Abstract

Constructivist approaches to human learning have lead to the development of a theory of cognitive apprenticeship. This theory holds that masters of skills often fail to take into account the implicit processes involved in carrying out complex skills when teaching novices. To combat these tendencies, cognitive apprenticeships are designed among others to bring these tacit processes into the open, where students can observe, enact and practice them with help from the teacher. As such, this paper attempt to elucidate the theory of cognitive apprenticeship, differentiate between the traditional apprenticeship method and cognitive apprenticeship, report some previous empirical studies on cognitive apprenticeship, propose the development of cognitive apprenticeship methodologies for teaching vocational, technical and technology education students in Nigeria's institutions of learning and suggest measures that could enable the nation achieve her educational goals via the application of this methodology.

Introduction

According to Wikipedia encyclopedia (2007), Cognitive apprenticeship is a theory of the process where a master of a skill teaches that skill to a learner or apprentice. This involves the use of modeling, coaching, reflection, on performance, and articulation methods of traditional apprenticeship, but with an emphasis on cognitive rather than physical skills (Collins, 1988). The term cognitive apprenticeship was coined by Collins, Brown and Newman (1986), who proposed that contemporary classroom instructional methods be combined with the concept of apprenticeship. In their landmark study, the age-old apprenticeship learning principles (modeling, coaching, fading) of on-the-job training were combined with the modern pedagogical practice of engaging students with problems in the context of real-world experiences. Their classroom methodology incorporated contextual learning, which is a natural element of apprenticeship that embeds practical application of classroom theory. Other researchers have identified cognitive apprenticeship instruction as a viable means of modernizing technical education (Rai/cn, 1989; Wilson & Cole, 1991; Brandt, Farmer, & Buckmaster, 1993) in Cash, Behrmann, Stadt and McDaniels (1996). Cognitive apprenticeship focuses on the development of learning and skills beyond the apprehension of subject matter content (e.g., troubleshooting procedures and applications of diagnostic skills used in workplaces). Cognitive apprenticeships include four essential features: content, methods, sequencing, and sociology (Collins, Brown and Newman, 1986). These four features contain descriptive elements that collectively comprise the cognitive apprenticeship features and elements into classroom instruction in various configurations (Berryman, 1992; Collins et al., 1986). Cognitive apprenticeships are adaptable to many traditional educational delivery systems including lecture situations.

In cognitive apprenticeship, instructors model the strategies and activities necessary to solve problems, while providing appropriate scaffolds (organizational strategies and other supporting materials) to support the students' own efforts. Coaching and correction are provided as the students work on increasingly complex problems and then, support is withdrawn as the students develop competency. These are steps that mirror the methods employed by experts and apprentices for hundreds, if not thousands of years. In the writing classroom, instructors initially perform as expert writers, modeling (thinking aloud) to share their strategies and composing processes with students. Think aloud modeling reveals the most complete description possible of their cognitive activities and strategies, while providing organizational scaffolds for the students. Instructors describe what they are thinking and doing, why they are doing what they are doing, and verbalize their self-correction processes. After modeling, instructors support students through similar problems by coaching the students, demonstrating the use of scaffolds and explaining the principles and rules that apply to the writing task. Each successive problem is designed to be increasingly complex, and the instructor provides less and less assistance as the students gain
experience. Ultimately, students develop competency and solve problems and develop their own expertise (Duncan, 1996). Bandura's (1997) theory of modeling stated that for modeling to be successful, the learner must be attentive, must have access to and retain the information presented, must be motivated to learn, and must be able to accurately reproduce the desired skill.

By using processes such as modeling and coaching, cognitive apprenticeships also support the three stages of skill acquisition described in the expertise literature: the cognitive stage, the associative stage, and the autonomous stage (Anderson, 1983; Fitts & Posner, 1967). In the cognitive stage, learners develop declarative understanding of the skill. In the associative stage, mistakes and misinterpretations learned in the cognitive stage are detected and eliminated while associations between the critical elements involved in the skill are strengthened. Finally, in the autonomous stage, the learner's skill becomes honed and perfected until it is executed at an expert level (Anderson, 2000).

Like traditional apprenticeships, in which the apprentice learns a trade such as tailoring or woodworking by working under a master teacher, cognitive apprenticeships allow the master to model behavior in a real-world context with cognitive modeling (Bandura, 1997). By listening to the master explain exactly what he is doing and thinking as he models the skill, the apprentice can identify relevant behaviors and develop a conceptual model of the processes involved. The apprentice then attempts to imitate those behaviors with the master observing and providing coaching. Coaching provides assistance at the most critical level - the skill level just beyond what the learner/apprentice could accomplish by himself. Vygotsky (1978), referred to this as the Zone of Proximal Development and believed that fostering development within this zone leads to the most rapid development. The coaching process includes additional modeling as necessary, corrective feedback, and reminders, all intended to bring the apprentice's performance closer to that of the master's. As the apprentice becomes more skilled through the repetition of these processes, the feedback and instruction provided by the master "fades" until the apprentice is, ideally, performing the skill at a close approximation of the master level (Johnson, 1992). Part of the effectiveness of the cognitive apprenticeship model comes from learning in context. Cognitive scientists maintain that the context in which learning takes place is critical (Godden and Baddeley, 1975 in Wikipedia, 2007). Based on findings such as these, Collins, Duguid, and Brown (1989), argued that cognitive apprenticeships are less effective when skills and concepts are taught independent of their real-world context and situation. As they state, "Situations might be said to co-produce knowledge through activity". In cognitive apprenticeships, the activity being taught is modeled in real-world situations.

### Table 1

<table>
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<th>Differences Between Traditional Apprenticeship and Cognitive Apprenticeship</th>
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<td><strong>Traditional Apprenticeship</strong></td>
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**Source:** Cash, Behrmann, Stadt & McDaniels (1996).

### Related Empirical Studies

Duncan (1996), examined the effects of incorporating the instructional methods of cognitive apprenticeship—specifically think aloud modeling and scaffolding—into community college writing classrooms. A nonequivalent control group design (Cook and Campbell, 1979), was used in this study; nine volunteer instructors and 159 students in intact sections of writing courses at Danville Area Community College (DACC) in Eastern Illinois. American College Testing's (ACT's) Collegiate Assessment of Academic Proficiency (CAAP) Writing Skills Test of 1993 was used as the quantitative pre-test and post-test. Because statistical adjustment was necessary to "equalize" the means of the non-equivalent groups in this study, only those students with complete sets of data was included in the statistical analysis. One hundred and fifty-nine students completed the CAAP and essay pre-tests. At the end of the semester, 91 students remained in these nine classes, and
those who had taken the pre-tests were administered post-tests. Students with incomplete data were removed; leaving 82 sets of complete data for statistical analysis. Each instructor had a single writing course involved in the study and taught using one of the treatments (modeling with scaffolds, scaffolds without modeling, and control groups). Proper training of instructors in the modeling with scaffolds treatment sections was believed to be critical (Fischbach, 1993; Johnson, 1992); therefore, modeling instructors participated in six hours of modeling training before the semester began. Combined scores and sub scores for Usage/Mechanics (punctuation, grammar, sentence structure) and Rhetorical Skills (strategy, organization, style) were graded by ACT and then entered into a database for statistical analysis. A second pre-test, an in-class persuasive essay, was also administered during the first week of classes. Prompts for the essay were those used by the Educational Testing Service for twelfth graders in the National Assessment of Educational Progress (NAEP). For the pre-test, equal numbers of the two essay prompts were randomly distributed to students in each class by their instructors. All pre-tests were given during the first week of classes. Post-tests were administered during final examination week of the 15-week semester; thus, pre- and post-tests occurred approximately 14 weeks apart. The CAAP pre-test. Post-test essays were written by all students in participating classes, and in one of the classes, these essays also functioned as final examinations. Pre-test essays were held by the researcher until post-test essays were written, so that both groups of essays would be evaluated by the same cadre of experienced readers during a single grading session. White's (1992), grading criteria, which parallels the numerical system employed by the NAEP but is simpler, was used during the holistic essay evaluation. The statistical analysis of the covariates found that cognitive apprenticeship methods were effective in teaching writing skills. Analysis of the ACT instrument data found that the students’ mean post test scores were higher at a statistically significant level (p = .05) than those of the control groups. These findings indicate that using think aloud modeling to teach writing tests is a viable instructional alternative; moreover it can result in increased students writing skill development. The follow up univariate analysis of covariance indicated significant differences in the CAAP Combined post-test mean scores, CAAP Mechanics post-test mean scores, and CAAP Rhetoric post-test mean scores. No significance was found among the treatment groups for the dependent variable, essay post-test mean scores.

University analysis of covariance revealed that statistically significant differences in mean post-test scores did exist among the treatment groups. Three one-way analyses of variance (ANOVA) were conducted to determine where significance between the groups occurred:

1. A one-way analysis of variance was conducted on the CAAP Combined post-tests means and resulted in an F value of 6.32 (p < .05. A Tukey - HSD test revealed that the means of both the modeling and scaffolding groups were significantly higher than those of the control group. A one-way analysis of variance was conducted on the CAAP Mechanics post-tests means and resulted in an F value of 3.69 (p < .05. A Tukey-MST) test revealed that the modeling group scored significantly higher than the control group.

3. A one-way analysis of variance was conducted on the CAAP Rhetoric post-tests means and resulted in an F value of 7.20 (p < .05. A Tukey-HSD test revealed that the means of both modeling and scaffolding were significantly higher than those of the control group.

Instructors who performed the modeling reported increased student attention and enthusiasm during modeling. They also reported that students quickly learned the errors they made during modeling and concluded that this occurrence supported the effectiveness of the instructional technique. Modeling instructors reported that more training and supervision during the semester would increase both their competency and comfort in modeling.

Cash, Behrmann, Stadt and McDaniels (1996), also carried out a study on the Effectiveness of Cognitive Apprenticeship Instructional Methods in College Automotive Technology Classrooms. The purpose of the study was to determine whether cognitive apprenticeship instructional methods represent an improved method for helping college automotive technology students learn information and diagnose problems. Specifically., the study compares the effectiveness of cognitive apprenticeship instruction with the traditional lecture paradigm in automobile air conditioning classes. Three research questions were posed to examine the differences between the two instructional methods. A quasi-experimental design was used to compare cognitive apprenticeship instructional methods with the traditional lecture method. The sample consisted of 28 students in two automotive classes of the College of Technical Careers with age ranging from 19 to 49 years (M = 23.75. at Southern Illinois University in Carbondale. Four percent were freshmen, 36% were sophomores, 14% were juniors, and 46% were seniors. Although both groups had a mixture of grade levels, the experimental group was composed mostly of sophomores and the control group was composed most of seniors. Three students in the control group had received air conditioning training during the four years prior to the study. The experimental treatment consisted of a series of laboratory experiences specifically designed to be consistent with the cognitive apprenticeship characteristics described in Table 2 below. The control group received the same content primarily through presentations of theory in a lecture setting followed by some laboratory experiences. One of the distinct contrasts between the experimental and control group methods had to do with the sequencing (Table 2) of theory and application.
The instructor of both the experimental group and the control group are experienced people who had received high student rating. The instrument was a multiple choice test containing a total of 25 questions subdivided into three major areas: (a) air conditioning information, (b) troubleshooting procedures, and (c) application of diagnostic skills. Content validity for the data collection instrument was enhanced by using the Automotive Service Excellence certification preparation tests as a guide for developing the 25 questions. Two college automotive air conditioning professors assisted in the construction of the instrument. This was done to ensure content validity. Additionally, internal consistency reliability coefficients (Cronbach Alpha) were computed for each subscale after Time 1 administration of the questionnaire. A repeated measures ANOVA was used to test differences between groups (experimental vs. control), across time (Time 1 vs. Time 2 vs. Time 3), and group-by-time interaction effects. In addition to tests of the main effects (group and time) and interaction effects, post-hoc contrasts for each subtest were also calculated. A t-test was used to examine pre-treatment differences (Time 1) between the 5 control group students who had previous air conditioning training and the other 11 control group students. The Time 1 test was administered the day before the four-hour air conditioning lesson. Time 2 test measures were collected immediately after the treatment and Time 3 four weeks after the treatment. An alternate test form was used for both Time 2 and "Time 3. The results of this exploratory study, suggest promise for the use of cognitive apprenticeship methodologies in technical areas. When compared with the traditional, lecture-based control group methodology, the cognitive apprenticeship treatment results were significantly more effective for the acquisition of air conditioning information, knowledge of troubleshooting procedures, and application of diagnostic skills. While the cognitive apprenticeship method was more effective over the duration of the instructional period, the longer term retention effects were non-conclusive.

Implication for training Vocational, Technical and Technology Education Students in Nigeria

According to Johnson and Parker (1987), 41% of new jobs in 2000 A.D. will require high-level reasoning skills, compared to 24% in 1987. Similarly, the Secretary's Commission on Achievement of Necessary Skills (SCANS) 1991 report identified problem-solving as one of the five competencies of effective workers (U.S. Department of Labor, 1990). Teaching high-level reasoning and diagnostic skills in college-level technical programs is critical to serving the workforce (U.S. Department of Education, 1995). But as a by-product of the specialization of learning in schools today, skills and knowledge taught in schools have become abstracted...
from their uses in the world. In apprenticeship learning, on the other hand, target skills are not only continually in use by skilled practitioners, but are instrumental to the accomplishment of meaningful tasks. Said differently, apprenticeship embeds the learning of skills and knowledge in the social and functional context of their use. This difference is not academic but has serious implications for the nature of the knowledge that students acquire (Collins, Brown and Newman, 1986). In many respects, the principles of cognitive apprenticeship are familiar to technical educators. Techniques such as modeling, coaching, fading, reflection, articulation, and situated learning are well understood and have been effectively used in technically-oriented, laboratory-based courses for years. Industrial and technical educators recognize these as effective instructional practice. What is somewhat new to many industrial and technical educators is the recent emphasis on constructivist instructional practices. Specifically, the sequencing of delivery has traditionally involved establishing a base factual knowledge of components, theory, etc. (typically delivered through the lecture method) prior to application in laboratory settings. The cognitive apprenticeship approach (as defined in this paper) reverses this sequence by beginning with the development of a broad understanding of systems as a base for exploration and learning.

The goals of Vocational and Technical Education (VTE) according to Federal Government of Nigeria (2004) are to:

a. provide trained-manpower in the applied sciences, technology and business, particularly at craft, advanced craft and technical levels;
b. provide the technical knowledge and vocational skills necessary for agricultural, commercial and economic development.
c. give training and impart the necessary skills to individual who shall be self-reliant economically.

In view of the above goals, employers want VTE graduates who are adaptable and can solve problems in workplaces. In Electronic technology for instance, technicians are expected to be capable of doing more than replacing components. They must be able to apply diagnostic skills to solve problems. These skills have become increasingly important as technologies become increasingly more complex. And in order to achieve these goals, cognitive apprenticeship methodologies cannot be over emphasized. The sociological aspects of cognitive apprenticeships such as situated learning, cooperative learning, and verbalization are also important. Vocational, Technical and Technology Education students should study in laboratories which are reflective of workplace practice (i.e., construction, manufacturing, and service). Methodologies as well as content should be as realistic as possible. Cognitive apprenticeship paradigms may be use to simulate planning, production, and troubleshooting situations in technical and trade programs and should be part of the array of methods practiced in courses in pedagogy.

The utility of cognitive apprenticeship may be even greater in technology education. Because of the emphasis on exploration in pre-specialized learning about the world of work, technology education should involve students in the kinds of tasks, projects, etc., which workers in various parts of the industrial spectrum and along the responsibility continuum deal with daily. Certainly, teachers should be well-prepared to engage students in individual and group problem-solving situations. Further, cognitive apprenticeship principles are appropriate to informing early learners about various technologies and how they are used in varieties of workplaces. Problems in robotics, materials transfer, packaging, power distribution, etc., are only a few of the myriad applications of the cognitive apprenticeship modality (Cash, Behrmann and McDaniels, 1996). In view of the above, we hereby propose the development of Cognitive Apprenticeship methodologies by all stakeholders for the effective delivery of practical learning instructions in Vocational, Technical, and Technology Education institutions in Nigeria.

Suggestions

In order to achieve our educational goals via the application of Cognitive Apprenticeship methodologies, the following measures must be taken:

1. Our institutions of learning should be equipped with latest facilities, machines and other equipment that could be used to create the atmosphere or environment that will reflect how knowledge and skills will be used in real life situation.
2. VTE Teachers should be computer literate to enable them make optimal utilization of technology [e.g. computer aided programmes, software, troubleshooting tutors, simulations etc] to realize apprenticeship learning environment that were either not possible or cost effective before.
3. Since Cognitive apprenticeships are adaptable to many traditional educational delivery systems (e.g. lecture situation), VTE teachers should utilize various features and elements like contextual learning to develop cognitive apprenticeship models in accordance with facilities, students, field of study, and teacher skills.
4. Training and retraining of VTE teachers should be given priority by the State and Federal Government to improve and update teachers' skills and knowledge on current trend in their area of specialization. This will enable them develop new instructional models that could be used to prepare workers for fast changing workplaces that are characterized by critical and analytical skills.

Conclusion
Researchers have consistently predicted that the workplace of the future will be ever more high-tech and workers will have to be effective team members and competent in problem solving, mathematics, and communication if they are to perform successfully in this complex work environment. In like manner, Johnson and Packer (1987), warned that individuals with minimal skill levels will not be adequately qualified for positions of responsibility in the high-tech workplace of the future. Therefore, in order to produce Nigerian workforce that will meet the standard or qualities stated above, Cognitive apprenticeship methodologies should be adopted for teaching practical skills in our institutions of learning.

References


IN: Hudson Institute.


