Imagery for constructing meaning in the information search process: a study of middle school students

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INTRODUCTION

More complex contexts of information seeking require extensive thinking that involves an intellectual leap which carries the user 'beyond the information given' (Bruner, 1973) to the construction of something 'new'. According to Arnheim (1969) such thinking is directly affected by one's visual perception of the world and he argues that the most productive thinking results from this imagery. The application of visual or mental imagery to the relationships and structure in information seeking situations may be thought of as a constructive strategy for making meaning. This paper explores the use of mental imagery in the constructive process of information seeking. For the individual, the meaning of information is not inherent in the information itself but in his or her perception of it and how it fits into an image of the world or personal construct system (Boulding, 1961; Kelly, 1963). The use of imagery may facilitate a user's mental image of information and its relation to previously acquired knowledge and, thus, also facilitate new construction during the information seeking process.

Mental imagery has been found to play an important role in creativity and problem solving. Shepard (1978) argues that some of the most creative thoughts and solutions which humans devise are those which are not confined to expression within linear verbal communication but rather spring from mental imagery that embraces a spatial approach to problem solving. Mental imagery is more concrete and visually constructive in nature than verbal methods of problem solving. This paper explores the role of imagery in the constructive tasks of problem solving and learning in the information seeking process.

VISUAL IMAGERY

Arnheim (1969) describes visual perception as the basis for concept formation because thinking requires and depends on images. Paivio (1978) further states that it is impossible to engage in higher order thinking without using imagery. The role of visualization in cognition involves representations and processes that are in some way picture-like and have such qualities as form, size, pattern, and colour (Winn, 1982).

Petterson (1993) explains that there are primary and secondary visual images. A primary visual image is one that is formed as a response to external visual stimuli. A secondary visual image is one that is self-generated as a product of imagination or internal stimuli. However, internally produced images can be generated from information received when one reads text or listens to audio messages. Self-generated visual imagery may be more effective than external visual stimuli in a constructive process because the person is forced to analyse and reconstruct information in order to form a mental image (Couch, 1991). Recalled imagery may be considered a lower level of self-generated imagery, not directly primary but derived from a primary visual image. That is, a recalled image enables one to re-visualize something that has been stored in memory. While, in a sense, it is a self-generated image since it springs from internal memory rather than external visual stimuli, it is still the memory of a previously experienced external visual stimuli and not self-generated as a product of imagination.

Mental imagery appears to play an important role in creativity and problem solving. Shepard (1978) analyzed the use of mental imagery in the creative process of a number of scientists, including Einstein, Maxwell, Faraday, Galton, and Watson, and noted the striking consistency with which various scientists have used such pictorial phrases as 'flashed before my mind' in describing sudden insights. He proposed that 'a strong visual component and richness of concrete visual imagery may foster the noticing of significant details and relationships that are not adequately preserved in a purely verbal formulation.' This is also supported by Paivio (1978), who observed that many creative workers emphasised the role of imagery and visual thinking in the creative process. He found substantial evidence of a relationship between imagery and creativity as measured by a wide variety of tasks in the production of creative works.

IMAGERY AS A COGNITIVE STRATEGY

Kaufmann (1990) discussed the effects of imagery on problem solving, noting the different types of problems which a person might encounter based on the

information processing functions related to different task demands. Imagery served to arrange information into a meaningful configuration, an essential cognitive ability in information seeking processes. An earlier study of the usefulness of imagery in information seeking tasks by Zinchenko and his colleagues (1973) found that problem novelty and task complexity were associated with the use of imagery in problem solving. They found that visualizing increased with increasing task complexity and that imagery was especially useful in the information search phase of problem solving. In more complex information seeking tasks the use of visual imagery may serve as a cognitive strategy toward meaning making in the process of information seeking.

THE ROLE OF IMAGERY IN THE ISP

Kuhlthau's studies (1993) have examined cognitive and affective aspects of information seeking within the stages of the Information Search Process (ISP). This work has concentrated on information seeking as a process of construction from the user's perspective within the context of task complexity (Kuhlthau, 1996). The use of imagery as an integral aspect of construction in information seeking, however, had not been specifically examined. Evidence of visualization in the ISP may indicate ways that individuals use imagery to construct meaning within the context of information seeking. An examination of the use of mental imagery within the ISP may lead to greater insight into the cognitive strategies that people employ in their efforts to find, understand, and use information. Knowledge in this area may in turn suggest further research efforts which may lead to a better understanding of meaning making related to task complexity in the context of information seeking and use.

SIX STAGES OF THE ISP OF SECONDARY STUDENTS

One context for studying the user's perspective of information seeking was secondary schools in the United States. The model of the ISP derived from these studies described the primary tasks of information seeking in six stages of the search process, along with the thoughts, actions, and feelings that students commonly experience in the process of learning from a variety of sources. These stages are: Initiation, Selection, Exploration, Formulation, Collection, Presentation (Kuhlthau, 1993). Initiation marks the beginning of the process when an assignment is first introduced. Selection is an early stage when a general problem for investigation is selected. Exploration is a confusing, uncertain stage when a wide range of information is explored for forming a focus for the project. Formulation marks the turning point when a clearer understanding of the information is achieved through formulation of a focused

personal perspective. Collection calls for gathering information that defines, extends and supports the focus formed in the prior stage. Presentation is the last stage of the ISP when the search is concluded and the information is organized for presentation and application. An important contribution of this research is identification of feelings commonly experienced at each stage of the ISP. The process begins with uncertainty which increases during Exploration and decreases after Formulation. Experience of uncertainty is symptomatic of the early stages of the ISP when thoughts are vague and unclear. Certainty increases with construction in the later stages of the ISP.

STUDY DESIGN

This paper reports on an exploration of the use of imagery in the constructive process of information seeking. The use of visual imagery was recognized and suggested by Cooper following an examination of data collected by Kuhlthau within the context of middle school students engaged in an extensive science project. The research question addressed in this paper is: How do students use imagery to construct meaning in the context of the information search process? A class of twenty four students, twelve years of age, was selected for study in a middle school located in a suburban community in a major metropolitan area in the United States. The students were assigned to plan the delivery of supplies to a settlement on the planet Mars under the adverse weather conditions of a dust storm. They were to gather information related to the problem and to report their findings in a written paper and then to build a model to demonstrate the experiment. The work was conducted by forming five teams each focusing on a different aspect of the project.

Data for analysis were collected from three sources. First, the students were given a survey in the early stage of the project including a time line and a list of descriptive terms that were used to identify where they were in the ISP, according Kuhlthau's six stage model. At this time the students also were asked to write short problem statements describing their part in the project, that were later analyzed for evidence of imagery in the early stages of the process. Second, written reports, from each of the five teams summarizing the information they had gathered in preparation for building the model and conducting the experiment, were used as a data source for evidence of imagery at the midpoint in the project. Third, focus interviews, conducted and taped by Kuhlthau with students from each of the five teams after the model-building and experiment portion of the project, were analyzed by Cooper for evidence of the use of imagery. The students' use of imagery in the ISP was compared at these three stages in the project. Although the three sources of data varied widely each served to elicit imagery for exploratory examination of changes over time in the process of constructing meaning in information seeking and use.

DATA ANALYSIS AND EVIDENCE OF IMAGERY

Three sources of data were examined:

1. Students' process surveys and problem statements early in the project;
2. Student team reports written after information seeking but before experiment/demonstration;
3. Taped focus interviews with each of the five teams of students at the conclusion of the project.

Analysis of process surveys

The first source examined was the students' process surveys at the beginning of the assigned project. Findings were as follows: one student placed himself on the timeline of the ISP at 'receive assignment' indicating the Initiation stage. Eight students placed themselves at 'select problem' indicating the Selection stage. Nine students placed themselves at 'explore for focus' indicating the Exploration stage. Three students placed themselves halfway between 'select problem,' indicating the Selection stage and 'explore for focus' indicating the Exploration stage. Only three students placed themselves at the 'form focus' indicating the Formulation stage. Therefore, the vast majority of students at the beginning of the project placed themselves in an approximate even division between the Selection stage and Exploration stage on the ISP time line. Students' self placement on the process survey timeline on the ISP is shown in Table 1.

Place an X on the timeline to indicate where you are in the information search process.

1 X receive assignment ***Initiation***	8 X select problem ***Selection***	3X explore for focus ***Exploration***	
9 X form focus	3 X refine focus		prepare to present
Formulation		***Collection***	***Presentation***

Table 1: Students' self placement on process survey timeline of ISP at the beginning of project

Within these two stages, Selection and Exploration in the ISP, students selected terms from those listed to identify their feelings at this point in the process. They used 38 terms to describe their feelings at the time, 10 terms indicating confidence (5 confident, 3 optimistic, 2 satisfied) and 14 indicating a lack of confidence (7 uncertain, 3 confused, 2 frustrated, 1 apprehensive, 1 disappointed). This is in keeping with earlier studies of the ISP indicating a higher degree of uncertainty and lack of confidence in the early stages of information seeking. Interest in the project was high with 13 students indicating that they were interested in the project and only 1 uninterested. Terms chosen by students in the Selection and Exploration stages of the ISP to describe their feelings are shown in Table 2.

Terms indicating confidence	**No.**	**Terms indicating lack of confidence**	**No.**
Confident	5	Uncertain	7
Optimistic	3	Confused	3
Satisfied	2	Frustrated	2
		Apprehensive	1
		Disappointed	1
Totals	10		14
Terms indicating interest		**Terms indicating lack of interest**	
Interested	13	Uninterested	1

Table 2: Thirty eight terms chosen by students in the Selection and Exploration stages to describe their feelings

Examination of problem statements written by students at the beginning of the project did not reveal evidence of the use of imagery at this time in the ISP or even indicate that students were aware that the project might require the construction of a mental image prior to the actual physical construction of the model and demonstration of the experiment.

Analysis of student team reports

Reports were written by each of the five student teams at the completion of information seeking in preparation for the model building and experiment demonstration contained a substantial number of references indicating the use of visual imagery. The teams examined Basic Facts, Atmosphere, Geography, Landing Craft, and Settlements. Evidence of imagery was identified within each team report and examples are described below.

The Basic Facts team report revealed the use of imagery in comparisons of Martian conditions to Earth conditions. For example, 'Mars' temperature usually ranges from 87 degrees F (summer in the tropics) to -125 degrees F (winter near the polar ice caps)' and '...if you were on the planet Mars you would weigh about one third what you do on earth.' Both of these comparisons to the earth's environment indicate recalled mental imagery. Comparison of Martian and Earth conditions led the team to report '...it is probable that the planet once supported simple forms of life.' Students on this team reported that they used past exploration of Mars to 'give us ideas by seeing how others landed on Mars' and 'Past exploration helped us greatly in landing the payload on the Marsville settlement.' Students' choice of words indicated that information gathered gave them ideas by 'seeing' how others explored the planet. While this team did not participate in the physical construction of the project, use of mental visualization was nevertheless noted at this point in the manner in which they articulated their ideas.

The team that reported on Atmosphere also made visual comparisons between conditions on Mars and Earth. These comparisons were of the ozone levels on the two planets protecting them from the Sun's rays. Comparisons were made in miles of ozone protecting each planet, calling up a visual image of a particular level of protection. Dust storms were also described in miles high and pronounced 'very dangerous.' These descriptions reveal the use of visual imagery as a method of comparing for making meaning of information gathered during information seeking.

The report on Geography was characterized by a number of adjectives which indicate visual images of the Martian terrain. For example, Marsville was described as being built on a terrain having 'volcanoes surrounded by large quantities of smooth, desert-like land.' This, as opposed to a more unsuitable location that was 'heavily cratered' and another that featured an 'enormous canyon 4,000 km long and 500 km wide' and another that was in the 'polar ice caps region.' Other areas of Mars were described as looking like 'thick red fogs' or as usually 'dry, desert-like' consisting of a surface made of a 'brick coloured mineral.' The frequent use of adjectives, especially adjectives of colour, which is by nature a visually imagined descriptor, revealed use of visual imagery.

The Landing Craft team also used of adjectives evoking visual images when they wrote about 'pictures of a barren, waterless landscape.' Finally, the Settlements team described the different buildings they wanted to establish in Marsville. Visual imagery was revealed in their hope to make the settlement 'as much like Earth as we could' and their combination of building functions to keep the number of buildings to eight. They listed their original sixteen building functions and then revised the list to eight buildings of combined function.

The use of visual imagery by all five student teams was revealed in their use of adjectives and adverbs to describe Mars and Marsville. It was, also, noted in

their consistent comparison between Mars and Earth. These are examples of recalled imagery which was described earlier as a lower level of self-generated secondary imagery derived from the memory of a primary, external visual image. Students have seen these images before and remember them and use them to make meaning of new information. In order to understand what they were trying to say about Mars, they visualized conditions on earth and then set up a comparison to Mars. Specific instances indicating the use of mental imagery in team reports are shown in Table 3.

Basic Facts Team

'summer in the tropics'
'winter in the polar caps'
'give us ideas by *seeing* how others landed on Mars'

Atmosphere Team

comparison made in miles of ozone protecting Earth and Mars dust storms described in miles high

Geography Team

'volcanoes surrounded by large quantities of smooth, desert-like land'
'thick red fogs'

Landing Craft Team

'pictures of a barren, waterless, landscape'

Settlements Team

hope to make the settlement 'as much like Earth as we could'

Table 3: Evidence of recalled imagery mid-point in the project

Analysis of focus interviews with students

Kuhlthau initiated the focus interview session by asking the students to 'Tell me about the project.' This elicited responses of a general descriptive nature. Students responded, 'Well, we had to soft land supplies to a Marsville Settlement during a dust storm,' '...first of all we had to research what kinds of things the settlement would be made out of to see of they were compatible with the atmosphere,' 'We also needed to (think about) what kind of buildings were the most important.' When queried about how the project was different from ones they had done in the past, students cited the long term and co-operative nature of

the project. They spoke of feeling overwhelmed and confused at first and of the need to browse extensively before settling on a focus area.

'... we were trying to make walnut shells *look* like rocks.'
'You had to use your *imagination*.'
'*Artistic* license!'
'Well, most projects we do are not like make-believe ones like this - its *like real*...'
'... there isn't really a village on Mars ... its not real but you have to *act like it is*.'
'... you could design something - you could design a space craft, you could design what the buildings would *look* like..'
'...we had to research it and we started *building a model* and landing craft and kept having to test the different things'
'...we had a lot of arguments over how we should put it, the settlement, *arrange* it...'
'...when I was *building* the pay-load I would apply the information to the pay-load ... and it would help me...'
'... we took that research and we *made it into things* that would be good for our topic(s)... and turn them into something that's not real to help us *make a make-believe* settlement.'
'...at the end we fixed up the whole entire settlement and we made it *look* as much as we could like Mars.'
'..we had a little bit of problems figuring out which way we should *position* it cause we didn't know - like we had to figure...'
'... in order to *build* it we had to do research..'
'... we *didn't have a lab sheet* that told us what to do - we had to figure everything out.'
' there was a different way of using the information cause... you could manipulate it to help you - not change it totally but use that towards your advantage. The *research was important and you can see things* and use them actually instead of just putting it in you head and saying Oh...'

Table 4: Evidence of self-generated images at conclusion of project

When queried regarding what they liked best about the project, however, the students most often mentioned the hands-on, constructive nature of the project as the thing they like best about it. 'I liked making buildings and switching them around and spreading them out and figuring out which one would go in front and which one would go in the back and sort of just organizing it all,' '..we actually did it...''That's what I liked about it too, I liked building it and then actually

doing the tests and stuff to see if it would land.' The students noted that the project was 'more involved' because they had to physically build the Marsville Settlement, that it was 'more interactive' because it involved a combination of research and actual physical construction of a model. In order to 'make sure everything...was accurate...we had to do research and were in the library a lot doing it.' Another student noted that, ' ..we took that research and we made it into things that would be good for our topic whatever we were doing so we would take all that research, actual facts, and turn them into something that's not real to help us make a make-believe settlement.' Another comment was, '...I think most of our ideas...were less factual, they were more like designing...' To design is to conceive in the mind. And after designing, conceiving in the mind, the students needed to physically construct their conceptions. In order to do this, they needed to imagine how it would look and to visualize their constructs. In this way, the students were using self generated, secondary imagery. As one student explained, 'We didn't have a lab sheet that told us what to do - we had to figure everything out.'

Students remarked on the difference of the project being 'make-believe' but 'like real' - they 'had to adapt to that...get used to its not...real but you have to act like it is.' One student said, 'peoples' lives were...in you hands because you had to decide what was most important and stuff.' Another student summarized their experience when he said, 'In this project, there was a different way of using the information because when you looked it up ... you could manipulate it to help you - not change it totally but use that towards your advantage. The research was important and you can see things and use them actually instead of just putting it in you head.' Specific instances indicating students' use of mental imagery during the focus interview are shown in Table 4.

DISCUSSION

Use of mental imagery appeared to increase as the project progressed. Examination of students' problem statements and descriptions at the beginning of the assignment did not reveal the use of visual imagery. Students began to use more adjectives, adverbs, and visual comparisons (recalled imagery) in their team reports midpoint in the project and, finally, use of imagery was in greatest evidence during the students' verbal description of their experience of designing the village (self-generated imagery) at the conclusion of the project as summarized in Table 5.

Building the models of the settlement is what students cited most often as their favourite part of the project and this physical construction of the village necessitated mental imagery on their part. As previously indicated, they were not working from a plan or model. When constructing their Marsville Settlement they were not only intellectually constructing ideas but imagining how the ideas

would look and moving the ideas around in their heads and later with their hands, thus changing their perceptions of conceptual relationships, changing

Beginning: Students filled out process surveys	Middle: Students wrote team reports	End: Focus interviews with students
little use of mental imagery in process surveys, problem statements, or project descriptions written by students	use of visual comparisons and visually descriptive adjectives indicating students' use of recalled mental imagery	use of self-generated mental imagery in order to construct physical representation of what they picture a Mars settlement would look like

Table 5: Progression of use of mental imagery during the ISP

their understanding, and making meaning of the information they gathered. They were constructing meaning by first imagining how their ideas looked and then building them. Using self-generated mental imagery, the students attempted to physically construct the ideas they were working with. When their construction plan did not work out, the students went back to the text to search again - to re-search the information - and re-integrate, re-construct the meaning of the text so that the physical construction could be modelled. The process was one of continual reiteration until the students arrived at an intellectual, imaginal, and physical model that solved the problem. In this way, visual imagery was a strategy for constructing a better understanding of the information that the students were gathering. The students may not have completely understood the information at first but through the use of mental imagery they were able to construct a model. The constructive process involved imagining the model, trying out the model, and going back to the text when the model was inadequate. By constructing a mental image the students moved closer to understanding the information gathered in the ISP. The model of the village that the students visualized and built was a concrete construction of their understanding of the information. This physical construction which arose from the students' mental imagery helped them to derive meaning from the information found in the text. The act of visualization enabled meaning making within the ISP for these students.

SUMMARY AND IMPLICATIONS FOR FURTHER STUDY

This study explored the use of imagery as a cognitive strategy for making meaning in the process of information seeking in a complex task to solve a novel problem. At the beginning of the process little use of imagery was evident. The students approached their task as fact finding for direct application to the solution of the problem assigned to them. After they had proceeded further into the project and had collected considerable amount of factual information about their problem they used simple imagery in the form of recalled images for drawing comparisons from prior experience that related to the problem before them. In this way, they began to apply imagery as a cognitive strategy for making meaning in the midst of the ISP. In the last stages of the ISP the students used self-generated imagery to go beyond the facts they had gathered and the experiences they had recalled to create new solutions for the problem at hand. This exploratory study indicates that imagery may be an important cognitive strategy for constructing in the ISP, within the context of complex, novel problems and tasks. Further examination of the use of mental imagery for constructing meaning in the ISP may lead to greater understanding of the cognitive strategies that people employ in their efforts to find, understand, and use information.

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