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From a Vicious Circle of Anxiety to a Virtuous Circle of Learning: Experience of Teaching Statistics to a Heterogeneous Clientele

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Abstract: A considerable body of literature suggests that significant psychological barrier and anxiety characterize the teaching and learning process in statistics. This study investigates the incidence of statistics anxiety, the extent to which it can be overcome and the factors that contribute to the process of overcoming it. Self-study and overall teaching quality, amongst others, significantly contributed to this outcome. This study identifies factors contributing to overall teaching quality. The teaching and learning process typified a highly effective communication mechanism based on an appropriate diagnosis of individual needs. This cumulative change resulted from circular causation. It is argued that given appropriate conditions the vicious circle of anxiety can be transformed into a virtuous circle of learning.

Key words: Statistics Anxiety, Problem-Based Learning, Cumulative Change, Circular Causation

INTRODUCTION

Many students regard courses in statistics, or for that matter, courses of quantitative nature as somewhat akin to a 'foreign language'. The available literature provides ample evidence of prevalence of 'statistics anxiety' among students [1, 2, 3, 4, 5 , 6 and 7]. [3] states that the proportion of graduate students experiencing 'uncomfortable levels of statistics anxiety could range between two thirds and four fifths. At its worst statistics anxiety could be so high that students often delay enrolling in statistics type courses for as long as possible sometimes leaving until the last semester of their degree program' [1, 2].

In the context of teaching statistics in sociology progammes, [8] argue that 'statistics is perhaps the most anxiety-provoking course in any sociology department's curriculum. … This anxiety often leads to a less than optimum learning environment'. [9] suggests that statistics anxiety may in part stem from mathematics anxiety which may quite often lead the students to try to memorise every step of a statistical procedure rather than gaining an understanding of the underlying principle.

[10] provide a similar characterization of statistics anxiety that manifests itself in feelings of anxiety, dread nervousness and associated bodily symptoms similar to those related to doing mathematics [11].

In contrast to the above view of a seemingly positive association between mathematics and statistics anxiety, [12] argue that the two are not the same. A similar view is expressed by [1].

According to [4] '*statistics anxiety* refers to the apprehension that occurs as a result of encountering statistics in any form at any level'. The existing literature also identifies situation-specific nature of statistics anxiety [1, 7] ranging in intensity from mild to severe. While the mild form of statistics anxiety may 'induce only minor discomfort', 'severe forms can result in nervousness, panic and worry. Statistics anxiety may be a critical factor in influencing and attaining a student's academic and vocational goals' [4]. A large body of empirical research to-date has documented a strong and consistent negative association between statistics anxiety on the one hand and academic performance on the other [7, 8, 11, 13 and 14]. However, it can be argued that statistics anxiety is not necessarily a demotivating factor resulting in lower achievements. Conceivably, the relationship could be inverted U-shaped with too little and too much anxiety resulting in poor performance.

MATERIALS AND METHODS

Hypotheses: The preceding argument and our own experience of teaching and learning statistics at the university level, leads us to believe that statistics anxiety is not insurmountable. Rather it is proposed that:

* Students' level of statistical anxiety is dependent upon students' self-study habits
* Students' level of statistical anxiety is predicted by overall teaching quality.
* There is a significant interaction between students' study habits, and teaching quality which differentially impact on statistical anxiety.

Moreover, it is proposed that overall teaching quality is a function of a multitude of factors including feedback; learning environment characterized by lecturer's willingness to help and his/her accessibility to students, regularity of consultation with the lecturer. This study argues that in an environment, which is conducive to learning, students, can significantly overcome statistics anxiety. Fig. 1 presents a conceptual model encapsulating the process of overcoming statistics anxiety.

The Data: The data for this study were derived from primary surveys in Statistics for Business Economics course at an Australian university (the two semesters in 2001 and the First Semester in 2002). The information gathering process primarily consisted of the questionnaire method, supplemented by participation and observation method, and small group-cum-individual discussion method. In all, 163 students participated in the survey of whom 116 students indicated that suffered from statistics anxiety. Data were collected on each of the following:

* Students' initial anxiety (the incidence of statistics anxiety to start with): if the student suffered from any statistics anxiety/psychological barrier about statistics being 'hard and dry' (categorical: yes, no).
* Students' outcome: The incidence of overcoming statistics anxiety at the end of the semester: If the student overcame statistics anxiety (categorical: yes, no). Data about the degree to which statistics anxiety was overcome [ordinal score (1-5): 1-2: did not overcome at all; 3: moderately overcame; 4-5: significantly overcame)] were also collected.
* Mediating factors: self-study habits, teaching quality, accessibility to lecturer, lecturer's willingness to help, lecturer's feedback, classroom environment and discussion with peers. The extent to which these factors helped the students overcome statistics anxiety was measured on a 5 point scale. Low scores (1 and 2) implied that a particular factor did not contribute significantly to overcoming statistics anxiety, while a score in the 4-5 range implied that it made a significant contribution.

Course Profile and the Student Clientele: The introductory postgraduate course which presupposes no prior training in statistics is designed to provide a solid understanding of the basic quantitative concepts used in economics, business and finance and as a foundation to higher-level quantitative courses in economics. The student clientele is very heterogeneous typified by preponderance of students enrolled in non-economics programs and those with non-English speaking background (NESB). Less than twenty per cent of the students graduate to higher-level quantitative courses in economics.

Instruction Strategies, Initiatives and Methods: The instruction in this course employed a combination of techniques focusing on problem-based learning. Essentially the course employed a combination of lecture-based learning and problem-based learning (LBL-PBL) modes. Instruction strategies consisted of the following components:

a. **Lectures:** A two-hour lecture per week introduced the theoretical underpinnings of techniques and their applications to the problem solving [15].

b. **Tutorials:** Lectures were complemented by a one hour tutorial per week using a problem-solving approach [16] involving a process of highly interactive learning.

c. **The semester project:** The primary goal of the project was to test students' ability to think about a real word issue and their ability to apply the analytical tools of statistics to real world problems and developing the ability to work independently. The project revolves around regression analysis. The tasks embodied in the project constituted three discernible components: (a) descriptive statistics**;** (b) basic regression analysis involving estimation of correlation coefficient and linear regression equation, and their interpretation in terms of overall statistical quality of the estimates; hypothesis testing involving t and F statistics and (c) extension of basic regression analysis to multiple regression; forecasting/prediction; the underlying assumptions and the consequences of their violations

Presentation and Delivery of Course Materials and Related Issues: The presentation and delivery of course materials centred on overhead transparencies, extensive use of black/white board and distribution of hard copies of lecture notes. Materials were also posted on the website. The teaching and learning process underscored the critical importance of adequate feedback on written work in two distinct phases:

Phase 1: Almost immediately after the mid-semester test results were published, the lecturer invited each and every student to go through his/her exam regardless of the score. This process was intended to identify the

strengths and weaknesses of each student and the potential sources of errors.

The mid-semester test represented a useful learning experience for the low-scoring students. It was made unambiguously clear that students with lower scores in mid-semester often perform appreciably better in subsequent tests. It was also discovered the low scores were attributable to: (a) minor mistakes scattered throughout the answers, (b) getting used to the statistics environment and (c) acclimatisation of bulk of the students with English language difficulty to the foreign educational environment.

Phase 2: Upon completion of marking the statistics project (toward the end of the instruction period) every student was invited to discuss his/her project regardless of the score. Potential sources of conceptual or computational errors were identified and the importance of theoretical soundness is highlighted.

Overseas Students: The high incidence of NESB students poses a special problem of its own in that they have different needs which require to be handled differently [17, 18]. Because of the 'special situation of overseas students trying to cope with an alien culture, society and environment as well as a new academic world, does mean that some small adjustments are necessary to the traditional boundaries of a teacher's responsibilities' [18]. Consider the two statements [18].

* 'They chose to come here, so they've got to learn to cope, to make their own way with our system. It is not *my* responsibility to look after them. I just teach them'. (*Engineering lecturer*).
* 'I look forward to being your student. Although it is my first time to leave my country and my beloved family, I know you will be my father and the university will be my family'. (letter from a prospective Chinese postgraduate student to her supervisor).

In the above example, the overseas and non-English speaking background (NESB) student might be a bit lost if the lecturer takes the typical view embodied in the first of the two statements above statement. This might be called the *classroom view*. On the other hand, the student expected something more than the typical *classroom view* as embodied in the second statement. To an overseas student, the Engineering lecturer's view, if it was typical of the lecturing community, might seem to be an arms' length approach which can potentially make the student feel alienated and isolated. In this situation the student might find the learning environment to be less hospitable than he/she expected. Where cultural contexts differ, both the lecturer and the student can potentially suffer from communication gap without either side being aware of. Consider the two situational contexts embodied in the two statements [18]:

* 'Have I got the point across? How can I be sure if they understand if all the feedback I get is a polite smile?' (Maths lecturer).
* 'One major problem is that tutors/lecturers assume that we are well versed in Aussie culture/literature/history/politics. And that we can follow their quick speech. This gives a big disadvantage to us the overseas students' (Hong Kong Commerce student).

The first statement typifies the predicament of the teacher not knowing whether he/she was able to communicate the message up to the expectation of the student. The second statement typifies a situation where the lecturer is unaware of the disadvantages that the overseas student faces in the teaching and learning process. This generates a process of communication gap.

The present study underscores the critical importance of the lecturer taking a more proactive role in creating an environment in which the students can feel comfortable in communicating their strengths and weaknesses of the instruction process to the lecturer with a view to reducing asymmetry of expectation and asymmetry of communication. The teaching and learning environment in the present study took three factors into account: (a) the teaching practices in students' countries of origin. (b) teaching practices in the students' current degree program (e.g. commerce), and (c) the special features/peculiarities of statistics as a discipline itself. One could add two more challenges e.g. teaching students who (a) suffer from statistics anxiety (acute or chronic) and (b) are extremely intellectually demanding.

RESULTS AND DISCUSSION

Overall Outcome: Students' perception of overcoming statistics anxiety is summarized in Table 1. There was only a very small fraction (less than 10 per cent) of the students expressed a perception of not overcoming statistics anxiety. In Semester 2, 2001 the top end of the scale displays a concentration below the 50 per cent mark which contrasts with the pictures of the two other semesters. On the whole, however, more than 55 per cent of the students in the sample (three semesters combined) perceived that they had significantly overcome statistics anxiety while 37 per cent moderately overcame it. The overall median score of 4 seems to indicate that the average student had overcome the perceived statistics anxiety.

Table 1: Percentage Distribution of Student Perception of the Extent to which Statistics Anxiety was Overcome

Semester	Relative frequency of rating (on a 5 point scale) (percentage)			Median score
	1-2 range	3	4-5 range	
Semester 1, 2001 (31)*	6.5	32.3	61.3	4
Semester 2, 2001 (35)*	8.6	45.7	45.7	3
Semester 1, 2002 (50)*	8.0	34.0	58.0	4
Total (116)*	7.8	37.1	55.1	4

Notes: *Number of students who expressed a perception statistics anxiety. A score in the 1-2 range means that the student did not overcome statistics anxiety at all. A score of 3 means that the student moderately overcome statistics anxiety while a score in the 4-5 range implies that the student significantly overcome statistics anxiety.

Table 2: Factors Contributing to the Perception of Overcoming Statistics Anxiety

Factor	Relative frequency of rating (on a 5 point scale) (percentage)			Median score
	1-2 range	3	4-5 range	All Semesters Combined
Self study	4.2	14.3	81.5	4
Teaching Quality	3.3	11.6	85.1	4
Accessibility to lecturer	11.7	17.5	70.8	4
Lecturer's willingness to help	5.8	14.0	80.2	4
Lecturer's feedback	5.0	18.5	76.5	4
Overall learning environment	15.8	28.3	55.8	4
Discussion with peers	27.3	16.5	56.2	4

Notes: A score in the range 1-2 implies that the factor is not perceived to be important at all. A score of 3 implies that the factor is perceived to be moderately important while a score in the 4-5 range means that the factor is perceived to be very important.

Table 3: Test of Equality of Group Means, Standardised Canonical Discriminant Function Coefficients and Structure Matrix

Factor	Wilks' λ	Coefficient	Structure matrix[a]
Self study	0.892**	0.572*	0.679*
Teaching quality	0.904**	0.516*	0.638*
Regularity in consultation	0.940**	0.322*	0.493*
Lecturers feedback	0.944*	0.300**	0.477*
Lecturer's willingness to help	0.949*	0.228**	0.456*
Accessibility to lecturer	0.986	-0.488	0.234
Classroom environment	0.986	0.002	0.234
Discussion with peers	0.999	-0.157	0.058

NB: df (1,110)
** Significant at p<0.01; * Significant at p<0.05
[a] Pooled within-groups correlations between grouping variables discriminating variables and Standardized canonical discriminant functions. Variables are ordered by absolute size of correlation within function

Table 4: Fisher's Linear Discriminant Function: Classification Function Coefficients

Factor	Coefficients of the dichotomous variables	
	Did not substantially overcome statistics anxiety (coded 0)	Substantially overcame statistics anxiety (coded 1)
Self study	4.923	5.641
Teaching quality	4.374	5.048
Lecturer's willingness to help	1.659	1.909
Lecturer's feedback	1.163	1.497
Regularity in consultation	0.368	0.686
Discussion with peers	0.952	0.828
Classroom environment	-0.008	-0.006
Accessibility to lecturer	-0.683	-1.147
Constant	-25.079	-31.695

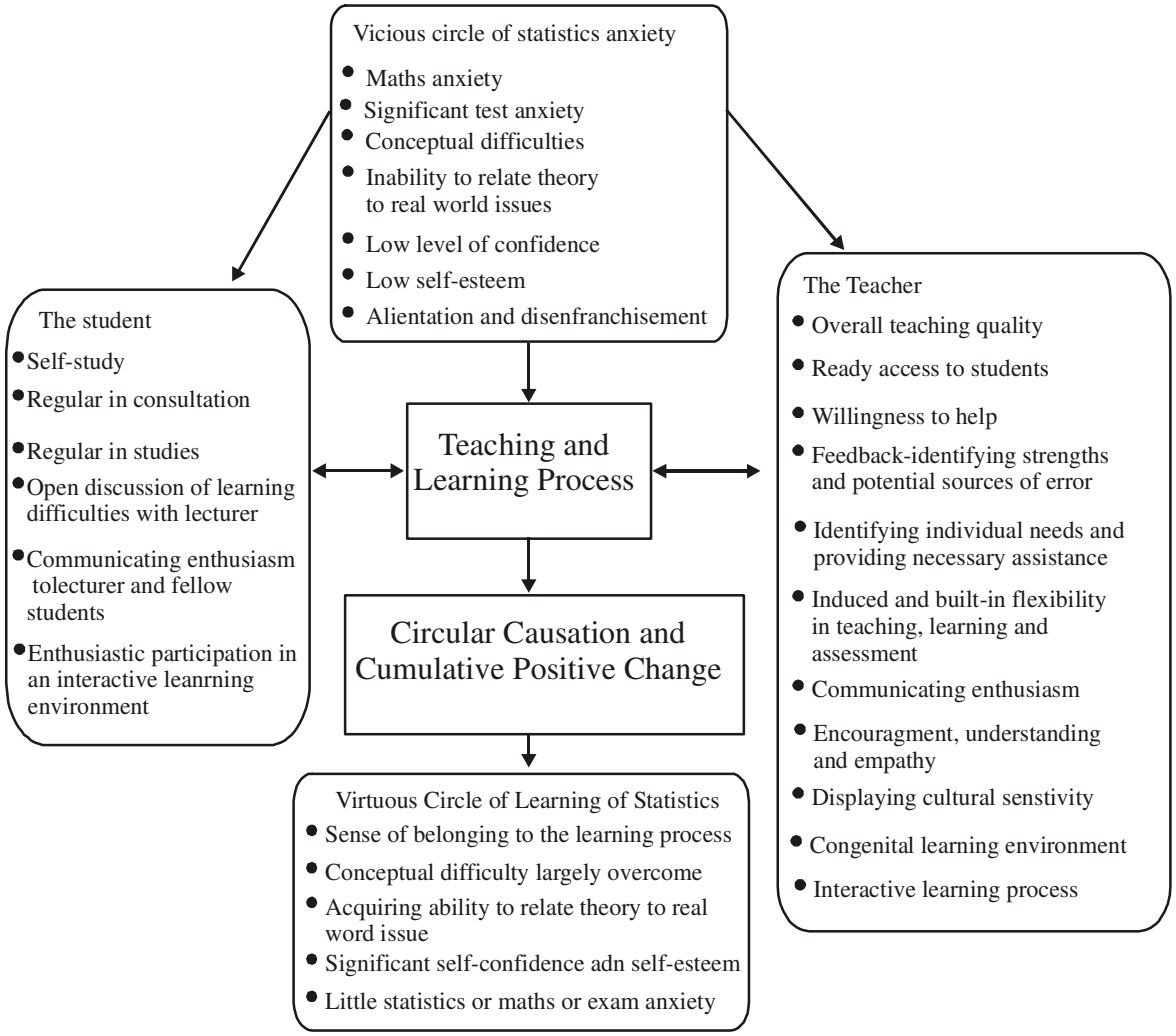

Fig. 1: From a Vicious Circle to a Virtuous Circle: A Conceptual Model of Overcoming Statistics Anxiety

Identifying the Factors Underlying the Overall Outcome: It is reasonable to assume that a multitude of factors rather than any single factor underlie the process of overcoming statistics anxiety. One could posit a positive association between the student perception of factors such as self-study (time and effort that students expend), teaching quality, ready accessibility to the lecturer, lecturer's willingness to help, lecturer's feedback, overall teaching and learning environment, and discussion with peers on the one hand and the student perception of overcoming statistics anxiety on the other.

Table 2 sets out distribution of student perception scores of various Factors. The results presented in Table 2 suggest that all the factors were perceived to have made a positive contribution toward overcoming statistics anxiety in all the semesters.

Multivariate Analysis: A discriminant analysis was conducted to investigate the constellation of factors which best predicted student's propensity to overcome statistics anxiety. Students were grouped into two groups according to their scores on the statistics anxiety scale: students who did not perceive to have markedly overcome statistics anxiety (a score in the 1-3 range of the ordinal scale) and those who perceived to be able to do so (a score in the 4-5 range of the ordinal scale).This classification was used as the grouping variable in a subsequent discriminant analysis (corrected for unequal group sizes). It revealed that one significant function discriminated between students who had failed to substantially overcome their fear of statistics from those who had made marked improvements in their fear [Wilk's λ =0.793, $\chi^2(8) = 24.60$, $p < 0.01$][#].

Table 3 sets out the results of test of equality of group means, standardised canonical discriminant functions, and the structure matrix. It can be clearly seen that factors such as self-study, teaching quality, lecturer's feedback, lecturer's willingness to help and regularity in consultation significantly discriminate between the two groups. It appears from Table 3 that two factors which make the most important contribution to the student perception of overcoming fear of statistics are self-study and teaching quality. These are followed by regularity in consultation, lecturer's feedback and lecturer's willingness to help. This pattern is confirmed by the structure matrix.

Table 4 presents Fisher's linear discriminant functions for the two groups. The significant role of the discriminating variables is quite clear which suggest the relative roles of the student and the teacher. One could discern two types of variables that are critical to overcoming the fear of statistics. Self-study and regularity in consultation are primarily student-induced variables while teaching quality, lecturer's feedback on written work and lecturer's willingness to help are the teacher-induced factors.

Self-study has the highest discriminatory power closely followed by teaching quality. Three other variables which feature in providing a fair degree of discrimination between the two groups are lecturer's willingness to help, lecturer's feedback and regularity in consultation with the lecturer. This may indicate that anxious students want more help from the lecturer and (perceive themselves to) benefit from it.

At this stage it is worthwhile to consider the ingredients of teaching quality. Teaching quality was measured using a five-item scale covering accessibility to lecturer, lecturer's willingness to help the students, lecturer's feedback, the classroom environment and academic standards. The scale had an acceptable reliability (Chronbach's $\alpha = 0.81$).

CONCLUSION

The preceding discussion demonstrates that many of the students perceived to have completely overcome the psychological fear of statistics. The basic instruments of instruction strategy were simple but effective in creating a congenial learning environment. Thus, a hospitable learning environment characterized by free teacher-student interaction and communication can help student overcome statistics anxiety to a significant degree.

It is also clear from the preceding discussion that the teaching and learning outcomes are a complex phenomenon especially in a course characterized by significant incidence of anxiety and heterogeneity of the student clientele. Nevertheless, these parameters listed earlier provided a challenge as well as an opportunity for the teaching and learning process. Overall success of teaching and learning outcomes depends crucially on the efforts expended by the teacher as well by the student. Essentially, the process boils down to a partnership between the teacher (proxied by the *teaching quality* variable) and the student (proxied by the *self-study* variable).

No course can achieve the desired learning outcomes unless there is a total commitment of the part of the teacher and the student to fully participate in the process. In this context popular enthusiasm – communicating enthusiasm both ways plays a critical part [19][##].. This seems to be demonstrated by the results of this case study. The circular causation of a good learning environment and enthusiasm instilled confidence and set in motion a process of positive cumulative change that in turn helped transform the vicious circle of a seemingly insurmountable psychological barrier and statistics anxiety to a virtuous circle of learning for most students if not for all [###].

Finally, the conclusions of this study need to be judged in the light of the *caveat* that it is based on a limited number of observations. Its limited scope, micro-nature and local orientation make generalizations difficult. Nevertheless, the findings are indicative of the forces at work as well as an emerging pattern in the process of teaching and learning statistics especially in relation to managing and overcoming statistics anxiety.

The solution accounted for approximately 21 per cent of the variance in student improvement. The resultant discriminant function correctly classified 72.3 per cent of

the function successfully classified 82 per cent of those who markedly improved.

This is analogous to the context of development planning where 'popular enthusiasm is both a lubricating oil of planning and the petrol of economic development – a dynamic force that makes all things possible. Even the most backward country will progress rapidly if its government knows how to tap this dynamic force' [20].

[21] introduced these concepts in the context of economic development of underdeveloped countries in his seminal work *Asian Drama* [21].

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REFERENCES

1. Onwuegbuzie, A.J., 1997a. Writing a research proposal: The role of library anxiety, statistics anxiety and composition anxiety. Library and Information Sci. Res. 19: 5-33.
2. Onwuegbuzie, A.J., 1997b. The teacher as a researcher: The relationship between enrolment time and achievement in a research methodology course. Reflection and Research, 3 (1) [Online] Available: http://www.soe.gonzaga.edu/rr/v3n1/tony.html
3. Onwuegbuzie, A.J., 1998. Prevalence of statistics anxiety among graduate students. Unpublished manuscript.
4. Onwuegbuzie, A.J., 2000. Statistics anxiety and the role of self-perception. J. Educational Res. 93: 323-30.
5. Onwuegbuzie, A.J., D. Da Ros and J.M. Ryan, 1997. The components of statistics anxiety: A phenomenological study., Focus on Learning Problems in Mathematics, 19: 11-35.
6. Onwuegbuzie, A.J., 1999. Writing apprehension among graduate students: Its relationship to self-perception, Psychological Reports, 84: 1034-39.
7. Zeidner, M., 1991. Statistics and mathematics anxiety in social science students - some interesting parallels. British J. Edu. Psy. 61: 319-28.
8. Schacht, S. and B. J. Stewart, 1990. What's funny about statistics? A technique for reducing statistics anxiety. Teaching Sociology, 18: 52-56.
9. Blalock, H.M. Jr., 1987. Some general goals in teaching statistics. Teaching Sociology, 15: 164-72.
10. Fennema, E. and J.A. Sherman, 1976. Fennama-Sherman mathematics attitudes scales: Insturments designed to measure attitudes toward learning mathematics by males and females. Catalogs of Selected Documents in Psychology, 6: p.31.
11. Tobias, S., 1978. Overcoming Math Anxiety. Boston: Houghton Mifflin.
12. Cruise, R.J., R. W. Cash and D.I. Bolton, 1980. Statistics anxiety rating scale manual. Berrin Springs, MI: Andrews University (unpublished).
13. Elmore, P.B., E.L. Lewis and M.L.G. Bay, 1993. Statistics achievement: A function of attitudes and related experience. Paper presented at the annual meeting of the American Educational Research Association (ERIC Document Reproduction Service No. 360 324).
14. Onwuegbuzie, A.J., P. Bailey and C. E. Daley, 1999. Factors associated with foreign language anxiety. Applied Psycholinguistics, 20: 217-39.
15. Becker, W.E., 1988. Engaging students in quantitative analysis with short case examples from the academic and popular press. American Econ. Rev. 88: 480-86.
16. Hilmer, S.C., 1996. A problem-solving approach to teaching business statistics. American Statistician, 50: 249-56.
17. Watson, J. and T. Barber, 1997. Overseas and migrant students in economics: Are we addressing their needs?', Australian Economic Papers, (special issue), 26: 94-99.
18. Ballard, B. and J. Clanchy, 1992. Teaching Students from Overseas. Melbourne: Longman Cheshire.
19. Patrick, B.C., J. Hisley and T. Kempler, 2000. What's everybody so excited about?: The effects of teacher enthusiasm on student intrinsic motivation and vitality. J. Exp. Edu. 68: 217-34.
20. Lewis, W.A., 1965. The Principles of Economic Planning. London: Allen and Unwin.
21. Myrdal, G., 1968. Asian Drama. New York: Pantheon.