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Teacher Candidates' Conceptual Understanding of Conceptual Learning: From Theory to Practice

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Abstract: Education researchers suggest that teacher education candidates be taught that meaningful learning is essential and that conceptual understanding be infused into all lessons. However, many teacher candidates are unable to successfully develop conceptual level lesson plans and some are unable to differentiate between skills and concepts. The purpose of this study was to enhance the conceptual understanding of teacher candidates and in turn help to develop their understanding of the learning process. This was accomplished by presenting the candidates with ideas concerning conceptual learning in a way that facilitated more meaningful learning and higher-level thinking. From survey analysis and evaluation of course projects, this method seems to achieve the goal of breaking down the cognitive barriers and allowing teacher candidates to conceptualize the difference between instruction that focuses on skills and instruction that focuses on conceptual understanding.

I. Introduction

The notion that skills instruction is so essential to students' ability to achieve (especially in the field of mathematics) has been prevalent in the U.S. for many years (Tournaki, 2003). Drill and practice ideologies have taken the forefront in many instructional plans due to the perceived efficiency and effectiveness of the processes (Swanson & Sachse-Lee, 2000). Especially with the onslaught of high stakes testing in the classroom, teachers often feel that direct instruction of skills is the only way to ensure that students are to achieve academically (Case, 2002; Gulek, 2003). The research, however, downplays the effectiveness of rote learning and suggests a more meaningful, conceptual understanding in order to promote problem solving and increase knowledge generalization. In addition, teachers who (as students) learned using drill and practice may find it difficult to break free of this more rigid paradigm.

The purpose of this study was to enhance the conceptual understanding of teacher education students (teacher candidates) and in turn help to develop their understanding of the learning process. The intent was that the candidates develop insight into the critical difference between skills and concepts and the notion that conceptual understanding leads to richness and flexibility in problem solving both within and outside the classroom.

II. Background

Concept learning focuses on the aspect of category formation and the use of concepts to interpret experiences and solve problems (Ormrod, 2001). A variety of theories have been developed proposing processes by which concepts such as schemas, exemplars, prototypes, etc.

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are formed (Anderson, 2000). Information processing theory embraces the ideas of conceptual understanding because it is the essence of meaningful learning and is the key to higher-level thinking. Additionally, in education, proponents of constructivism weigh heavily on the need for conceptual learning since it is the basis of all knowledge *constructed* by the learner (Mestre, 2002).

In cognitive psychology, a *concept* is a group or category of similar events or objects (Ormrod, 2003). The ability to form concepts allows an individual to make sense of the vast amount of information processed everyday. Students taught to develop a conceptual understanding of various domains will be more proficient at problem solving, abstract reasoning, generalizing their knowledge to new situations and more likely to make connections to related information (Ormrod, 1999). The converse of conceptual learning is rote memorization and drill and practice techniques (Snowman & Biehler, 2003) which tend to emphasize a skill acquisition approach. "Skill learning" is the term used to define learning a set of steps or memorization of a procedure in order to accomplish a task (Mayer, 2002).

Though there is acceptance of drill and practice methods for some domains, the consensus of many professionals in the K-12 classroom and at the university level is that learning must entail conceptual understanding for it to be meaningful and for it to facilitate problem solving (Stingler & Stevenson, 1994; Fuys & Liebov, 1997; Carlson, 1995). Convincing teacher candidates, that meaningful learning is vital and that conceptual understanding is essential for all lessons is part of almost every Educational Psychology text. The difficulty lies, however, in training teacher candidates to develop lessons that promote conceptual understanding versus ones that promote purely routine skills training.

III. Specific Programmatic Concerns

In our teacher education program, when teacher candidates were asked to develop conceptual lessons they consistently produced skill level lessons, even though the need for conceptual learning was part of their college curriculum. In this particular situation, all teacher candidates received training in conceptual learning early on in their program during the Educational Psychology course that preceded all teaching methods courses. Then, while in the methods classes, teacher candidates were expected to apply this information in the development of a variety of lesson plans, specifically in the areas of math and science. For the most part, they were unable to do so. Not only were the teacher candidates unable to develop conceptual level lesson plans but more simply, they were unable to differentiate between *skills* and *concepts*. It became our task to determine a reason for this lack of understanding, and then to develop a course of study to remedy this situation.

It was immediately apparent that information concerning the differences between concept learning and skills acquisition was not fully understood by these candidates. Therefore, it was necessary to determine what lesson changes should be made to facilitate better understanding of these essential points.

IV. Specific Conceptual Concerns

While delving into the specific college level lessons it became clear that one of the main problems concerning concept formation was that the lessons themselves were not taught *conceptually*. By its very nature, the "terms and definitions" format presented in the Educational Psychology course lead candidates to learn material in more of a rote fashion, despite the instructor's efforts to initiate meaningful learning. In many instances throughout the course, techniques such as real life examples, discovery learning and imagery helped to develop the candidate's understanding of the concepts at hand. However, when specifically dealing with *the concept of concepts* candidates regressed to old habits of rote memorization. That is, they were able to define the term "concept", list examples and even recall theories, but when it came to higher level thinking skills; application, analysis, synthesis, etc. they were unable to utilize previous learning.

A second observation regarding the problem of concept learning was the candidates' inability to differentiate a *concept* from a *skill*. This seems more prevalent when working with less complex material. For example, when developing a lesson plan on a more sophisticated topic such as gravity, the candidates seemed to understand the concept of gravity must be demonstrated and understood by children before moving on to higher-level aspects of this scientific idea. However, when dealing with more simplistic notions such as addition, the concept of "*what is addition?*" did not occur to candidates as an essential part of the lesson. Candidates consistently moved directly into the manipulation of symbols without regard for the child's level of understanding of the *concept of addition*. Apparently, the concept of addition was not perceived as novel most likely due to the candidate's familiarity with the concept. As students often complain about professors teaching at too high a level, the candidates did not perceive a similar corresponding difference between their conceptual knowledge and that of the child in their classroom.

Based on this information it seems imperative to present teacher candidates with ideas concerning conceptual learning in a way that facilitates more meaningful learning and higher-level thinking. Additionally, it is important to ensure that candidates identify the concept to be taught and develop lessons for children that clearly center on concept formation.

In this study, our goal was to determine a way to integrate concept learning into the teacher education curriculum in a way that will facilitate more meaningful learning and assist in application of conceptual level lesson planning. To accomplish this, we developed a three-part intervention. In the first part, we created a "mock" elementary school lesson, acting out a skills-approach arithmetic lesson and utilizing a numeration system foreign to the candidates. For the second part, we developed a college-level lesson outlining the properties of conceptual understanding. In the last part, we assisted the candidates in applying the conceptual ideas to mathematical methodologies.

V. Methodology

This was an experimental program that was carefully developed, presented and reviewed at various stages. This study was developed in order to "acquire in-depth and intimate information about a smaller group of persons <and> …to learn about how and why people behave, think, and make meaning as they do" (Ambert, Adler, Adler & 1995, p.880). However, this study would not strictly be classified as either quantitative or qualitative in nature. Brown (1992) referred to such studies as design experiments, which center more specifically on improvement of instruction as opposed to hard empirical evaluations. According to Kember (2003), designs such as this one are more likely to yield useful results if triangulation of data occurs. Triangulation is a method for utilizing multiple sources of data in order to "establish claims beyond a reasonable doubt" (Kember, 2003, p. 99). The data utilized in this study came from survey responses obtained immediately after the intervention and projects developed by the students at a later time.

A. Subjects

Candidates from two teacher preparation classes were combined to participate in the experimental class. Fourteen of the candidates were from the 200 level Educational Psychology class, and the 32 were from the 300 level Mathematics Methods class. There were several reasons for combining the classes. First, as it was indicated earlier, candidates learn the basic framework for concept learning in the 200 level class, yet they must apply these theories in the 300 level class. It was unclear at the time which group would benefit more from this instruction, so both groups were presented the material simultaneously.

B. Procedure

We felt it essential that candidates, in order to have a more meaningful learning experience, must recall the experience of learning novel information. As stated earlier, candidates found it difficult to “think like children” and approach a familiar topic as a novice learner.

It was also necessary that the candidates experience the information and come to their own conclusions without being told specifically what they should be learning. In other words, in order for the information to be meaningful, the candidates needed to construct their own understanding of what it means to be a novice learner. This would take more than simply giving examples of concept level lessons or identifying developmentally appropriate practice. The candidates needed to discover for themselves what *a concept* is and what it is not.

Lastly, it was vital the concept taught be simplistic enough that when the lesson was complete the candidates could see the parallels between their concept learning and the concept learning desired by schoolchildren. If the candidates spent too much effort attempting to learn a sophisticated concept, they might possibly miss the point of the entire lesson.

In order to do this we developed a basic, base-ten numeration system that consisted of unfamiliar symbols instead of the well-known Arabic system. We used the Wingding font (Microsoft, 2000) and simply replaced each number in the base-ten system with a symbol, as shown in Table 1.

Table 1. Base ten symbolic numeration system.

□	⊡	○	⊙	▯	⊠	⊗	◇	⟐	
1	2	3	4	5	6	7	8	9	
□●	□●□	□●⊡	□●○	□●⊙	□●▯	□●⊠	□●⊗	□●◇	□●⟐
10	11	12	13	14	15	16	17	18	19

Then we developed a few demonstration problems requiring addition and regrouping. We scripted the class lesson intentionally to model a less than adequate classroom lesson for elementary school children. An example of this script is:

> *“We are now going to attempt some two digit addition problems. Does everyone remember how to regroup {short pause}, good. Now, let’s try one together, dot circle plus dot diamond equals square dot circle, alright, good, and when we regroup it leads to square plus square plus*

> *dot square… which of course equals…anyone {short pause}, good, dot circle".*

The instructor presenting the mathematics lesson did so as a confederate. That is, in no way did she indicate the lesson was scripted, and the information presented was anything less than authentic. After completing the sample lesson, the second instructor proceeded with the standard Educational Psychology lecture that normally accompanies a unit on conceptual learning. This included definitions and specific examples of the presentation of concepts in a classroom, and included such terms as *feature lists, exemplars, prototypes, and schemas.* The specific text used was Ormond (2001).

After the presentation, the students were then "debriefed". We explained that their frustration with the Wingding system is similar to the frustration school children have when teachers teach only the *skill* of addition and not the *concept* of addition. To illustrate, we showed Table 1 to the candidates and explained the construction of the Wingding system. We also practiced a few more addition problems. Within minutes, the candidates were as fluent in Wingdings as their instructor.

We anticipated candidates would understand the connection between their frustration and their schoolchildren; however, they would still need guidance in applying the conceptual learning theories to instructional planning. We then gave an additional explanation of sample concepts specifically with simple classroom methodologies in mind, with results as shown in Table 2.

C. Analysis

Candidates completed a short Likert-scale questionnaire on various aspects of the class. Several of the questions were directed to the overall quality of the presentation. One question specifically asked the candidates about their perception of the need for such information as a teacher. Several questions (targeted the candidates in the methods class) asked candidates to rate their own understanding of concepts in the classroom and their ability to apply the information learned in the class.

Table 2 . Sample lecture notes from class debriefing.

Exemplar View
• Exemplars are actual memories of specific members of a category, and we use these to compare to an item in question to see if that belongs to that category • *Intersections and roads seen everyday as we travel to school*
Schema View
• We recognize some objects simply by our own experiences, regardless of their group membership or their attributes. • *Using measuring cups and spoons to "experience" fractions.*

Candidates were also invited to write in comments about this class at the end of the evaluation. These comments were collated and analyzed. In addition, the methods' instructor evaluated the lesson plans and mathematics education methodological projects created by the methods candidates.

VI. Results and Discussion

A. General Results

For the question "This class helped me develop a skill I will need as a professional", a Chi Square analysis was calculated for both classes combined. There were a total of 46 candidates. The $\chi 2$ obtained was significant at the $\alpha = .01$ level. All students indicated agreement or strong agreement with this statement.

For the upper-level methods candidates, 32 candidates participated in the class and completed the survey. For the questions:

> I remember studying *concept learning* in P250.
> I understood *concept learning* and its application prior to this class today.
> I found this class enriched my knowledge of *concept learning* compared to what was presented in P250.

Candidates indicated either agreement or strong agreement for all three questions using a five point Likert Scale. Again, response were significant at the $\alpha = .01$. Some of the candidates' comments included: "Great review and reminder for actual use in the classroom. It increased application knowledge." "Very helpful class, helped apply and put into perspective previous info learned." "It helped give me more concrete examples of concept learning." "This was a great experience – to see theory apply realistically to what I hope and will strive to do as a teacher."

B. Specific Results

During the remainder of the semester, the methods instructor evaluated candidates' work for examples of conceptual understanding and applications of conceptual learning. Examples were prevalent in lesson plans, presentations, and reflective papers. After viewing a model of the constructivism approach to teaching in the combined class, candidates seemed to understand that in order to teach schoolchildren concepts they needed to also allow these children to discover the concepts.

One candidate shared an instructional strategy on how to teach the concept of factors. He asked children to use Lincoln Logs (stackable rods for building structures) and group them into even groups. For example, using ten logs, a child can group those logs into 1 group of 10, 10 groups of 1, 2 groups of 5, or 5 groups of 2. These group numbers are the total number's factors. The number 10 has factors of 1, 2, 5, and 10.

In another discovery-approach lesson plan a candidate used the process of grouping objects to teach the concept of division. The instructions for this lesson are reported below:

> Give each student manipulatives and a compartmentalized craft box or divided cardboard box. The manipulatives should be similar in some attributes and different in others (i.e. M&M's of various colors, beads with different colors/shapes, cars and trucks, blocks with numbers/letters/colors, cards, or fruit). Let the students then play with/ manipulate the items. Walk around the room and

> observe. Ask questions, "Why did you group these this way?" and "What is the same/different about these?" "How many do you have in each group?" and "How many did your start with?" "How did your separate the blocks, toys, etc.?" Bring the class together with a discussion about how they sorted/divided up their toys.

The lesson ended with the concept presentation that sorting is division.

Other candidates' lesson plans included hands-on activities such as using measuring cups to help students understand the concept of equivalent fractions and using paint rollers and paint to understand the concept of a line. One candidate's reflection indicated a complete understanding of the importance of using learning theories, particularly concept learning to enrich instructional planning.

> "Percents are so widely used in day to day situations, it is imperative that students develop a good understanding. Unfortunately, studies show that students and even adults do not understand the basics of percents. This tells me as a future educator that more time needs to be spent developing an understanding of percents before jumping ahead to calculating percents."

These lessons overall were far advanced conceptually, compared to projects from previous semesters where the majority of the lessons, presentations and projects consisted of skill-level lessons. Candidates in previous classes would develop lessons that consisted of showing students how to add 2-digit numbers, how to multiply fractions, or how to do long division, using only symbol manipulation for demonstration purposes. The students were required only to duplicate the pattern accurately. These lessons lacked conceptual learning and discovery, while the lessons produced by the conceptually trained students were rich in discovery, conceptualization and number sense.

VI. Discussion

The purpose of this study was to determine a way to integrate concept learning into the teacher education curriculum in a way that will facilitate more meaningful learning and assist in application of conceptual level lesson planning. It seems apparent from the content of the methods candidates' projects after the conceptual learning class, candidates glean conceptual understanding necessary to teach children utilizing the constructivist approach. It also appears from the survey analysis, the method used to teach these lessons effectively achieved the goal of breaking down the cognitive barriers and allowing teacher candidates to conceptualize the difference between instruction that focuses on skills and one that focuses on conceptual understanding.

There are many sources that cite the importance of concept learning and others that demonstrate examples of concept-level lessons for schoolchildren (Ormrod, 2001, 2003). However, there is little research concerning effective methods for instructing teacher candidates on how to *develop* concept level lessons. It is essential in the field of education that teachers have the skill of analyzing the methods used to teach children, and assess the goal of these methods to ensure meaningful learning is occurring (Mayer, 2002; Snowman & Biehler, 2003).

In future studies, a wide range of cognitive domains (outside of mathematics) could be evaluated, ensuring that teacher candidates generalize the information concerning conceptual knowledge beyond the one presented in this study. Additionally, a further analysis about the timeliness of teaching concept learning in the pre-professional teacher education courses should be investigated.

VII. Conclusion

It takes a leap of faith for many teachers and teacher candidates to leave the security of the, "teach to the test" philosophy. For so long, teachers' understanding of learning has encompassed skills instruction, drill and repetition, that they no longer have the faith children can be taught to think. "Many studies document a preoccupation with transmission of information and rote application of 'skills', and a paucity of class time devoted to promoting students' ability to think critically" (Case, 2002, p.11).

This study demonstrated aspects of the process of teaching conceptual understanding in the classroom. It demonstrates how teacher candidates, when given a lesson that focuses on the development of their conceptual understanding, are able to see ways to incorporate conceptual understanding in their own lesson plans. With equal importance, however, this study demonstrated the need for the *discovery approach*, a conceptually based lesson for the teacher candidates themselves. Without the epiphany and the realization of their own roots of conceptual learning, the candidates slip too easily into a purely skills approach. With this method candidates were able to gain the realization that *they* know what they know, not from exacting drill and practice, but through constructing their own knowledge based on meaningful learning and conceptual understanding.

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