Thinking Skills and Creativity 8 (2013) 92–101

Contents lists available at SciVerse ScienceDirect

Thinking Skills and Creativity

journal homepage: http://www.elsevier.com/locate/tsc

Gender and prior science achievement affect categorization on a procedural learning task

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ARTICLE INFO

Article history:
Received 17 April 2012
Received in revised form 13 June 2012
Accepted 23 July 2012
Available online 2 August 2012

Keywords:
Classification
Categorization
Science learning
Cognitive process
Gender difference

ABSTRACT

Categorization is one of the main mental processes by which perception and conception develop. Nevertheless, categorization receives little attention with the development of critical thinking in Taiwan elementary schools. Thus, the present study investigates the effect that individual differences have on performing categorization tasks. Same-object and Different-object identification and categorizing activities were conducted with students asked to perceive various chemical properties by comparing touch before and after washing hands with laundry soap and cosmetic soap. 135 fourth and sixth-grade elementary students from a Taipei County elementary school participated in this experiment. For the purposes of this study, students completed worksheets describing their perception and categorization activities. We then used a scoring rubric to convert data on the learning sheets into quantitated data, which we plotted on a mapping tree. The results of this study indicated that firstly, overall perception performance by female students was significantly superior to that of the male students. Secondly, students who had achieved higher scores in prior science activities displayed better overall categorization performance than those students with low prior science scores did. Teachers could apply our method to cultivate elementary student cognitive processing in science by assigning practice categorization practice to students.

1. Introduction

Partitioning the world into meaningful categories is a formidable task, especially considering the vast number of comparisons made during the categorization process. Cognitive processes that direct how the world is perceived heavily influence the ability to form categories (Murphy & Medin, 1985). Cognitive psychologists use categorization and conceptualization to describe how people perceive and understand the world around them (Malt, 1995). International achievement tests carried out in Taiwan show Taiwanese students doing well in calculation, yet ranking at, or close to, the bottom in critical and creative thinking (Wu, 2004). Education policy and practice fail to stimulate natural curiosity and individual thinking amongst

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http://dx.doi.org/10.1016/j.tsc.2012.07.005

children (Wu & Albanese, 2010). Critical and creative thinking have an effect on mental development, where categorization is the most fundamental mental activity (Azrieli & Lehrer, 2007). Kruschke (2005) defines categorization within the context of purpose, and stated that critical thinking primarily uses categorization. Müller and Turner (2010) propose the leadership competency profile to count for critical thinking involved categorization of projects by their application type, complexity, importance and contract type. Result indicates high expressions of categorization effect to critical thinking performance. Additionally, creative thinking can benefit from categorization (Chiu, in press; Förster, Friedman, & Liberman, 2004). Categorization provides an effective way to handle a large amount of data as a facilitator to develop individual reasoning or imaginative skills in the creative cognition (Li, 2011). These creative thinking processes appear to result in the opening of unusual memory categories to be used in the creative combination process. Schilling (2005) notes that categorization acts as a basis for major scientific breakthroughs which provides connections of category elements to network or form a new model.

Taiwanese students who are weak at categorization and analytical skills do not perform well at critical thinking tasks (Yang & Chung, 2009). Despite realizing the importance of categorizing skills in education, schools do not have a good record of applying this knowledge. Thus, to respond to the need for more categorization activities in classroom practice, this study examined the effects of practicing categorizing skills in science education to understand how to maximize the potential for developing creative thinking skills.

Categorizing activities can engage students' interest in acquiring science knowledge. Students in elementary education, who cognitively transit from a period of concrete operations to a period of formal operations, have developed the ability to categorize (Piaget & Inhelder, 1969). The process of categorization is intrinsic to exploring things in our daily lives by sensory experience; critical thinking becomes a normal way of learning for students (Burke & Williams, 2008). The focus of the present study was to create a pairing exercise for categorization by classifying the features of objects and noting similarities between different properties, thus providing a domain index for concept mapping. Moreover, we attempted to integrate perception with categorization by the example of classifying chemical properties using sense of touch, and investigated differentiation in categorization performance.

2. Research content and hypotheses

Categorization provides a systematic means for hierarchical decomposition of knowledge; it allows a domain to be successively dissected via differentiation into smaller pockets of related concepts (Murphy & Ross, 2010). In other words, categorization functions as a way to conceptualize experiences, and general notions are developed. For cognitive economy, we classify the world into different categories, this helps reduce the information load for learning, perceiving, memorizing, and identifying (Collins & Quillian, 1969; Ellis, 2007). According to this view, categorization is created from multiple sources of information for solving specific tasks.

2.1. Types of categorization

Since the establishment of cognitive science in the 1950s, several major psychological theories of classification have been advanced, including the classical theory, the prototype theory, the exemplar theory, and the knowledge view. The classical theory, which is one of the longest held views of categorization, holds that the world displays a universal taxonomic order. All natural things belong to classes related by type relations, and form a hierarchical structure (Murphy, 2002). Concepts are regarded as terms, which consist of defining features that constitute a condition for category membership.

According to prototype theory, concepts are a distribution of properties, some of which are more central or typical than others. In its weakest form, a prototype is a collection of properties that describe typical instances of the concept. The prototype view shares some qualities with the classical view (Smith & Medin, 1981). Prototypes are comprised of features that are probabilistically characteristic of the category, but are not necessarily true for every instance (Hampton, 1995). Family resemblance theorists (Rosch & Mervis, 1975) suggest a somewhat weaker view of prototypical representation. However, a clear problem for prototypical views is an inability to account for continuous dimensions. Views that arise from this paradigm are often referred to as "similarity based views" and are characterized by the notion that concepts contain, and are defined on some level by shared attributes. A characteristic of both prototype and Family resemblance views is that the classification of category members is based upon on similarities.

Similarity is a fundamental construct in cognitive science, with implications for everything from basic color and pattern perception, to object and phoneme recognition, memory retrieval, analogical reasoning, and problem solving (Goldstone, 1995). The ubiquity of similarities in human perception and cognition makes it a central concept, and so similarities unify many aspects of perception and cognition (Taylor & Hummel, 2009). These are the principles we use to identify distinguishable characteristics of things, such as shape or smell, and group them into appropriate categories. Over time, the same cues in many task-contexts lead to similarities in emergent categories (Hund & Plumert, 2005). However, there are literature reports of conclusions about categorization based on between-subjects comparisons that will be associated to the development of comparative skills (Schmittmann, Visser, & Raijmakers, 2006).