Explaining Student Cognition during Class Sessions in the Context Piaget's Theory of Cognitive Development

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Abstract

The purpose of this study was to explain student cognition during class sessions in the context of Piaget's Theory of Cognitive Development. The objective of the study was to describe comprehensively Piaget's active experience influence through six variables: four professor variables (cognitive level of professor discourse, cognitive level of professor questions, cognitive level of course objectives, and percent of lecture used during class sessions), and two student variables (student engagement and cognitive level of student questions) and, specifically, to describe their relationship to student cognition, which has not previously been operationally defined as it is defined in this study. Using a regression model, professor discourse and the percent of lecture used during class sessions explained more of the variance in student cognition. Recommendations included increasing professor and student awareness of the ability to teach and think using formal operations strategies for increased cognitive development, and to conduct further research to explain independent variables affecting student cognition.

Introduction

Critics of higher education believe that the university system is failing in the preparation of students (Tom, 1997). The Boyer Commission on Educating Undergraduates in the Research University (1998) advocated that students are not being prepared sufficiently to think beyond the lower levels of cognition. If a purpose for higher education is to meet the demand for high quality students to enter the workforce, universities and colleges must examine that which is occurring in their classrooms (Whittington, 2003), and be ready to produce evidence of that which has occurred (Brown and Lane, 2003) that contributed to critical thinking and problem solving for entry-level employment and beyond.

To meet this accountability challenge, Nordvall and Braxton (1996) recommended examining course-level academics to identify institutional quality, and advocated Bloom's Taxonomy (Bloom et al., 1956) for assessing level of understanding related to course content. Similarly, Sanders (1966) proposed using Bloom's Taxonomy as a way of observing and identifying levels of cognition for questions that were being asked by instructors. Bloom et al. (1956) stated that the taxonomy was designed for classifying student behaviors. The authors of the taxonomy believed that student and teacher behaviors could be observed and could be classified in a variety of content areas and educational levels (Bloom et al., 1956).

Woolfolk-Hoy (2004) suggested strategies for effective teaching appropriate for Piaget's stages of cognitive development. In the preoperational stage, the teacher uses actions and verbal instruction (lower level teaching strategies). Teaching in the concrete and formal operations stages requires higher-level teaching strategies. For example, concrete operations strategies involve hands-on learning, performing experiments and testing of objects while teaching in the formal operations stage involves giving students the opportunity to advance their skills in scientific reasoning and problem solving by offering open-ended projects, and exploring hypothetical possibilities (Woolfolk-Hoy, 2004). The level of cognitive development of a student may impact the level of difficulty in the transition to the undergraduate environment (Markwell and Courtney, 2006). At what Piagetian stage are our college students operating, and are our college of agriculture professors providing cognitive development opportunities appropriate for these stages of cognitive development? Transfer of learning is increased when students engage in materials are higher cognitive levels. If transfer of learning is not the primary objective of our institutions of higher education, the question begged is, “What is the relevance of formal schooling?” (Pugh and Bergin, 2006, p. 156). “One purpose of postsecondary education is preparing

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students for their future professional lives" (Thompson et al., 2003, p. 133). To meet this purpose, students' critical thinking abilities must be examined and explained in the context of teaching and learning in higher education.

Theoretical and Conceptual Frameworks

Piaget introduced his biologically-motivated Theory of Cognitive Development early in the last century, and from that time to today, educators and researchers have eagerly worked to exhibit a link between students' cognitive stage of development and their capacity for learning (Markwell and Courtney, 2006). Piaget (1964) believed that learning came prior to development.

In his theory of Cognitive Development, Jean Piaget posited that individuals did not advance one distinct step at a time through the stages, nor that progress was automatic. In fact, Piaget suggested viewing cognitive development as a continuum involving the interaction of four influences: maturation, active experience, social interaction, and a general progression of equilibrium (Piaget, 1961). Wadsworth (2004) stated, "Movement within and between stages of development is a function of these factors and their interaction" (p. 28).

A paucity of current research exists regarding the cognitive stage of development of college students. Cohen and Smith-Gold (1978) did find that the two cognitive stages at which most college students are operating are concrete operations and formal operations. The researchers cited several studies showing that the transition through the developmental stages occurs at much later ages, and that some individuals never obtain formal operations. Schwebel (1975) in a study of first-year college students found that formal operations, such as thinking in abstractions and logically, occurred much later in some people or not at all, and that many college students failed to attain full operational thinking. Cohen and Smith-Gold (1978) found, with a paper-pencil test, that a majority, 75%, of the students were not at the formal operations level when entering college. Pascarella and Terenzini (1991) stated that evidence suggests that close to half of entering college students are not operating at advanced stages of cognitive development and that postsecondary education plays a key role in exposing students to experiences that encourage development. Foster et al., (2009) reported results regarding Piagetian stage of cognitive development that aligned with previous findings with a majority of students not operating at the formal operations level. In addition, Bee (2000) stated that studies based on Piaget's model reveal that only half of adults function at the level of formal operations.

Piaget (1964) stated, regarding the stages of cognitive development, "although the order of succession is constant, the chronological ages of these stages varies a great deal" (p. 178). Woolfolk (2007) wrote, "Some students remain at the concrete operational stage throughout their school years, even throughout life. However, new experiences, usually those that take place in school, eventually present most students with problems they cannot solve using concrete operations" (p. 35).

Piaget further theorized that teachers had little impact on the maturation influence, but teachers, through the active experience influence, provided exploration, observation, testing, and information organization, all of which were likely to alter thinking processes. In addition, Piaget felt that teachers would impact the social transmission influence (i.e. learning from others) depending on the stage of cognitive development the student had already reached when entering a classroom relationship with the instructor.

Building upon Piaget's (1970) active experience influence, the cognitive level of classroom activity can be framed with assistance from Bloom's Taxonomy (Bloom, 1964) which is useful for documenting the cognitive levels at which teachers and learners process classroom content. Bloom's et al. (1956) six-step hierarchical system of thought processing (knowledge, comprehension, application, analysis, synthesis, evaluation) moves from the knowledge level, emphasizing subject matter recall, to the evaluation level, that entails making judgments.

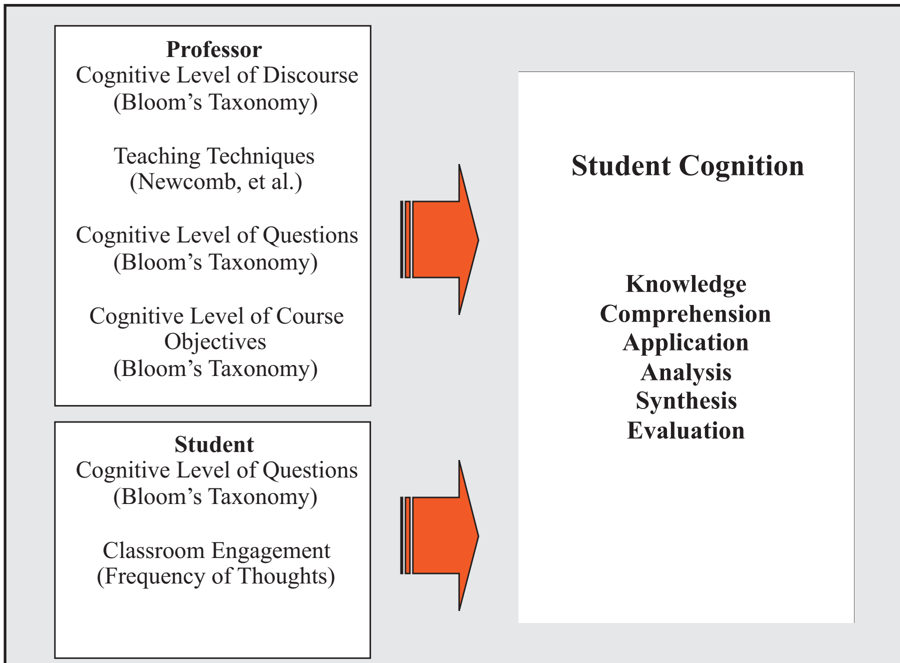

Figure 1. Conceptual Framework of Proposed Factors Influencing Student Cognition

Each level is reflected through cognitive classroom activity.

Given that learning is enhanced by increasing the percentage of student and instructor cognitive classroom activity occurring at the higher levels of cognition, Bloom's Taxonomy provides focus and direction to teachers who desire to enhance the quality of teaching and learning in their class sessions (Bowman and Whittington, 1994). Therefore, based upon Piaget's (1970) conclusion that activity influences student thinking, four professor variables and two student variables were examined in this study to explain student cognition during class sessions (see Figure 1). Student cognition, in this study, was operationally defined as a mathematical computation derived from measuring and assessing student thoughts during class sessions and applying a cognitive weight to students' brain processes during class (see Instrumentation).

Purpose and Objectives

The purpose of this research was to explain student cognition, those levels at which students were thinking based on classroom engagement, during class sessions in the context of Piaget's Theory of Cognitive Development. The objective of the study was to comprehensively describe Piaget's active experience influence through six variables; four professor variables (see Figure 1) and two student variables (see Figure 1). Specifically, the objective of the study was to describe the relationship of these six variables to the dependent variable, student cognition. Student cognition has not previously been operationally defined as defined in this study, nor has student cognition been explained, in a regression analysis.

Methods

The researcher met with all department chairs in the college of agriculture (N = 8), at a large land-grant university in the Midwest. The researchers explained the study and asked the department chairs to nominate three faculty members from their departments who received good student evaluations, positive student exit interview data, and favorable annual reviews of teaching. These teachers were identified as being good, and it should be noted that this may bias the results when compared with teachers with different skills and abilities. Individual appointments were scheduled, with those whom were nominated, to explain the study (a protocol was used such that all professors received identical information) and to seek their participation. Professors were informed of the importance of the study, the timeline, and the events that would take place in their classrooms as a result of their participation.

Twelve nominated faculty members, across all disciplines in the college, participated. The researchers scheduled observations and videotaping for each professor's class session two times during the quarter. However, scheduling conflicts prevented two observations for three of the professors. In-class observations were conducted by two researchers.

In addition, 21 students participated in the study; one student from each observed class session was randomly selected from the professor's class roster to participate in the student think-aloud protocols. As advocated by Kucan and Beck (1997), the think-aloud protocols had to be administered as immediately as possible to the time of the class session. Therefore, for students to be eligible for the study, they could not have academic commitments immediately following the scheduled class session observation. The think-aloud protocols were conducted by asking the students to watch a videotape of the class session they had just attended and record, using a hand-held cassette recorder, all that they were thinking during the class session. These thoughts were then transcribed and analyzed using Bloom's Taxonomy (1956).

Instrumentation

Six instruments were used to measure the professor and student variables. In each instrument in which Bloom's Taxonomy was used as the cognitive framework, content validity was based upon its direct development from Bloom's Taxonomy (1956) and the support, from theory and evidence (Ary et al., 2002), generally given to Bloom's hierarchy of cognitive behaviors. Based originally upon the cognitive levels identified by Bloom et al., Pickford and Newcomb (1989) developed a system to weight each of the cognitive levels. The cognitive factors' weight increases as the level of cognition increases; thus, awarding more overall weight to the higher levels of cognition.

Cognitive Level of Professor Discourse

The Florida Taxonomy of Cognitive Behavior (FTCB) was used in this study to determine the cognitive level of professor discourse during a class session observation (Webb, 1970). During each class session, the total number of cognitive behaviors that the professor displayed was recorded using the FTCB. The total number of observations per professor was summed to give an overall frequency at each cognitive level for each individual professor. A percentage of teaching behaviors was then determined for each cognitive level of professor discourse. The cognitive weighting factor (Pickford and Newcomb, 1989) for each level of cognition (see Table 1) was multiplied by the percentage for each level of cognition to yield a cognitive weighted score for professor discourse at each level of cognition. The cognitive weighted scores for professor discourse from each level of cognition were summed to yield a total cognitive weighted score for professor discourse during each class session.

Intra-rater reliability for the instrument was assessed using observations of two videotapes of teaching. The overall intra-rater reliability was $r_{(9\ weeks)}$ = .91. Inter-rater reliability was established for this study by having an expert in cognition research complete an assessment of a sample videotape. The inter-rater reliability was r = .94.

Table 1. Cognitive Weighting Factors

Level of Cognition	Weighting Factor *(Professor discourse)*	Weighting Factor *(Questions, objectives, and student cognition)*
Knowledge	.10	.10
Translation	.20	.20 (Comprehension)
Interpretation	.25	.20 (Comprehension)
Application	.30	.30
Analysis	.40	.40
Synthesis	.50	.50
Evaluation	.50	.50

Note. Bloom et al. (1956), Newcomb and Trefz (2005) identified levels of cognition.
Note. Pickford and Newcomb (1989) development of weighting factors.

Professor Teaching Techniques

Frequencies for each group-and individualized-teaching technique, as described by Newcomb et al. (2004), were recorded while viewing each videotaped class session. Percentages for lecture versus non-lecture techniques used by individual professors during class sessions were calculated. Inter-rater ($r_{(3\ weeks)}$ = .84) and intra-rater ($r_{(3\ weeks)}$ = .90) reliabilities were established by watching a videotaped class session for a second time and recording each teaching technique observed. Two individuals, who have studied and experienced multiple teaching techniques, conducted validity tests and determined the instrument to be face and content valid.

Cognitive Level of Professor Questions

The cognitive level of each professor question that elicited student engagement with the class content was categorized using Bloom's Taxonomy (1956). The percentage of professor questions asked at each level of cognition during the class session was calculated. The cognitive weighting factor (see Table 1) for each level of cognition was then multiplied by the percentage of professor questions at each level of cognition to yield a cognitive weighted score for professor questions. The cognitive weighted scores for professor questions at each level of cognition were summed to yield a total cognitive weighted score for professor questions. Inter-rater ($r_{(3\ weeks)}$ = .93) and intra-rater ($r_{(3\ weeks)}$ = .84) reliabilities were established. The instrument was deemed to be face and content valid.

Cognitive Level of Course Objectives

Course objectives provided by the course syllabi were analyzed and categorized by cognitive level using Bloom's Taxonomy (1956). A percentage for course objectives written at each level of cognition was calculated by dividing the number of course objectives at each level of cognition by the total number of course objectives. The cognitive weighted score for course objectives was calculated at each level of cognition by multiplying the percentage of course objectives at each level of cognition by the appropriate weighting factor (see Table 1). The cognitive weighted scores for course objectives at each level of cognition were summed to yield a total cognitive weighted score for course objectives.

The intra-rater reliability for the cognitive level of course objectives was $r_{(3\ weeks)}$ = .92. An expert in writing course objectives and cognition completed inter-rater reliability (r = .98). The cognitive framework was Bloom's Taxonomy (1956).

Cognitive Level of Student Questions

Questions asked by students during class sessions were analyzed and categorized by cognitive level using Bloom's Taxonomy (1956). A percentage for cognitive level of student questions was calculated for each level of cognition by dividing the number of questions at each cognitive level by the total number of questions asked by students during class sessions. The cognitive weighting factor (see Table 1) for each level of cognition was then multiplied by the percentage of student questions at each level of cognition to yield a cognitive weighted score for student questions at each level of cognition. The cognitive weighted scores for student questions at each level of cognition were summed to yield a total cognitive weighted score for student questions. Inter-rater ($r_{(3\ weeks)}$ = .90) and intra-rater ($r_{(3\ weeks)}$ = .88) reliabilities were established by watching a videotaped class session for a second time and recording the level of cognition for each question asked by students during the class session.

Classroom Engagement

Classroom engagement was recorded based on students' completion of think-aloud protocols. Student thoughts were transcribed and each thought was categorized into one of six thought-types. The six thought-types, based on previous research (Lopez and Whittington, 2000), were: (1) thoughts or observations about the professor, (2) nonsense or unrelated thoughts, (3) thoughts connected to previous learning, (4) thoughts about past experiences prompted by class subject matter, (5) deeper learning/questioning thoughts, (6) thoughts about behavior that got/maintained attention. Student thoughts that were categorized into thought-type 3, 4, 5, or 6 were deemed engaged thoughts. Engaged thoughts were directly related to, or were prompted by the course subject matter.

Reliability was established using a sample transcript and recording the level of student engagement during the class session. The intra-rater reliability for student engagement was $r_{(3\ weeks)} = .92$. Another individual, who was familiar with student engagement and teaching/learning, analyzed a sample transcript to establish inter-rater reliability (r = .89). Two students, who have studied and been trained in cognition research, analyzed face and content validity for this instrument. The raters indicated that the instrument was appropriate for categorizing student thoughts.

Student Cognition

All classroom engagements, acquired from the think-aloud protocol sessions, were classified into one of the six levels of Bloom's Taxonomy (1956), and a percentage was calculated for each cognitive level. The cognitive weighting factor (see Table 1) for each level of cognition was then multiplied by the percentage of classroom engaged thoughts at each level of cognition to yield a cognitive weighted score for student cognition at each level of cognition. The cognitive weighted scores for student cognition at each level were summed to yield a total cognitive weighted score named student cognition. Reliability was established using a sample transcript, and recording the level of cognition for each student thought during the class session. Intra-rater reliability for student cognition was $r_{(3\ weeks)} = .94$ and inter-rater reliability was (r = .91). The cognitive framework was Bloom's Taxonomy (1956).

Data Analysis

All professor and student data were entered into SPSS 14.0. Descriptive statistics were generated for each variable. A linear regression model, using the Enter method, was completed to explain the professor and student variables that influenced student cognition during class sessions. Four professor variables and two student variables (see Figure 1) were entered into the regression model at the ratio level of measurement.

Results

In Table 2, the descriptive statistics related to professor variables and student variables are displayed. The total cognitive weighted score for professor discourse mean was 18.95 *(SD = 4.26)*, indicating that the total cognitive weighted score average for professor discourse was between the knowledge and comprehension levels of cognition.

Professors used lecture as a teaching technique 56% of the time *(M = 55.76, SD = 26.28)*. Professor questions asked during class sessions carried a total cognitive weighted score for professor questions mean of 23.44 *(SD = 10.16)*, indicating that the total cognitive weighted score for professor questions was between the comprehension and application levels of cognition. Course objectives yielded a total weighted score for course objectives mean of 21.29 *(SD = 6.22)*. The objectives were primarily written at the comprehension level of cognition.

As can be seen in Table 2, for student variables, the mean total cognitive weighted score for student cognition (dependent variable) was 24.20 *(SD = 5.35)*. A total cognitive weighted score for student cognition of 24.20 was categorized between the comprehension and application levels of cognition. Student cognitive level of questions yielded a total cognitive weighted score for student questions mean of 17.93 *(SD = 13.57)*, indicating that the average cognitive level of student questions during class sessions was between the knowledge and comprehension levels of cognition. The percent of classroom engaged thoughts during class sessions was 42%.

As can be seen in Table 3, correlations between professor variables and total cognitive weighted score for student cognition were .501 (substantial) for total cognitive weighted score for professor discourse and .511 (substantial) for course objectives (Davis, 1971). Therefore, as the total cognitive weighted score for professor discourse and the total cognitive weighted score for course objectives increased, the total cognitive weighted score for student cognition increased substantially. As professor use of lecture increased, the total cognitive weighted score for student cognition decreased moderately (-.489).

Table 2. Descriptive Statistics Related to Professor and Student Variables

	Mean	SD	n
Total cognitive weighted score for student cognition	24.20	5.35	21
Total cognitive weighted score for professor discourse	18.95	4.26	21
Total cognitive weighted score for professor questions	23.44	10.16	21
Total cognitive weighted score for course objectives	21.29	6.22	21
Total cognitive weighted score for student questions	17.93	13.57	21
Percent of classroom engagement for students	41.72	17.6	21
Percent of lecture for professors	55.76	26.28	21

As can be seen in Table 4, given the small number of class sessions observed in this study (n = 21), the Adjusted R-square is the appropriate measure of interest for the model. Thus, 15.4% of the variance in

Table 3. Correlations for Total Cognitive Weighted Score for Student Cognition to Professor and Student Variables

	TCWSPD	Lecture (%)	TCWSPQ	TCWSCO	TCWSSQ	Engaged thought (%)
TCWSST	.501	-.283	.069	.511	.350	.024
TCWSPD		-.489	.002	.338	.467	-.172
Lecture (%)			-.244	-.258	-.041	.369
TCWSPQ				.338	-.132	-.307
TCWSCO					.239	-.050
TCWSSQ						-.034

Note. TCWSST = Total Cognitive Weighted Score for Student Cognition; TCWSPD = Total Cognitive Weighted Score for Professor Discourse; TCWSPQ = Total Cognitive Weighted Score for Professor Questions; TCWSCO = Total Cognitive Weighted Score for Course Objectives; TCWSSQ = Total Cognitive Weighted Score for Student Questions.

the dependent variable, student cognition, can be explained by the six independent variables (four professor variables and two student variables) entered into the model.

Table 4. Model Summary for Professor and Student Variables to Total Cognitive Weighted Score for Student Cognition

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.639	.408	.154	4.92

Conclusions/Implications/ Recommendations

Professors in this study are delivering content to students at the lowest cognitive levels during class sessions. Professor discourse, professor questions, and course objectives were found to be at the two lowest levels of Bloom's Taxonomy (knowledge and comprehension; 1956). Piagetian theory indicates that the professors in this study were using strategies best used with students operating at the preoperational cognitive stage of development, which is not the stage of development expected for college students.

Students, during the class sessions observed and recorded, were not being cognitively challenged to operate at higher levels for further cognitive development. Professors of these classes, therefore, should expect students to operate at higher cognitive levels after professors make conscious changes to write course objectives, plan classroom questioning, and deliver course content using strategies for formal operations of cognitive development. Porter and Brophy (1988) advocated that a professor's ability to address both low and high levels of cognition aid in promoting higher levels of student thinking.

Professors are often unaware of the cognitive levels of their current practices and behaviors (Newcomb and Trefz, 2005). However, most, upon learning of higher cognitive classroom techniques and strategies, adjust their practices to enrich their learning environments (Bowman and Whittington, 1994) including enhanced student cognition.

Students in the study are asking questions and engaging in content at the lowest cognitive levels during class sessions. Student questions and student cognition were found to be at the two lowest levels of Bloom's Taxonomy (knowledge and comprehension; 1956). Students must be able to think critically and to analyze information that has been presented to them (Education Commission of the States, 1995). If students are thinking primarily at lower levels of cognition during class sessions, critics of undergraduate education may be correct in stating that undergraduate students are not prepared to think at higher levels of cognition after leaving the university (Tom, 1997) and entering employment.

Students in the study are cognitively engaged in class content, during class sessions, less than half of the session. Students need to be engaged in the class session for meaningful learning to occur (Piaget, 1970; Woolfolk, 2001). Students not engaged with the class content are not able to retain and transfer the information for future use. Research (Barr and Tagg, 1995; Boggs, 1995) shows that students retain information better if they are active in their learning. Professors should use strategies, such as professor questions (Blosser, 2000) that guide students through the course content, and planned student activities (King, 1993), to encourage student thought and engagement during class sessions. When professors fail to assist students with developing a deeper understanding that will enable them to apply their knowledge in new and challenging situations, the full potential of education cannot be realized (Newcomb and Trefz, 2005).

The cognitive level of professor behaviors affects student cognition during class sessions. Lecture by itself does not often allow for active learning on the part of the student (Mangurian et al., 2001), but by employing other teaching techniques in the classroom, professors can help students learn (Bonwell and Eison, 1991).

Further research must explore other variables, among wider student populations, that explain student cognition during class sessions. Environment variables (Fraser, 1998; Fassinger, 2000) are known to influence learning, so discovering the extent to which additional professor, student, and environment variables are related will improve classroom practice. For example, Piaget's (1970) maturation (student variable), Fassinger's (2000) classroom climate (environment variable), and Weimer's (2002) student-centered techniques (professor variable), to name a few; need to be explored for potential relationships that explain student cognition, as it was defined in this study.

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