Toward Meaningful Learning in A Global Age: How Gestalt Principles Can Facilitate Organization of Student Learning of Product Lifecycle Management Concepts

Lisa B. Ncube and Alexander W. Crispo
Department of Organizational Leadership & Supervision, College of Technology
Purdue University, West Lafayette, IN 47906 lncube@purdue.edu; alwc@purdue.edu

Abstract - **The paper discusses ways in which Gestalt theory can inform learning organization practice regarding concepts of Product Lifecycle Management (PLM) in a global economy. PLM is the process of managing the lifecycle of a company's product from its conception, through design and manufacture, to service and disposal. The use of Gestalt principles in technology and engineering education aims to facilitate meaningful learning in a global environment through the application of holism, relating learning to the environment, development of mental models, and team learning. The paper presents a brief overview of Gestalt theory and shows how Gestalt principles (proximity, closure, symmetry, figure-ground segregation, good continuation, and similarity) can be applied to improve a learner's comprehension of PLM concepts. Adding Gestalt principles complemented the information-organization feature of more commonly used knowledge maps and thereby enhancing factual recall, concept development, and application. Learning was enhanced by active processing strategies such as visualization, summarization, and by designing maps according to Gestalt principles of organization**.

Index Terms - Curriculum development, Instructional design, Gestalt theory, Product Lifecycle Management (PLM).

INTRODUCTION

Product Lifecycle Management is an integrated, information driven approach to all aspects of a product's life from its design inception, through its manufacture, deployment and maintenance, and culminating in its removal from service and final disposal (Gould, 2003). PLM encompasses numerous components, including engineering, manufacturing, sales, and marketing and numerous processes, including design, manufacturing, in-use product information or knowledge management, supply chain, customer support, and product recycling or disposal (Hines, Francis, & Found, 2006; Teague, 2007).

Product life cycle management is the latest information technology innovation that has caught the attention of the manufacturing industry (Chang & Miller, 2005). Although the concept of Product Lifecycle Management (PLM) has been around for many generations, it is still developing as a paradigm (Grieves, 2005). PLM focuses on managing a product's related data, information, and knowledge generated during its lifespan, presenting a totally different business perspective. PLM's holistic approach to business enhances decision making by providing relevant and appropriate information and data. In a global economy the primary strategic value of PLM is to give manufacturers a competitive edge through faster time to market and a reduction in costs, often resulting in premium pricing and increased market share (Marien, 2006; Dohrman, 2007). However, it is important that employees are effectively trained. Chang and Miller (2005) point out that a major concern for industry is that new graduates lack adequate knowledge and skills in PLM to effectively apply the concepts to problem solving. While these new manufacturing engineering graduates may be proficient in technical and engineering skills they have significant shortcomings in terms of their ability to recognize real-word problems holistically.

One way to resolve these curricular shortcomings and develop an understanding of PLM's characteristic and boundaries in students is to apply Gestalt principles that would help them conceptualize both holistic and component views of PLM. Gestalt principles provide both a rich way of thinking about overall concepts and can identify areas where in-depth exploration of issues that PLM raises is needed.

GESTALT PRINCIPLES OF ORGANIZATION

Gestalt principles are not as concerned with what students learn as much as *how* they learn it. Gestalt is a German word for "form." The theory of pattern perception relies on overall form and is not predictable by considering the components (Nesbitt & Friedrich, 2002). In other words the whole is greater then the sum of its part. In viewing the "whole," a cognitive process takes place – the mind makes a leap from

comprehending the parts to realizing the whole (Polito, undated). Gestalt psychologists believed that the whole is more than the sum of the parts, for instance, there are wholes, the behavior of which is not determined by that of their individual elements, but where the part-processes are themselves determined by the intrinsic nature of the whole (Moore & Fitz, 1993).

The fundamental principle of Gestalt—holism, is vital to developing an understanding of PLM. It is essential that students recognize that in PLM it is not the individual parts of the process that are important but the entire lifecycle. Each stage of the lifecycle affects the whole product. For example, the disposal of the product is an important consideration during the design and manufacture of the product. The selection of materials and components will be determined by how the product is to be disposed at the end of its lifecycle.

Gestalt principles suggest that as the learner receives new material, the new material is assimilated and undergoes cognitive and existential remodeling (Polito, undated). Learning is not considered as accumulation of knowledge but a remodeling of thought and development of insight. Each new experience such as a new case to be studied, an exposition in science, or a problem—begins by seeming relatively formless and unstructured (Torrans, 1999). The learner, who is initially unfamiliar with the material, begins by seizing upon what appear to be important features or figures. The material is then reformulated cognitively and insight gradually becomes more and more structured until finally the learner reaches an understanding or a solution to the problem (Encyclopedia Britannica, 1999).

Gestalt principles were developed to help explain holistic characteristics of perception. Gestalt theory focuses on the mind's perceptive processes (Kearsley, 1998). The word "Gestalt" has no direct translation in English, but refers to how something has been *gestellt*; that is, 'placed,' or 'put together;" other translations include 'form and shape,' and 'organized structure' (Encyclopedia Britannica, 1999, Kearsley, 1998). Gestalt theorists followed the basic principle that the whole is greater than the sum of its parts. In other words, the whole, for example, the concept of a car carries a different and altogether greater meaning than its individual components such as paint, tire, paint, metal, (Torrans, 1999).

GESTALT FACILITATING PLM LEARNING

One of the most appealing aspects of these principles is that they are simple to state, understand, and apply. The use of Gestalt theory in PLM education can help ensure that concepts are understood and that designs are dynamic. The Gestalt principles of organization that were considered included:

1. *Law of Simplicity*
2. *Law of Familiarity*
3. *Law of Similarity*
4. *Law of Good Continuation/Law of Common Fate*
5. *Law of Closure or Connectedness*
6. *Law of Proximity*
7. *Figure-Ground Segregation*
8. *Law of Symmetry*
9. *Principle of Pragnanz* (Nesbitt & Freidrich, 2002 Moore, Fitz 1993, Fultz, undated). In the following section these principles are illustrated briefly with examples taken from PLM courses.

1. Law of Simplicity

Every stimulus pattern is seen in such a way that the resulting structure is as simple as possible. The development of basic simple models is one way in which the concept of PLM is simplified.

The main components of PLM that need to be incorporated in programs include Product Data Management (PDM), a generic term for knowledge management activities in PLM including revision and configuration of specifications; Collaborative Product Design (CPD) which involves support of geographically distributed development teams through online conferencing and design or visualization applications; Direct Material Sourcing (DMS) which involves automation of the supply chain; Customer Needs Management (CNM), dealing with customers' requirements and specifications; and Product Portfolio Management (PPM) which provides visibility to the NPI (new product introduction) and supports the business decisions (Smith & Burkett, AMR Research Inc, 2007). Figure 1 below is a simple model of the PLM cycle incorporating the five elements:

- Design: PDM and CPD
- Planning: CPD
- Manufacturing: DMS
- Sustaining: CNM, PPM, supports and business decisions

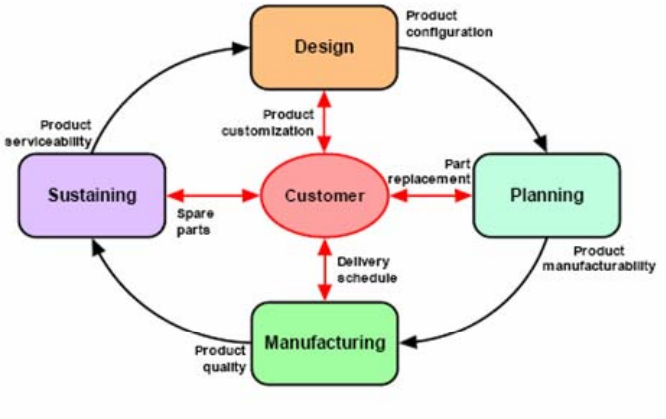

FIGURE 1
THE LIFECYCLE OF A PRODUCT (Chang & Miller 2005)

Simply stated, PLM course objectives should facilitate the development of competencies in students including the abilities to:

- Organize and manage product information of the entire life cycle, from concept to re-cycling of the product
- Manage knowledge
- Collaborate internally and externally with users like OEM's (original equipment manufacturers), suppliers and customers for the iteration of new designs
- Maintain a repository of product information for design reuse and to reduce part redundancy
- Gather and analyze customer or market product requirements
- Streamline supply chain
- Streamline resource management and analyze the cost-benefits of allocating resources for specific projects (Williams & Stemper, 2002; Cimalore, 2007).

2. Law of Familiarity

This law states that "things are more likely to form groups if the groups appear familiar or meaningful" (Fitz 1993). The development of understanding of PLM requires that the material presented to students appears to be familiar to make it meaningful for them. Figure 2 illustrates the PLM model. Various components of PLM are presented in a manner that engenders familiarity with students.

FIGURE 2
PLM MODEL

3. Law of Similarity

Similarity is a grouping principle, which states that those elements that share qualities (of color, size, or shape, for example) will be perceived as part of the same form. Gestalt theory states that objects that appear to be similar will be grouped together in the learner's mind (Moore& Fitz 1993). For PLM instruction, this requires that similar course content be grouped together as this will allow the learner to develop meaningful knowledge maps more effectively and efficiently. In the Figure 3 below, the learner is likely to discern a shape in the middle, though each individual object is the same color. However this requires more effort than if the material is intentionally grouped together on the basis of its similarity.

FIGURE 3
LAW OF SIMILARITY (Fultz, undated).

4. Law of Good Continuation/Law of Common Fate

This Gestalt law states that "shapes tend to be perceived to continue beyond their ending points." This law also holds true for objects moving in the same direction, even for objects which move in any structured way (Nesbitt & Freidrich, 2002 Moore, Fitz 1993).

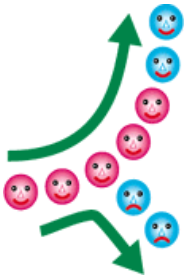

FIGURE 4
LAW OF GOOD CONTINUATION (Fultz, undated).

The example above (Figure 4) illustrates that learners are more apt to follow the direction of an established pattern rather than deviate from it. Elements that continue a pattern tend to be grouped together. The principle of good continuity suggests that learners prefer to perceive smooth, continuous contours rather than abrupt changes in direction. This suggests that content should be presented in such a manner that is perceived as be connected and continuous.

Figure 5 below shows the PLM cycle illustrating the law of good continuation. Students' understanding of PLM is enhanced when the basic model is maintained in curriculum development.

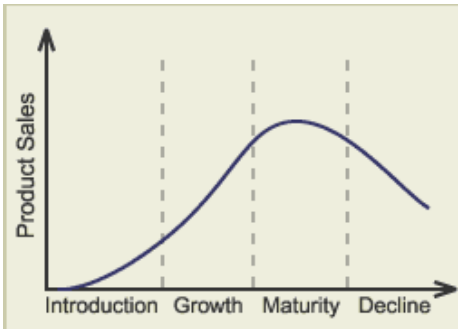

FIGURE 5:
PLM CYCLE

5. Law of Closure or Connectedness

The principle of closure states that we tend to enclose spaces by completing contours and ignoring gaps in figures. It follows from good continuity and allows us to group elements together or to interpret forms as complete though parts may be missing. In figure 6, below, the triangles and dots are perceived as wholes rather than incomplete structures.

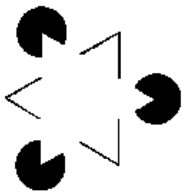

FIGURE 6
LAW OF CLOSURE (Fultz, undated).

This theory suggests as with shapes that aren't closed and seem incomplete, incomplete information may lead the learner to want to discover what's missing, rather than concentrating on the given instruction. For a complete understanding of PLM, the product lifecycle needs to be presented completely rather than with missing parts that students will need to seek additional knowledge for. A more complete outline of PLM would include the following topics:

- **Requirements Management**: Used throughout creation, manufacturing and distribution. Keeps track of total costs ("cost rollup") and manages constraints (if one part is changed, what are effects on others). Also provides collaboration and feedback.
- **Product Data Management**: Manages data in all phases and interrelationships between all databases (see PDM).
- **Configuration Management**: Provides sophisticated change control for as-designed, as-manufactured and as-serviced product structure databases. Shows interrelationships between data; for example, if a part has to be replaced in a product years later, it can locate original requirements.
- **Program and Project Management**: Program management provides the overall schedule for building multiple products, while project management provides the individual timelines for each team building a part.
- **Authoring Tools**: CAD (computer-aided design), CAM (computer-aided manufacturing), CAE (computer-aided engineering) and process planning applications (Chang & Miller 2005).

6. Law of Proximity

The Gestalt law of proximity states that "objects or shapes that are close to one another appear to form groups" (Moore & Fitz, 1993). Proximity is another grouping principle is that of perceptual organization. It states that, all else being equal, elements that are close together tend to be perceived as being associated. Even if the shapes, sizes, and objects are very different, they tend to appear as a group if they are close together (Fultz, undated). How they are grouped is also important, as in the Figure 7 below:

FIGURE 7
LAW OF PROXIMITY (Fultz, undated).

In applying this principle to PLM, related concepts should be closely aligned while keeping apart concepts that may be confounding. This allows learners to perceive the holistic nature of PLM.

7. Law of Figure-Ground Segregation/Law of Surroundedness

Figure/ground organization is an important phenomenon of Gestalt perception. For a figure to be perceived, it must stand apart from its background. Surroundedness is another principle that organizes figure and ground. The elements of an image seen as surrounded will be perceived as the figure, and the elements that are surrounding will be perceived as the ground.

FIGURE 8:
LAW OF FIGURE-GROUND SEGREGATION

In Figure 8 above, one element is black and the other white and although the elements are on top of each other, both elements are clearly visible. If the question mark is seen first, then a swan, the question mark is the figure and the swan is the ground and the opposite is also true (Hunt & Bullis, 1991).

FIGURE 9:
YOUNG OR OLD WOMAN

In the familiar example above, Figure 9, the figure-ground segregation is lost. Is the figure a young or old woman? This may result in confusion.

8. Law of Symmetry

Gestalt theory espoused the symmetrical so that the learner is not given the impression that something is out of balance, or missing, or wrong (Moore & Fitz 1993). Again, if an object is asymmetrical, the learner will waste time trying to find the problem instead of concentrating on the instruction. The chunking, or grouping, of information should follow a logical pattern (Moore & Fitz 1993).

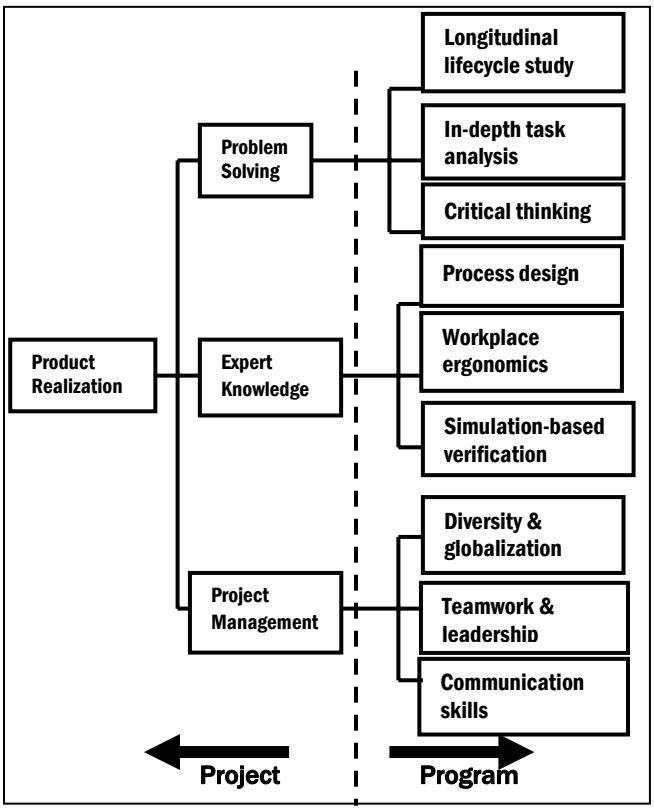

FIGURE 10
PLM CURRICULUM (Chang & Miller, 2004)

The PLM curriculum (see Figure 10) at Purdue University has been organized symmetrically to enhance understanding and transfer to the real world situation. In PLM, particularly, in the teaching of PDM, critical data must be clearly and sharply focused as compared to insignificant or immaterial data that should be recessed to the background. The corollary is also true, for data in the background to be relevant it must be moved to the foreground (Hunt & Bullis, 1991).

9. Principle of Pragnanz

Gestalt psychologists maintained that perceptual organization supported holism, and the principle of Pragnanz was an attempt to explain this effect. It claims that we will perceive an image as well as the stimulus conditions allow. Preferred perceptual organization should be the simplest, most regular interpretation of the elements in the image because individuals organize their visual experience in as simple, symmetrical, and complete manners as possible (Fultz, undated).

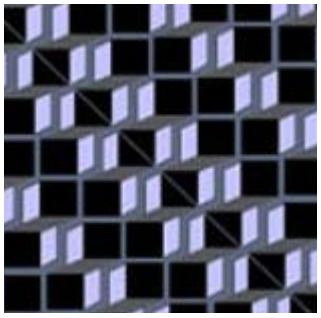

FIGURE 11:
PRINCIPLE OF PRAGNANZ

Pragnanz states that "when things are grasped as wholes, the minimal amount of energy is exerted in thinking" (Driscoll, 1994). In Figure 11, above, a repeating pattern can be seen, within which are elements that play upon figure/ground, symmetry, and smallness/area. To look closely requires some adjustment before the image is perceptually organized (Driscoll, 1994, Encyclopedia Britannica, 1999). This is Pragnanz at work. For example, motion pictures are just many pictures in motion, played at 24 frames per second; the images onscreen appear to be in motion (Seels, 1989). PLM is considered as a vision or a strategy, a different way to think and to do business. Students need to have a holistic understanding of this concept to become skilled PLM employees.

ASSESSING STUDENT LEARNING

Student perceptions solicited through classroom surveys and informal communication suggested that the application of Gestalt principles enhanced understanding and learning of PLM principles.

Overall, the results of these surveys and informal discussions suggest that students found the Gestalt organization of the curriculum beneficial and useful in developing a more complete understanding of PLM. A critical aspect of the use of Gestalt principles in curriculum development was the holist approach to learning. Gestalt, albeit, quite different from the traditional approaches to curriculum development, provided students with diverse learning styles new and more effective learning tools and strategies.

CONCLUSION

Curriculum Development

Gestalt theory encourages the learner to reveal the underlying nature of a topic or problem, seeking the answer to how the

elements relate to each other (Kearsley, 1998). The question then becomes "How can the elements or problem be restructured so that the learner gains knowledge?" In developing curricula, content must be visually attractive, inviting, and easy to access, follow, and understand—conforming to Gestalt laws (Moore & Fitz, 1993).

Problem-Solving

With these principles of grouping and perception, Gestalt theory influences thinking and problem-solving skills by "by appropriate substantive organization, restructuring, and centering of the given 'insight' in the direction of the desired solution" (Torrans, 1999).

In other words, Gestalt theory introduces the idea of regrouping and restructuring the whole problem, or idea, in order to solve it or make sense of it. Wertheimer (1924) applied Gestalt theory to problem-solving demonstrating that the parts of the problem should not be isolated but instead should be seen as a whole (Kearsley, 1998). By focusing on the whole rather than the part the learner obtains a new, deeper insight of the problem.

Student Roles

The interchange between learners and teachers, as well as other learners, is given value and weight. Ultimately, it is the teacher who allows the potential for this exchange to take place (Moore & Fitz 1993).

The instructor's role is to stimulate discussion and weave ideas together like the threads of a fine tapestry. As the learner ingests new information he or she continually restructures, what appears to be, the important elements or ideas. The ideas flourish and become easily understood as part of the Gestalt process.

Ideas come together to form groups and the learner quickly fills in the blanks as he or she discovers what is missing. The learner chunks or groups the information in logical patterns and continually projects beyond any ending point. A skilled instructor will not only facilitate but continually interject the overarching concept to help the learner see beyond any one specific topic.

A great example of this process is an experimental class that authors taught on several different occasions. The classes were two week accelerated modules consisting of the same information that would be normally presented in the traditional 15-week semester. The total amount of class time was the same, but instead of 30, 75 minute sessions, time was compacted to 10, 300 minute sessions. The students in the accelerated sessions seemed to develop a more holist understanding of the concepts compared to students in the traditional format who tended to isolate individual topics on a class to class basis. In general the learning was better, ideas were synthesized into real work place environments, and the instructor's evaluation feedback was greatly improved.

Subsequent discussions led the authors to believe that Gestalt was more effective in developing a more complete understanding of the concepts. Further studies will help determine if that hypothesis is valid. A recent accelerated session showed similar results. The question might be asked as to whether shorter semesters could lead to improved and learning?

REFERENCES

[1] Blosser, P., "Principles of Gestalt psychology and their application to teaching junior high school science." *Science Education,* 57, 1973, 43-53

[2] Burkett, M. & Smith, A., **"**Is PLM Right For Your Business?" *Industry Week,* January 7, 2007, [On-line] Available: http://www.industryweek.com/ReadArticle.aspx?ArticleID=13217

[3] Cimalore, C., "PLM's changing role." *Tooling & Production,* 73 (4), 2007, 32-33.

[4] Dohrman G., "Seven steps to complete PLM." *Machine Design*, February, 2007, 72-76.

[5] Driscoll, M., *Psychology of learning for Instruction,* 1994, Needham Heights, MA: Allyn & Bacon.

[6] Encyclopedia Britannica, "Pedagogy." 1999. [On-line] Available: http://search.eb.com/bol/topic?eu=115322&sctn=17#s_top

[7] Fultz, J. (undated). Gestalt Psychology. [On-line]. Available: http://users.anderson.edu/~jfultz/Gestalt.html

[8] Hines, P. Francis, M., & Found, P., "Towards lean product lifecycle management: A framework for new product development." *Journal of Manufacturing Technology Management,* 17, 2006, 866-887.

[9] Hunt, E. H.; Bullis, R. K. "Applying the Principles of Gestalt Theory to Teaching Ethics**."** *Journal of Business Ethics;* 10, 1991, 341-347.

[10] Kearsley, G., "Explorations in learning & instruction: The theory into practice database: Gestalt Theory." 1998, George Washington University [On-line] Available: http://www.gwu.edu/~tip/wertheim.html

[11] Marien, E. J., "Meeting the Product Lifecycle Challenge." *Supply Chain Management Review,* 10, (7), 2006.

[12] Moore, P., & Fitz, C., "Gestalt theory and instructional design**.** *Journal of Technical Writing and Communication,* 23 (2), 1993,137-157.

[13] Nesbitt, K. V. & Friedrich, C. "Applying Gestalt principles to animated visualizations of network data." Proceedings of the Sixth International Conference on Information Visualisation. (2002).

[14] Polito, M. (date unknown). "How Gestalt theory can facilitate teaching and learning processes." *Society for Gestalt Theory and Its Applications.* [On-line]. Available: http://rdz.acor.org/lists/Gestalt!/gerhards/polito.html

[15] Seels, B., "The instructional design movement in educational technology." *Educational Technology,* 29 (5) 1989, 11-15.

[16] Teague, P., "PLM breaks down silos. That's why you need it." *Purchasing*, 136(2), 2007, 17-19.

[17] Wertheimer, M. (1924). "Gestalt Theory." *Society for Gestalt Theory and Its Applications* [On-line]. Available: http://rdz.acor.org/Gestalt!/gerhards/wert1.html

[18] Williams, P. & Stemper, M., "Collaborative product commerce-the next frontier—The next big differentiator for technology companies will be the ability to harness collaboration for new-product development. Many of the tools exist today." *EBN*, 6, (1311), (2002).31.