LEVELS OF CRITICAL THINKING OF SECONDARY AGRICULTURE STUDENTS

Timothy J. Rollins, Assistant Professor
Pennsylvania State University

Agriculture students must be prepared to cope with this world in order to function in their future occupations and roles in a less-agriculturally oriented society. To accomplish this feat, students must deal with increasing amounts of complex information and knowledge in purposive and systematic ways.

What kind of knowledge are agricultural educators imparting to their students? Glaser (1984) described knowledge that students receive and express, but cannot use effectively for thinking and learning as "passive knowledge". Lee (1980) expressed a concern about the use of instructional methodologies that "allow students to assume a passive rather than active role in the learning activities of the classroom/laboratory" (p. 5). Crunkilton (1988) alluded to perhaps an even greater problem when he stated, "The often overlooked aspect of critical thinking is that thinking is to prepare one only for action, when, in fact, thinking should also prepare one for feeling" (p. 8).

Sixty years ago, Lancelot (1929) indicated that a person's knowledge and thinking ability were crucial for that person to function efficiently and successfully in the then present age of science and technology. He attributed a person's success in solving everyday problems to a "general thinking ability."

Dewey's (1933) philosophical effort to define thinking, i.e. reflective thinking, was aimed toward improving an individual's thinking to "change his own personal ways until they become more effective; until...they do better the work that thinking can do and that other mental operations cannot do so well" (p. 3). Dewey recognized the problem solving aspects of thinking in the second of his five phases of reflective thought.

The early efforts of Ennis (1962) to define critical thinking helped delineate skills that called for the application of formal and informal logic. Ennis has since expanded his concept of critical thinking to include 13 dispositions:

1. Seek a clear statement of the thesis or question.
2. Seek reasons.
3. Try to be well-informed.
4. Use credible sources and mention them.
5. Take into account the total situation.
6. Try to remain relevant to the main point.
7. Keep in mind the original and/or basic concern.
8. Look for alternatives.
9. Be openminded.
10. Take a position (and change a position) when the evidence and reasons are sufficient to do so.
11. Seek as much precision as the subject permits.
12. Deal in an orderly manner with the parts of a complex whole.
13. Be sensitive to the feelings, level of knowledge, and degree of sophistication of others (Ennis, 1985, p. 46).

Ennis' (198.5) definition of critical thinking evolved into "reflective and reasonable thinking that is focused on deciding what to believe or do" (p. 45). This definition involves dispositions and abilities, and is a practical activity.

Meanwhile, Sternberg and Baron (1985) provided a connection between critical thinking and problem solving. They described critical thinking skills as including the abilities to "define and clarify, judge information, and infer-solve problems and draw reasonable conclusions" (p. 42).

Thomas and Litowitz (1986) cited findings from information processing research that reveals knowledge already present influences what is learned, how it is stored, and its meaning and potential use to the individual. New knowledge is "learned" by combining what an individual already knows with the new information, thus leading to differences in problem-solving behaviors between novices

and experts. Implicit in the Thomas and Litowitz finding is that there is an experiential or maturational basis used to acquire critical thinking skills.

Knowledge is of limited value to competent human functioning without reasoning, thinking, and learning skills needed to use such knowledge in diverse situations. Students must be capable of knowing, doing, and thinking. They should possess the dispositions and thinking skills necessary to work with and solve problems. However, to apply the principles of critical thinking requires a level of competency over and above knowledge of the principles themselves (Ennis, 1980; Norris, 1984). This realization can lead to the conclusion that critical thinking is ideally taught within subject matter areas rather than as a separate body of knowledge (Glaser, 1984).

If this supposition is tenable, then questions must be raised about teaching critical thinking skills in agricultural education. Can a lack of knowledge in a subject matter area such as agriculture be compensated for by a well-developed set of critical thinking skills? Or is knowledge of the subject matter, experience in the area in question, and good judgment essential for the application of critical thinking skills to be successful?

Purpose and Objectives

Few studies have examined the level of critical thinking of high school students. Ennis and Millman (1985) studied two groups of high school students to establish norms for the Cornell Critical Thinking Test. No study was located, however, that examined the level of critical thinking of high school vocational agriculture students. Thus, the central purpose of this investigation was to determine the level of critical thinking of high school agriculture students in Iowa. Specific objectives of this study were to:

1. Assess the level of critical thinking of Iowa high school agriculture students in terms of grade level.
2. Compare the level of critical thinking of Iowa high school agriculture students to those of two other high school populations.
3. Determine the amount of variance in critical thinking scores that can be explained by selected variables.

Procedures

Population and Sample: The population for the study consisted of 10,603 agriculture students enrolled in 262 secondary agriculture programs in the public high schools in Iowa during 1987-88. Cluster sampling was used because it was not possible to obtain a list of all members of the population. It was determined from Oliver, et al. (1983, 1985) that the minimum sample size should be 325 respondents. This sample size was increased by 50% to assure that the cluster sample adequately represented the population. A new minimum sample of 487 respondents was determined to be necessary. The effect size was set at .20 based upon user norms established by Ennis and Millman (1985).

The number of schools needed to generate the sample was based upon the statewide average number of students in each program. A computer-generated table of random numbers was used to initially select the schools for sampling. Telephone interviews were conducted to ascertain teachers' interest in cooperating in this study and to estimate the number of unduplicated 9th, 10th, 11th, and 12th grade students enrolled in agriculture courses. Eighteen schools were selected for inclusion in the study. One instructor taught in two of the schools. A total of 668 students enrolled in agriculture courses in the 18 schools participated in the study. This total represented approximately 6% of all high school agriculture students in Iowa. The sampling error was estimated to be 3.8%.

Instrumentation: An information sheet was developed to collect demographic data. The findings of Thomas and Litowitz (1986) about the influence of maturation and experience on critical thinking provided the rationale for the following variables which were included on the information sheet: grade level, age, semesters in agriculture classes, years in the FFA, and leadership positions held. In addition, the locations of their home was sought. Information available from the Cornell Critical Thinking Tests Level X and Level Z Manual (3rd edition) by Ennis and Millman (1985) established relationships with scholastic aptitude and standardized, subject matter achievement tests. Demographic data on populations previously studied were not available.

The Cornell Critical Thinking Test Level X^R (Ennis and Millman, 1985) is a 71-item multiple-choice test intended to be taken in a 50 minute period. Each item has three choices and one keyed answer. This commercially-prepared instrument evaluates the critical thinking skills of 4th--14th graders. Reliability estimates for the instrument with various populations ranged from .87 to .91. Aspects of critical thinking measured by the instrument include identification of assumptions, induction, deduction, observation statements, and judging credibility. This instrument was selected because it measured critical thinking in an objective manner, could be machine scored; and normative data were available on two populations of high school students most nearly like the ones in the sample. Other instruments, for example the Watson-Glaser Critical Thinking Appraisal Form YM, reportedly had lower reliability coefficient estimates or the subtests were not valid for testing different aspects of critical thinking (Landis & Michael, 1981).

The Iowa Tests of Educational Development (ITEDs) are standardized achievement tests used nationally to measure skills of secondary students in the following areas: recognizing the essentials of correct and effective writing (Test E-expression); solving quantitative problems (Test Q-quantitative thinking): critically analyzing discussions of social issues (Test SS-social studies): understanding nontechnical scientific reports and recognizing sound methods of scientific inquiry (Test NS-natural sciences); perceiving the mood and nonliteral meanings of literary materials (Test LI-literature); and using a variety of sources of information (Test SI-sources of information). The Reading Total score is based on analyses of reading selections from other subtests and the Composite Score represents a total picture of the individual's educational ability.

Data Collection: Students were administered the Cornell Critical Thinking Test Level X^R during the prescribed 50 minute period of time. Cumulative grade point averages were not available for ninth grade students because data were collected before the completion of the fall semester. In addition, ITED scores were not available for freshmen because they had not been tested. Eight telephone calls were conducted to encourage nonrespondent instructors to complete the testing procedures, verify identification numbers, and ascertain other data which were missing. Data collection began in October and was completed in December 1987.

Findings

Characteristics of the Sample: Descriptive data about the respondents (n = 668) are provided in Table 1. The 10th grade class comprised the highest percentage of respondents whereas the lowest was fmm the 12th grade class. The largest category of respondents had been enrolled in either one or two semesters of agriculture courses. More than half of the respondents had held one or two leadership positions while in high school and almost one-fourth had held three or four positions. Approximately three-fourths of the respondents lived on farms. The mean age of the respondents was almost 16 years. The mean number of years respondents had been in the FFA was slightly over three years.

Objective 1: Scores on the Cornell Critical Thinking Test are presented by grade level in Table 2. The mean score for all respondents was 36.9. The lowest mean critical thinking score was observed for respondents in the 10th grade (mean = 34.5) and the highest for respondents in the 12th grade (mean = 40.6). A oneway analysis of variance revealed significant differences in the critical thinking scores. Seniors had significantly higher critical thinking scores than that of any of the other three grades.

Objective 2: Percentile ranks, means, and standard deviations for scores that the sample and two comparison groups made on the Cornell Critical Thinking Test are presented in Table 3. High School XP was comprised of students randomly selected from a study hall in an upstate New York suburban school having a high pmportion of college-bound students (Ennis & Millman, 198.5). High School SQ was comprised of students completing a Biological Sciences Curriculum Study (BSCS) course of study (Ennis & Millman, 1985).

Objective 3: Table 4 presents Pearson correlation coefficients showing interrelationships among selected variables, including critical thinking. The number of leadership positions held in high school and cumulative grade point average were the only demographic variables examined in this study that were related to critical thinking at a level the author deemed to have practical significance (r=.25 or higher). The remaining variables shows in Table 4 are from the Iowa Tests of Educational Development.

Table 1
Description of Respondents

Variable	f	%
Grade		
9	172	2.5.8
10	187	28.0
11	163	24.4
12	146	21.8
Total	668	21.8
Semesters of agriculture		
l-2	268	40.2
3-4	180	27.1
5-6	142	21.3
7	76	11.4
Total	666	100.0
High school leadership positions		
l-2	223	50.2
3-4	106	23.9
5-6	56	12.6
7 or more	59	13.3
Total	444	100.0
Farm Resident	497	74.6

	f	Mean	SD
Age	666	15.9	1.3
Years in FFA	638	3.2	2.1

Table 2
Critical Thinking Means and Standard Deviations by Grade Level

Grade	f	M	SD
9	171	36.1	9.4
10	187	34.5	10.1
11	163	37.2	9.6
12	146	40.6	9.6
Total	667	36.9	9.9

($F = 11.1$; df = 3, 663; $p < .01$; Seniors had significantly higher mean scores)

The results of a stepwise multiple regression procedure used to explain critical thinking scores are presented in Table 5. Three variables entered the regression equation and accounted for 30% of the variance in critical thinking scores. The Reading Total score individually accounted for 28% of the variance. Another subtest from the ITEDs, Test SI-Sources of Information, accounted for an additional 1% of the variance. The remaining variable, number of leadership positions held in high school, accounted for another 1% of the critical thinking score variance.

Table 3
Percentile Ranks, Means, and Standard Deviations for Critical Thinking Scores of Agriculture Students Compared to User Norms[a]

Percentile rank	IA Ag. Stud.	(XP) HS	(XQ) HS
99	56	57	56
9.5	52	54	52
85	47	51	49
75	44	50	46
65	42	49	44
50	37	56	41
35	32	44	38
25	29	41	36
15	25	38	32
5	20	32	26
1	15	23	21
f	668	233	1673
M	36.9	45.3	40.6
S D	9.91	6.8	7.9

[a]User norms from Cornell Critical Thinking Tests Level X and Level Z Manual (3rd ed.).

Table 4
Interrelationships Among Selected Variables

	L	GPA	E	Q	SS	NS	LI	SI	RT	C	CT
		.25									
Leadership (L)	-		.32	.28	.30	.21	.28	.26	.32	.32	.25
*Grade Point Average (GPA)			.61	.64	.64	.64	.56	.65	.64	.68	.44
**ITED Subtests											
Expression (E)				.65	.79	.75	.77	.76	.82	.84	.48
Quantitative Thinking (Q)					.74	.74	.64	.74	.74	.80	.44
Social Studies (SS)						.85	.84	.84	.93	.93	.51
Natural Studies (NS)							.79	.79	.91	.91	.47
Literature (LI)								.76	.92	.88	.51
Sources of Information (SI)									.84	.89	.51
Reading Total (RT)										.93	.53
ITED Composite Score (C)											.53
Critical Thinking (CT)											

- (n = 341; all coefficients p < .01); high school GPA not available for freshman.
- * ITED (Iowa Tests of Educational Development) scores available only for grades 10 - 12.

Table 5
Stepwise Multiple Regression of Critical Thinking on Selected Variables*

Factor	Mult. R	R^2	R^2 Change	F
Reading Total (RT)	.53	.28	.28	13.02
Sources of Information (SI)	.54	.29	.01	7.49
Leadership (L)	.55	.30	.01	4.64

*For the Model: F = 49.6(3,337); only factors explaining significant amount of variance (p < .05) included in **Model;** ITED scores available for grades 10 - 12 only.

Discussion

The critical thinking mean score for all respondents (36.9) indicated that approximately 56% of the questions were answered correctly. Significant differences ($p < .01$) were observed among the mean scores for critical thinking of the 12th grade respondents and the respondents of the other three grade levels.

When compared with the other two populations of high school students, the agriculture students had comparable critical thinking scores through the upper third of the percentile rankings. However, a disparity in critical thinking scores appeared at the 50th percentile and increased rapidly thereafter. These differences remained uniform among all three groups to the lowest percentile ranking reported. The larger standard deviation also indicated that there was greater variation in individual critical thinking scores of the agriculture students than in the critical thinking scores of the other two populations. The two high school populations selected for comparison were comparable to the agriculture students in both age and grade level as shown in the Cornell Critical Thinking Tests Level X and Level Z Manual (3rd edition) by Ennis and Millman (1985).

The Reading Total (RT) subtest is based on exercises that require analysis of reading selections and includes sections from the natural sciences (NS), social sciences (SS), and literature (LI) subtests. The authors of the Cornell Critical Thinking Test emphasized the importance of students being able to read well enough. The regression analysis, in fact, verifies that student reading comprehension is a strong indicator of their level of critical thinking ability. Sources of Information (SI) evaluates a student's ability to utilize sources of information and to judge the appropriateness of various sources when specific information is required. Specifically, these skills include comprehension, interpretation, analysis, evaluation, and generalization.

According to Thomas and Litowitz (1986), factors associated with experience or maturation, i.e. age, grade level, semesters of agriculture, or years in FFA, should have some bearing on critical thinking. However, in this investigation these variables were of limited importance. The demographic variable that emerged as the best indicator of critical thinking was the number of leadership positions a student had held in high school.

Conclusions and Recommendations

The levels of critical thinking observed for Iowa agriculture students are indicative that some level of proficiency in this skill is indeed present. It may be even more important to note that much variability in this proficiency exists in the diverse characteristics of the respondents. When compared with the other two populations of high school students, the agriculture students' critical thinking scores were comparable down to the 50th percentile. Thereafter, scores for the agriculture students declined dramatically. The best indicator of a students' critical thinking score, accounting for 28% of the variance, came from the ITED subtest Reading Total which measures a students' ability to analyze reading selections from the natural sciences, social sciences, and literature subtests. The other variables, while statistically significant, were of limited practical significance in explaining critical thinking scores.

A cursory observation may lead one to conclude initially that the mean levels of critical thinking observed in the sample of predominantly rural high school agriculture students in Iowa are lower than the mean levels of the two comparison groups used in this investigation. An extensive review of the literature and the research on critical thinking did not reveal any investigations focusing on the group examined in this study. Accordingly, findings resulting from this study should be used as a foundation or basis from which to compare and contrast other agriculture students through a replication of this study.

Imminent authorities in the fields of education and cognitive psychology have not prescribed quantitative or benchmark criteria to base judgments about desirable levels of critical thinking. The nature of critical thinking currently precludes anything more tangible than curriculum based upon conceptual models of desirable cognitive skills. Research has shown that incorporating critical thinking concepts and teaching tactics into curriculum is the best strategy to improve a student's ability to think critically (Frederiksen, 1984). Instructors need assistance and direction to help their students develop the critical thinking skills necessary to function competently in today's society.

Given the basic tenets of agriculture education, its problem-solving approach to instruction, and the evidence provided from this investigation, agricultural educators should incorporate principles of

critical thinking and problem-solving into their curricula. Henderson (1983) advocated critical thinking skills be part of the "specific practices and strategies" used by agricultural educators in their instructional programs. The specific skills measured by this instrument are identifying assumptions, inductive and deductive reasoning, interpreting, analyzing, and evaluating statements, and judging credibility.

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