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AUTHOR	Lee, Yew Jin; Izard, John; Yeoh, Oon Chye
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ABSTRACT

Whether poor knowledge of evolution among Singapore students might be linked to low levels of content knowledge about evolution among junior high school and senior high school teachers was studied. A teacher questionnaire on biological evolution was developed. Twelve teachers from Singapore junior college (JC) schools and 42 from the lower secondary schools completed the survey, which was judged to have acceptable reliability. Classical item analyses and Rasch item analyses were performed. Both JC and lower secondary teachers had a reasonably good grasp of the subject matter in evolution and ecology, with JC teachers having significantly better understanding of evolution than that of lower-level teachers. Even though teachers displayed a fairly good understanding of the subject matter, there were some alternative conceptions observed, especially among secondary teachers. Avoidance of some of these alternative conceptions should be emphasized in teacher training. (Contains 4 tables and 24 references.) (SLD)

Teacher Knowledge of Biological Evolution from the Perspectives of Classical Test and Item Response Theory

Lee, Y. J., , Izard, J., Yeoh, O. C.

Mr Lee Yew Jin,
Dr Yeoh Oon Chye,
School of Science,
National Institute of Education,
469 Bukit Timah Road
Singapore 259756

Prof John Izard
Australian Council for Educational Research,
Melbourne,
Australia.

This paper was prepared by Lee, Y. J., Izard, J and Yeoh, O. C. , with initial face-to-face discussions followed by e-mail communications. Any comments should be referred to the first author.

Introduction

Biological Evolution in General

If there can be one basic theme which gives Biology a unifying coherence, it has to be the theory of evolution as first espoused by Charles Darwin in 1859, and later refined by countless other scientists. Evolution provides a system of coherence that aids our understanding of the biological world; both by experiment and by theory.

Research on Teaching and Learning about Evolution

Contrary to expectation, research into teaching and learning about this major concept in biology has been sparse despite its centrality to science literacy (Cummins, Demastes & Hafner, 1994). Indeed, what little that has been conducted has largely been in exploring students' alternative frameworks or on teaching for conceptual change in the various sub-areas of evolution, for example in natural selection, competition and population dynamics (see Cummins, Demastes & Hafner, 1994; Demastes, Settlage & Good, 1995).

A widespread and seemingly promising research methodology in teaching evolution that was employed was the conceptual change strategy as advocated by Posner, Strike, Hewson and Gertzog (1982). Demastes, Good and Peebles (1995) have however lamented that "previous research indicates that conceptual change seldom occurs during instruction on evolution" (p. 639). It was seen that even teaching methods using the often researched conceptual change approach (confronting directly the learners' prior knowledge, usually inadequate or incomplete, with scientifically acceptable conceptions) leave a large proportion of learners with unchanged conceptual frameworks with respect to biological evolution (Demastes, Settlage & Good, 1995; Jensen & Finley, 1995). These findings seem to point to two conclusions, namely; a) students' scientific knowledge of evolution is generally very poor before teaching, and b) even after much effort during instruction using the conceptual change approach, the results are inconclusive one way or the other.

Teacher Knowledge - Pedagogical Content Knowledge & Subject Matter Knowledge

It is here that the familiar work of Shulman (1986; 1987) on the knowledge base of teachers might shed some light on the apparent inadequacy of the conceptual change approach in teaching biological evolution. He has clearly distinguished between pedagogical content knowledge (PCK) and subject matter or content knowledge. The former enables the teacher to have the appropriate and necessary skills or techniques to teach a particular topic with maximum effectiveness (such as facilitating students' construction of the structure of knowledge). PCK can be described as the "blending of content and pedagogy into an understanding of how particular topics, problems, or issues are organized, represented, and adapted to the diverse interests and abilities of the learners, and presented for instruction" (Shulman, 1987, p. 8).

Content knowledge has often been described as the personal knowledge of the subject by the teacher, the "amount and organization of knowledge *per se* in the mind of the teacher" (Shulman, 1986, p. 9). This proposition has implied that the subject teachers' expert content knowledge by itself is not a guarantee that one will be able to facilitate the students' comprehension and understanding of the conceptual knowledge.

Therefore, it is might be reasonable to assume that lack of real success in changing students' conceptions in evolution using conceptual change strategies is possibly due to deficient PCK in biological evolution. In other words, teachers might not have been adequately prepared in conceptual change teaching in biological evolution (Jiménez, 1994) which properly is a subset of PCK (Shulman, 1986, 1987).

Competence in content knowledge must however not be neglected. In fact, strong content knowledge is a pre-requisite, but not sufficient condition (Tamir, 1992) for conceptual change teaching. Hasweh (1987) stated that if teacher knowledge was not strong, student knowledge did not improve, and in some cases became worse! Other researchers have similarly emphasised the importance of strong content knowledge in effective science teaching and changing alternative conceptions (Tobin, Tippins & Gallard, 1994).

The Research Questions

It is an intriguing question whether poor knowledge of evolution among students as reported widely in the literature might be linked to low levels of content knowledge in this topic among teachers. Thus it was felt worthwhile to examine one major source of knowledge in Singapore high school (both junior and senior high) classrooms - the teachers of biology and science. More specifically, the levels of content knowledge they possessed regarding biological evolution. The research questions are conceived as follows, namely;

i) What are the levels of comprehension of local high school biology teachers with regards to their content knowledge on the topic of biological evolution?
ii) How do senior high teachers differ from junior high teachers regarding their comprehension about the major concepts of Darwinian evolution?
iii) What are the alternative conceptions, if any, among the teachers?

Literature Review

Research on Teacher Knowledge

Shulman (1986; 1987) has emphasised the importance of a 'body of knowledge' in teaching. Competence in these different aspects of knowledge of which content knowledge is one domain is deemed necessary for a teacher to be an effective agent of learning and change (Grossman, Wilson & Shulman, 1989). Content knowledge in a particular subject was seen as one aspect of the multitude of factors involved in teacher knowledge, albeit a very fundamental one.

Subject Matter Knowledge and Content Knowledge

According to Grossman (1990), content knowledge can be subsumed under what is termed as 'subject matter knowledge'(SMK). The more inclusive term 'subject matter knowledge' (which includes content, substantive and syntactic knowledge) would be used in this study as understood by Grossman (1990), Grossman, Wilson and Shulman (1989) and Hasweh (1987).

It is argued that SMK relates to teachers in three ways; a) in terms of PCK especially with reference to instructional decisions in classrooms, b) in the process of teaching in general, and c) in the existence of erroneous or inadequate conceptions held by teachers in that particular subject area.

Subject Matter Knowledge and Pedagogical Content Knowledge

Pedagogical content knowledge represents the ways in which a teacher structures or constructs the content (bearing in mind the contexts of the students, school and community) in order for learning to be achieved with greatest effectiveness. A teacher strong in PCK will be mindful of using the most powerful analogies, illustrations and examples in teaching while being aware of what makes learning easy or difficult for students (Shulman, 1986). In other words, PCK is the blending of SMK and general pedagogical knowledge by a teacher for instruction.

Pedagogical Content Knowledge and Instructional Decisions

Much attention has been given to how PCK is effected in terms of teachers' instructional decisions in the classrooms. Interesting data have surfaced showing that teachers with low SMK exhibiting certain behaviours including, namely: heavy dependence on textbooks; less demand of synthesis from students (Hasweh, 1987); more of students' individual activities; avoidance of whole class activities, preference for lecture style; generating less alternative meanings; avoidance of eye contact with students (Tobin, Tippins & Gallard, 1994). These and many other studies, have highlighted how the teacher's extent of SMK mastery would affect instructional decisions (which is in the domain of PCK), and ultimately the quality of learning.

Subject Matter Knowledge and Teaching

Shulman's (1987) model of pedagogical reasoning and action ('good' teaching) incorporated a cycle of comprehension, transformation, instruction, evaluation and reflection with an underlying deep knowledge of SMK. There are close relationships between these behaviours and thought processes in the model and the knowledge base of teaching (Grossman, Wilson & Shulman, 1989). Comprehension and transformation processes, for example, have direct correspondence to competency in SMK and PCK respectively. Instruction and evaluation processes in the cycle are also closely associated with PCK for no competent teacher performs instruction without checking for learning. What undergirds all these five processes of teaching is none other than SMK; in the provocative words of Shulman (1986), "those who can, do; those who understand, teach" (p. 14).

Consequences of Poor Subject Matter Knowledge

It is unfortunate that while the primacy of SMK is unquestioned, research has shown that school teachers often lack SMK (Hoz, Tomer & Tamir, 1990; Smith & Lloyd, 1995). Subsequently, poor SMK have led to errors and misconceptions and resultant alternative conceptions amongst teachers and students alike. With regard to errors and alternative conceptions in biological evolution in teachers, most of these are recent studies reported in the United States and are elaborated in the following section.

Alternative Conceptions in Evolution Among Teachers

In the United States, the educational concerns about evolution education in schools have been particularly complicated by numerous highly contentious issues. Most noticeably has been the religious groups who argue for divine creation as possessing equal scientific status with Darwinian evolution in biological science. Religious issues do not necessarily complicate evolution education elsewhere in countries besides the United States though lamentably poor knowledge of this topic was widely reported amongst teachers.

Some generalisations from the literature reported include;

a) prevalence of Lamarckianism in teachers' explanations ranging from a low frequency reported from (Jiménez, 1994) to 17% in the study of Greene (1990) to over 60% of answers from Arditzoglou and Crawley (1990) and Zuzovsky(1994)

b) presence of alternative frameworks in biology such as anthropocentrism (Bloom, 1989), poor understanding of fitness (Arditzoglou & Crawley, 1990), natural selection (Greene, 1990; Jiménez , 1994) and the nature of science (Bloom, 1989; Zuzovsky, 1994)

c) Darwinian evolution was emphasised more than biblical Creationism in classrooms (Shankar & Skoog, 1993; Tatina, 1989; Van Koevering & Stiehl, 1989) though Creationism was still being taught mainly on the principle of fairness (Shankar & Skoog, 1993) in the United States.

This study then provides a guide to assess the levels of SMK in the conceptually difficult topic of biological evolution amongst Singapore high school biology teachers. Clarification in this respect will have implications for a) how best to facilitate the teachers' mastery of PCK in the teaching of Darwinian evolution in high schools, and b) promoting greater meaningful understanding in the teaching of evolution in biological science in schools and subsequent decisions on teacher education and re-education.

Method

The Sample of Biology Teachers and Schools

The intended population of practising biology teachers to be sampled was 70 teachers from a total of 52 high schools across grades 9 to 12. A stratified random sample of 56 schools from the three types (government, government-aided and independent) of junior high or secondary schools was selected from the entire list of 149 secondary schools in Singapore. All 14 senior high or junior colleges/JC (students in grades 11 to 12) in Singapore were surveyed. These institutions were either government or government-aided.

Instrumentation

A three-part biology teacher questionnaire for SMK in biological evolution was developed. Part A consisted of 36, five option multiple-choice-questions (MCQ) on evolution and ecology. This was based largely on assessment questions from the Cambridge GCE O and A level biology examinations. This combination of questions from both O and A level syllabi tested many basic concepts in evolution and ecology, for example natural selection, mutation, speciation, reproduction, trophic levels, food webs, energy levels, populations etc. Twelve items were on ecology with 25 on evolution, and both types of questions were randomly mixed in the first part of the questionnaire. Part A was unspeeded in order to discourage guessing behaviour and was also to be completed in one continuous session.

Part B gathered background information on the teachers, for example age, gender, teaching duties and academic qualifications. Anonymity of individuals' names and schools was guaranteed and emphasised to respondents although for data collection purposes, Ministry of Education had requested respondents to indicate their schools with the endorsement of the Principal.

Data Collection

One practising biology teacher from each secondary school was requested to complete the questionnaire while in the colleges, at least two biology teachers were asked to respond. A final total of 54 (12 from JC or junior college and 42 from secondary teachers) completed survey forms were returned after five months. These returns were from 7 colleges (out of maximum of 14) and 38 (out of 42 sampled) secondary schools. There was no distinguishable bias in the data from the late responding sample; the means of response data and demographic variables did not differ significantly from the early respondents.

Data Analysis

This unspeeded first section of the questionnaire was designed for completion in one continuous session, and the elapsed time recorded by the respondent. One mark was awarded for a correct choice among the 5-option MCQ items and there was no penalty for the wrong answer or for guessing. All items which had no response were regarded as an incorrect answer. Section B gathered background information from the respondents; there was no right or wrong answers here.

Analyses of the Multiple Choice Achievement Test

For the multiple choice achievement test, classical item analysis was performed by using the ITEMAN™ version 3.50 computer programme. Descriptive statistics together with parametric and non-parametric tests were run using WINKS™ version 4.21 software. The QUEST version 2.0 computer programme (Adams and Khoo, 1996) was utilised in item response theory (IRT) analysis.

Results and Discussion

Achievement Test of Darwinian Evolution

The 36 item test of 24 evolution and 12 ecology questions had achieved a satisfactory alpha reliability index of 0.77 despite the small sample size of 52 respondents and the fewer number of test items on ecology. Test completion took an average of 28.2 minutes (SD=13.5 minutes) with no significant difference between JC and secondary teachers. One respondent completed it in 10 minutes only while the slowest took a total of 65 minutes. The FI ranged from 0.15 to 0.98 while DI from 0.06 to 0.76. Question 1 was correctly answered by all teachers and thus had an FI of 1 and DI of 0. The point-biserial ranged from 0.11 to 0.60 with mean at 0.47.

Rasch analysis of items(M=0.0 logits, SD=1.23 logits) showed also that items had a wide spread in terms of difficulty from 3.05 to -3.10 logits. There were no items mis-fitting the Rasch model except for Question 1 which QUEST could not calculate as it had achieved a perfect scoring.

The Three Research Questions

1) What are the levels of comprehension of high school biology teachers with regards to their SMK on the topic of biological evolution?

The average score for the entire sample over all 36 items was 25.0 (69.6%) with a standard deviation of 4.9 ; lowest score was 15 and the highest 34. Generally the teachers have performed well; the average score for JC teachers was 79.4% and secondary teachers was 66.6%.

The range of logits for JC teachers was from 3.53 to 0.33 and for secondary teachers from 3.01 to -0.56. The ability scores from the entire sample ranged from -0.56 to 3.53 logits (M= 1.12, SD= 0.97) which means that the teachers' average ability levels were higher that the difficulty of many of the items. Consequently, the standard errors associated with the cases ranged mainly from 0.3 to 0.4 as there were not so many difficult items for more precise calibration of the high ability cases. This relatively high ability level of our teacher sample was somewhat unexpected given the extreme difficulty of biological evolution reported in the literature. There were eight mis-fitting cases (nos. 6, 19, 20, 38, 42, 44, 50 and 51) due to their outlying INFIT MNSQ (Adams & Khoo, 1996). However, these were not extreme values and did not adversely affect analysis.

2) Would JC teachers have better understanding than secondary teachers regarding the topic of biological evolution?

A t-test to compare the mean total scores for JC (M=79.4% or 1.86 logits, SD=1.0) and secondary teachers (M=66.6% or 0.89 logits, SD=0.9) was significantly higher at $p<0.005$ level for JC teachers. Table 1 shows the item/case map of the two sub-populations of teachers together with the items on evolution and ecology on the logit scale. Similarly, JC teacher scores over the sub-section of evolution (Table 2) was significantly higher ($p<0.001$) but not with regard to ecology. The evidence suggests that JC biology teachers have a much better understanding than secondary teachers with regard to evolution.

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                  CASES                              ITEMS
         Secondary      College         Evolution               Ecology
  4.0                             |
                                  |
                                  |
                          X       |
                                  |
                                  |
                                  |
  3.0        X            X       |     7      18
                                  |
                                  |
                          X       |
                                  |
             XXX          X       |
                                  |
  2.0        XX           XXXX    |
             XXX                  |     6
                                  |
             XX                   |     24
             XX                   |     16     30
                                  |
             XX           X       |
  1.0        XXXX                 |     20  21  23
             X                    |                              22
             XXXXXX               |                              36
             X                    |
             XXX          XX      |     11                       26
             XXXX                 |
  0.0        X                    |                              8
             XX           X       |     5   10   15    25        33
             XX                   |
                                  |     14
             X                    |     13                       27
                                  |                              34     35
                                  |     4   31                   32
 -1.0                             |     9   19   28    29
                                  |
                                  |     3                        2
                                  |
                                  |
                                  |
                                  |
 -2.0                             |                              17
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                                  |
                                  |
 -3.0                             |
                                  |     12
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                                  |
                                  |
                                  |
 -4.0                             |
--------------------------------------------------------------------------------
  Each X represents    1 Teacher
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Table 1. QUEST data output of the Item/Case map.

	Population			
Scores	Entire sample (n=52)	JC teachers only (n=12)	Secondary teachers only (n=40)	t- scores
Evolution items (n=24)				
Mean	15.7	18.9	14.7	-3.7****
SD	3.8	3.1	3.5	
Mean (in %)	65.3	78.8	61.3	
Ecology items (n=12)				
Mean	9.4	9.7	9.3	-0.7
SD	1.7	1.8	1.6	
Mean (in %)	78.0	80.6	77.3	

Table 2. Mean scores of the samples over the two sub-sections in raw scores and percentages.
**** $p<0.001$

Table 3 shows the answering pattern with regard to scoring on both sections of ecology and evolution by the three highest and lowest scoring teachers respectively. Harder Not Achieved (HNA) shows MCQ items which were of higher difficulty than the ability of the individual and answered incorrectly while Easier Not Achieved (ENA) shows questions of lower difficulty than the ability level of the person but still answered wrongly. These items which are highlighted in the table are those at least one standard error away from the ability of the case reflected in their KIDMAPs. The data suggests that lower ability persons were having more difficulty with questions on evolution than on ecology since the majority of HNA questions were evolution questions. Ecology questions did not seem to pose too great a challenge to our teachers. Ecology questions in the ENA section were probably due to carelessness on the teachers' part; these cases did not exhibit guessing behaviour in their KIDMAPs nor did they deviate significantly from the Rasch model.

Case Number	Ability in Logits	Sub-Population	Question Numbers & Type: HNA	Question Numbers & Type: ENA
34	3.53	JC	-	35c
35	3.01	JC	-	26c,35c
50	3.01	Secondary	-	22c
47	-0.56	Secondary	7v,11v,16v,18v,20v, 21v,23v,24v,30v	3v,17c,19v,28v
45	-0.27	Secondary	6v,7v,16v,18v,20v,21v,22 c,24v,26c,30v	2c,28v
15	-0.27	Secondary	6v,7v,16v,18v,20v,21v,22 v,23v,24v,30v,36c	19v,28v,32c

Table 3. Item response pattern of three highest and lowest scoring cases.
Note. HNA= Harder Not achieved; ENA= Easier Not Achieved; c= ecology question; v= evolution question

3) What are the alternative conceptions, if any, among the teachers?

Some concepts in evolution had proved difficult for the teachers, namely; the theory of evolution on general, definition of species, the process of speciation, fitness and natural selection. Two questions on the theory of evolution in general will be used to demonstrate how IRT can help elucidate alternative conceptions.

Question 18 offered a glimpse into some aspects of teacher belief in evolution. Fifteen percent of all teachers adopted a [1]nominalist view in option 'b'. It is interesting to note that a [2]positivistic view (option 'a') was adopted by 35% and 42% of secondary and JC teachers respectively. This is still much lower than the 86% of Texan high school teachers which responded that "there is much scientific evidence that indicates evolution has occurred" (Shankar & Skoog, 1993). In South Dakota, almost 73% of high school teachers claimed to believe in evolution and 75% thought it had a scientific basis (Tatina, 1989).

Q18. Do you think that the modern theory of evolution has a valid scientific foundation?
a. yes, because it is possible to test many predictions of evolutionary science
b. yes, even though we can never test many predictions in the past*
c. no, because we can never be sure about the past
d. no, because evolutionary science is principally based on speculation and not 'hard' scientific fact
e. no (for other reasons) Note. *=key

Item 18			Infit MNSQ = 1.13		Disc = 0.22	
Categories	0	a	b*	c	d	e
Count	2	19	8	1	12	10
Percent (%)	3.8	36.5	15	1.9	23.1	19.2
Pt-Biserial	-0.1	-0.02	0.22	-0.14	-0.17	0.10
p-value	.235	.439	.05	.157	.114	.231
Mean Ability	0.58	1.11	1.61	0.18	0.8	1.29
Step Labels	1	Thresholds 3.05		Error	0.41	

Table 4. Part of ITANAL data output for Q18 for whole sample.

The ITANAL output (Table 4) for this question showed that although only eight teachers chose option 'b', their mean ability in logits was 1.61 which is higher (thus implying competency in SMK) than the most popular option 'a' which had mean ability value of 1.11 logits. The point-biserial was only 0.22 ($p<0.05$) which meant that there was little correlation between answering this question correctly and the total scores in the test. This was felt to be understandable as the question had an element of subjective belief in it.

More seriously, a quarter of all local teachers felt that evolution was based on speculation (option 'd') and did not have a valid scientific foundation while 19% felt it had no scientific foundation for other reasons (option 'e'). Intriguingly, the 10 teachers who chose option 'e' had a high mean ability value of 1.29 logits and two of which had a level of 2.29 logits. The effect of belief on teaching evolution has not been conclusively settled yet (Bloom, 1989; Demastes, Settlage & Good, 1995; Van Koevering & Stiehl, 1989). Indeed, the issue is complex; Jackson, et. al. (1995) have demonstrated that personal beliefs, especially amongst strongly religious people were resistant to change despite increase in knowledge of biological evolution.

Q7. Which of the following best agrees with your impression of the modern theory of evolution?
a. The phrase "survival of the fittest"
b. Man evolved either from the gorilla or chimpanzee in Africa
c. Evolution occurred because the strong eventually eliminated the weak
d. Evolution occurred because different individuals left different numbers of offspring*
e. Evolution involved a purposeful striving toward higher forms(ie steady progress from microbes to man)

[1] A post-positivistic philosophy which understands that science can never be value-free and it is possible to acquire knowledge about phenomena other than by the empirical method, not directly observable by the senses.
[2] Among other things, positivism assumes that all knowledge claims must be able to be subjected to empirical, value-free observations else it does not have any objective reality.

Correspondingly, 75% of them associated the phrase 'survival of the fittest' closest with the theory of evolution in question 7, the hardest question (3.05 logits) in the test besides question 18 (see Table 1). Tatina (1989) argues that this response leads to a tautology unless 'fit' is equated with differential reproduction; most high school teachers (37%) in South Dakota had similarly associated 'survival of the fittest' with evolution. Also, only 3% of our secondary teachers answered this question correctly, and 7.1% (lowest amongst the options) of teachers in Dakota got it correct. Creationism based on the Christian bible is pervasive in Dakota; about 27% of teachers described evolution as 'purposeful striving' in contrast to our 15% and 17% in secondary and JC teachers respectively. The mean ability of 2.26 logits for the answer made it the highest in the entire test. There were only eight teachers, five of which were of very high ability that answered this correctly. Teacher number 42 also answered this question correctly although he/she had a low mean ability level. Using the KIDMAP function to analyse the pattern of responses, it was discovered that this 'misfitting' case probably exhibited guessing behaviour and thus obtained a correct answer.

Conclusions & Implications

The results have shown that the JC and secondary teachers have a reasonably good grasp of SMK in evolution and ecology. The ability scores from a total of 52 teachers ranged from -0.56 to 3.53 logits (M= 1.12 logits, SD= 0.97); that of JC teachers from 3.53 to 0.33 (M=79.4% or 1.86 logits, SD=1.0), and for secondary teachers from 3.01 to -0.56 (M=66.6% or 0.89 logits, SD=0.9). Teachers have managed to obtain an average score of 69.6% for the MCQ as a whole and 65.3% for items only on evolution and 78.0% for items on ecology respectively. JC teachers had a significantly better grasp of content than secondary teachers over the test as a whole ($p<0.005$) and over the sub-section of evolution ($p<0.001$). There was no significant difference with regard to the section on ecology. It is to be noted that the sample had only 52 teachers participating in the survey; conclusions based on this research have to take this into consideration.

The research findings has some implications for teacher professional development in the following areas;

Teacher Education

Since competency in SMK is the *sine qua non* in building the knowledge base of any teacher, some researchers have made a strong appeal to increase the emphasis on SMK during teacher training over instruction in other areas like pedagogy or classroom management techniques (Grossman, Wilson & Shulman, 1989; Shulman, 1986; 1987). Prospective teachers should be given time to reflect, learn or even to relearn content areas in greater depth.

The urgency to place emphasis on improving SMK, especially in the area of biological evolution, is exacerbated by the reported low emphasis and coverage of evolution experienced by teachers during their past education. It is felt that if the instruction received during college or university education was biased or inadequate in terms of poor SMK, then it would be understandable that teachers maintain alternative conceptions that are inappropriate. This might further lead to the perpetuation of these errors amongst students if this issue is not addressed.

A necessary and related emphasis would to include instruction in PCK and create awareness of its importance in biology teaching. Time and opportunity should be given to teacher trainees to try to integrate and transform their SMK, with the pedagogical skills they are being taught at the same time, into effective teaching of biological evolution.

These 36 items on evolution and ecology from the achievement test have each been standardised on the logit scale using the Rasch model in IRT. They are thus suitable for future item banking and test construction for assessment of SMK in these areas among teachers. The standardised items from this study are also suitable for computer adaptive testing in the field of evolution knowledge.

Teacher Re-education

Granted that the teachers' ability scores in this present study displayed a fairly good comprehension of SMK in biological evolution, there were some alternative conceptions observed, especially among secondary school teachers. During teacher training or even during in-service courses to practising teachers, instruction in avoiding some of these alternative conceptions could be emphasised (Tatina, 1989).

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