diversity of people. | SD D U A SA |
| E. B—scientific research should be completely detached from personal beliefs. | SD D U A SA |
| F. B—scientific research should be completely detached from social subjective values. | SD D U A SA |
| G. Neither of them provides a good example to learn from because science courses should not involve value-choices. | SD D U A SA |

| **15. From the perspective of the nature of science, what aspects of A and B's thinking do you agree with?** | |
|---|---|
| A. A—scientists should have a conscience when doing research. | SD D U A SA |
| B. A—consider both scientific research and social values simultaneously. | SD D U A SA |
| C. A—scientific research cannot be completely divorced from socio-cultural values. | SD D U A SA |
| D. A—respect diversity in human beings. | SD D U A SA |
| E. B—scientific research should be completely detached from personal belief. | SD D U A SA |
| F. B—scientific research should be completely detached from subjective values. | SD D U A SA |
| G. B—persisting with the highest value of science—pursuing the truth. | SD D U A SA |
| H. Both, since they both have scientific spirit though they are influenced by personal values. | SD D U A SA |
| I. Neither, neither are objective enough since they are influenced by their personal beliefs and values. | SD D U A SA |

Copyright (C) 2006 HKIEd APFSLT. Volume 7, Issue 2, Article 11 (Dec., 2006). All Rights Reserved.

# References

Aikenhead, G. S., & Ryan, A. (1992). The development of a new instrument: "Views on Science-Technology-Society" (VOSTS). *Science Education*, *76*, 477-491.

Chen, S. (2006). Development of an instrument to assess views on nature of science and attitudes toward teaching science. *Science Education*, 90, 803-819.

Erlandson, D. A., Harris, E. L., Skipper, B. L., & Allen, S. D. (1993). *Doing naturalistic inquiry: A guide to methods*. Newbury Park, CA: Sage.

Matthews, M. R. (1997). James T. Robinson's account of philosophy of science and science teaching: Some lessons for today from the 1960s. *Science Education, 81*, 295-315.

Rubba, P. A., Schoneweg Bradford, C., & Harkness, W. J. (1996). A new scoring procedure for the Views on Science-Technology-Society instrument. *International Journal of Science Education*, *18*, 387-400.

Solomon, J. (1995). Higher level understanding of the nature of science. *School Science Review*, *76*(276), 15-22.

Copyright (C) 2006 HKIEd APFSLT. Volume 7, Issue 2, Article 11 (Dec., 2006). All Rights Reserved.