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Inquiry Learning and Cognition: A Summary of Research and Implications for Geography Learning

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Abstract- An important student centered strategy practiced across the schools in USA is Inquiry Learning. However, inquiry involves the adoption of several complex procedures directed using scientific method and hence difficult to be practiced by an average learner unless he gets some external support. Students experiences in the process of Inquiry have been documented in a series of empirical studies. The Information Search Process model(ISP) of Kuhlthau describes seven stages as students proceed through their complex inquiry.However, students can be made to gain expertise in their inquiry learning when they are guided by teachers and experts. Scaffolding refers to supportive situations adults create to help learners extend current skills and knowledge to higher level of competence.The present study is an attempt to validate a new instructional strategy which combines the strong points of two differing strategies,viz.,the inquiry learning and scaffolding for teaching high school geography. Several studies by Bermingham (2016), Kukkonen (2014), Rae's & Schellens report on the effectiveness of these two strategies. The efficacy of the innovative approach on cognitive achievement is tested by comparing the terminal behaviors of two groups, one exposed to the innovative teaching method and the other to the practicing classroom pedagogy. The results show significant positive results in all the seven cognitive variables tested.

Keywords: *scaffolding, inquiry learning, cognitive achievement.*

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INQUIRYLEARNINGANDCOGNITIONASUMMARYOFRESEARCHANDIMPLICATIONSFORGEOGRAPHYLEARNING

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Inquiry Learning and Cognition: A Summary of Research and Implications for Geography Learning

Sreelekha Leelamma

Abstract- An important student centered strategy practiced across the schools in USA is Inquiry Learning. However, inquiry involves the adoption of several complex procedures directed using scientific method and hence difficult to be practiced by an average learner unless he gets some external support. Students experiences in the process of Inquiry have been documented in a series of empirical studies. The Information Search Process model(ISP) of Kuhlthau describes seven stages as students proceed through their complex inquiry.However, students can be made to gain expertise in their inquiry learning when they are guided by teachers and experts. Scaffolding refers to supportive situations adults create to help learners extend current skills and knowledge to higher level of competence.The present study is an attempt to validate a new instructional strategy which combines the strong points of two differing strategies,viz.,the inquiry learning and scaffolding for teaching high school geography. Several studies by Bermingham (2016), Kukkonen (2014), Rae's & Schellens report on the effectiveness of these two strategies. The efficacy of the innovative approach on cognitive achievement is tested by comparing the terminal behaviors of two groups, one exposed to the innovative teaching method and the other to the practicing classroom pedagogy. The results show significant positive results in all the seven cognitive variables tested.

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I. Introduction

The nature of geography has changed significantly during the last 100 years, especially since the second World War. Formerly a mnemotechnic discipline, rarely going beyond the stage of picturesque description and an introduction to history,it has now become the science of terrestrial space, a discipline which studies the spatial distribution of resources and human activities.The fact is that many areas in geography overlap with many areas of physical and life sciences. Concept -based teaching of science -oriented topics in geography is seldom attempted. Children should be taught to go beyond data and information given towards generation of useful and applicable knowledge-a process supported by inquiry learning. Hence more focus is to be given to the instructional practices suitable for realizing the core objective of this unique subject. The concept that every new generation teacher must be inducted into the modalities of scientific inquiry for developing concepts and principles through learner involvement is an accepted teacher training approach.

An important student centered strategy used in modern geography education is what is referred to as Inquiry learning. Inquiry is an approach to learning whereby students find and use a variety of sources of information and ideas to increase their own understandings of a problem, topic or issue. It espouses investigation, exploration, search, quest, research and pursuit. (Kuhlthau et al 2007). However, this strategy cannot be practiced by the average learner unless there is some externalsupport, sinceinquiry means the adoption of several complex procedures, directed using the scientific method.

Students' experiences in the process of inquiry have been carefully documented in a series of empirical studies. (Kuhlthau, 2004). The model of Information Search Process (ISP) describes feelings, thoughts and actions of students involved in complex inquiry tasks in which they are required to construct their own understandings. The seven process stages are *Initiation, Selection, Exploration, Formulation, Collection, Presentation and Assessment.* (Kuhlthau, Maniotes, Caspari, 2007). In a study of inquiry learning in ten schools in New Jersey, found the same pattern of students' feelings, with confusion and uncertainty increasing during the exploration stage in the technological information environment of today's school (Todd, Kuhlthau, and Heinstrom,2005). The stages of exploration and formulation are unpleasant experiences for students as they must encounter lots of new ideas that often conflict with what they already know. Sometimes these inconsistencies and incompatibilities become so threatening that some students want to drop out at this point of time. These research studies clearly point to the fact that learners need the intervention of more mature learners at appropriate points of time during the inquiry process to overcome their learning difficulties. This demands the greater use of scaffolds while employing inquiry learning approaches. The investigator was convinced that physical geography topics need a more specialized pedagogic treatment.

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The experimental instructional strategy (EIS) validated in the present study – 'Scaffold-Supported Inquiry Method 'combines the strong points of inquiry learning with sufficient opportunities for teacher intervention to give scaffolds whenever the students face difficulty in their inquiry process. The effectiveness of this innovative strategy is based on the comparison of two groups of learners exposed to two differing instructional strategies, the first group taught a selected curriculum area in secondary school geography using the EIS and the second group taught the same content using the practicing class room pedagogy. Comparison of the efficacy of the two strategies was done by comparing the outcomes of the two strategies in the two contrasted groups.

Several studies by Bermingham (2016), Kukkonen (2014), Raes and Schellens (2012), Morgan and Brooks (2012), Kuhlthau, Maniotes and Caspari (2007), and Furtak (2006) have reported on the effectivenessof two new important strategies -Inquiry learning and scaffolding and its potential for geography learning.. However, research studies attempting to combine these two strategies in to a single effective instructional method is seldom reported. Hence the investigator felt that integrating these two strategies into a single instructional method and applying it to geography learning would elevate the quality of geography teaching and learning several folds.

II. Literature Review

Inquiry-based learning emerged from a deep literature on constructivist approaches to teaching. Constructivist theories of learning argue that students learn best when discovering and unpacking content for themselves (Yu 2005; Cole 2009). Inquiry-based learning is a concept which encourages teachers to allow learners to get in touch with authentic situations and to explore and solve problems that are analogs to real life. (Li &Lim,2008)). Inquiry learning is a more powerful form of learning as students must engage all their senses. It entails sharp observation skills, critical thinking needed to sift essential from non-essential data, compile and record facts systematically, discover relationships between variables and above all creativity in thinking to give a new interpretation to the discovered generalization (Sreelekha &Uma,2017) .

A study by (Bermingham,2016)highlighted the importance of establishing student engagement and using appropriate questions to facilitate student-led inquiry in geography and found that the fieldwork booklets provided only limited opportunities for students to plan their fieldwork inquiries. In 2008, Spronken & Rachel reported on the effectiveness of inquiry based learning in geography and its benefits for teachers and students. The study revealed that when students become active in the learning process, they evinced improved understanding, more enjoyable learning, developed valuable research skills, higher order learning outcomes and showed better academic performance. Favier and Vanderschee (2012) conducted an Educational Design Research study. The findings highlight the fact that in order to effectively raise students geographic thinking to a higher level, teachers should coach students in structuring, correcting and expanding their geographic thinking via dialogical teaching.

Scaffolding is a term widely used in present - day educational practice to describe the precise help that enables a learner to achieve a specific goal that would not be possible without support. It refers to the supportive situations adults create to help children extend current skills and knowledge to a higher level of competence. The assumption underlying instructional scaffolding is that there is a cognitive distance between what learners know and can do on their own and what they can do with the assistance of a more knowledgeable person. Vygotsky called this area of potential growth the learner's Zone of Proximal Development(ZPD).Students gain competence in their inquiry learning when they are assisted by teachers and adults. But this does not mean full- length teacher support and authority. The teacher intervenes only at the most appropriate moment i.e. instructive interventions are planned at different stages of the inquiry process. This helps the students to move to higher levels of thinking and learning.

In 2016 Park, reported that emotional scaffolding is a critical pedagogical tool that could help teachers reach developmentally appropriate practices for early childhood education in an age of accountability. Astudy by Raes and Schellens(2012) reveal that multiple-scaffolding enhances both knowledge acquisition and meta cognitive awareness. In2008, Li & Lim examined the different dimensions of scaffolding for on-line historical inquiry. Rolls and Holmes(2012) compared the learning behavior of students in the unguided invention condition and guided invention condition. The findings suggest that process - guidance in the form of metacognitive scaffolding augmented the inherent benefits of the invention activities in the guided invention condition and led to gains at both domain and inquiry levels.

The research evidence reinforces the fact that the efficacy of inquiry learning can be increased considerably if it is supported by scaffolding (intellectual supports by mature professionals) at appropriate points which is envisaged in educational theories like the Zone of Proximal Development(ZPD) and other constructivist approaches.

III. Research Methods

a) Purpose

The main objective of the present study was to test the effectiveness of the Scaffold Supported Inquiry

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Method named in this report as the Experimental Instructional Strategy(EIS), in achieving defined cognitive outcomes in secondary level geography learning.

b) Research Questions

While carrying out the present study, the investigator formulated certain research questions to give a sense of direction to this research.

- Is the Scaffold - Supported Inquiry Method capable of promoting the achievement in geography of secondary level students significantly when compared to prevailing class room pedagogy?
- Does it enhance all components of cognitive achievement (knowledge, comprehension, application, analysis, synthesis and evaluation)?
- Will there be an observable change in the effectiveness of this method if the entering behavior of both the experimental and control groups were equated?

c) Hypothesis

There will be no significant difference between the experimental and control groups in their achievement in select areas of geography.

d) Objectives

- Assess the efficacy of the experimental instructional strategy for geography learning by comparing the level of learning of the EG and CG equated for their' level of entering behavior in geography' using 'total cognitive outcomes' in the select content in geography as the criterion for comparison.
- Assess the efficacy of the experimental instructional strategy for geography learning by comparing the level of learning of the EG and CG equated for their' level of entering behavior in geography' using each of the six components of the cognitive outcomes as the criterion for comparison.

e) Participants

The original groups of EG and CG (each of size 70 and 65) were reduced to two equated groups by controlling the students entering behavior in the subject-i.e. preliminary level learning in geography. This was done by reducing the two original groups (EG and CG) to two equated groups EG1 and CG1(each of size 57) by selecting equivalent pairs. Each member of the pair was randomly assigned to one of the two groups. When equivalent pairs were not available for any one member, this person was eliminated from final statistical analysis.

f) Method

The investigator mainly adopted the 'quasi-experimental design'- the pre-test post-test nonequivalent group experimental design with appropriate adjustments. This meant the comparison of an experimental group (EG) with a control group (CG) for their learning of a standard content, making use of the experimental instructional strategy for the EG and the conventional classroom teaching for the CG.

g) Instructional Design

The learning content was converted to six instructional units, using the procedures of the new experimental instructional strategy whose efficacy is to be tested viz., the Scaffold Supported Inquiry Method. The topic selected required the students to learn a complex scientific principle'Relation between the geographic latitude of places and their atmospheric temperature'. The innovative method was used to present the above geography content to the experimental group(EG). The same topic was presented to the control group(CG) using the practicing classroom pedagogy, also in six instructional units. Both the groups were taught by the same two teachers, each teaching half the teaching units.

The investigator's selection of the topic for experimental treatment was influenced by the fact that the selected topic provides adequate opportunities for using original experimentation and inquiry approach together with the need for scaffolding and teacher intervention .The area presented a number of complex concepts like the use of 'angular measurements for expressing longitudes and latitudes, how physical factors like the inclination of the sun's rays, at any time determines atmospheric temperature of a place, etc. Use of angles for expressing longitudes and latitudes on the globe, locating places on the globe using the measures of longitudes and latitudes, dividing the surface of the globe in to broad climatic regions based on their proximity to equator/ to the poles, etc. were areas identified for the study. Scientific concepts relating to heat transmission, atmospheric heating, effect of differing slanting of sun's rays from place to place and from one season to another were other areas selected for detailed inquiry.

In inquiry-oriented, materials-centered geography classrooms where text-based learning is de-emphasized, dialogue is a key resource for fostering students' cognitive growth. The teacher enters discussions with students to understand their thinking and move it along. The teacher provides verbal scaffolds--supports that enable students to build powerful thinking strategies and conceptual understanding. To support the students understanding of the concepts, verbal scaffolds in the form of discourse strategies (repeating, recasting, questioning, cued elicitation, use of analogy and meta comments) were used. Furthermore, multimodal scaffolds which include visuals (like maps, diagrams and pictures) gestural and actional cues were employed whenever necessary.

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h) Research Results

I) Comparison of The Total Cognitive Terminal Behavior of the two Experimental Groups equated for their entering behavior in Geography.

The fact that the efficacy of any learning situation will depend on the entering behavior of the learners, in respect of the content that the group is required to learn is well accepted in scientific literature. The entering behavior of the two groups were equalized with the help of a common test in geography. This helped to partial out differences if any and reduced the groups to two equated groups each of size 57.

Statistical Data used for Comparison of the Total Cognitive Terminal Behavior of the Two Equated Experimental Groups (EG1 and CG1).

Table1

	Experimental Group	Control Group
Mean	29.2 (M_1)	14.5(M_2)
Standard Deviation	0.8	3.0
Sample size	57(N_1)	57 (N_2)
Critical Ratio = 38.32 (t)		

The very high t-value shows a difference in favor of the EG1. The critical limit for significance at the 0.01 level is 2.58. The t-value obtained is much higher than the above critical limit. This helps us to conclude that the Total Cognitive Achievement for the equated EG1 is far higher than that of the equated CG1.

II) Comparison of the performance of EG1 and CG1 for each of the sub-components of cognitive achievement.

The previous section of the analysis attempted to assess the effectiveness of the experimental method for producing 'Total Cognitive Outcomes' over the practicing classroom pedagogies. The present section goes deeper in to the question: the efficacy of the EIS for developing each of the six sub-components of the cognitive domain as defined in Bloom's Taxonomy- Knowledge, Comprehension, Application ,Analysis, Synthesis, and Evaluation.

a. *Statistical Data used for the Comparison of the performance of EG1 andCG1 'KnowledgeComponent 'of Terminal Behavior of the Two Experimental Groups*.

Table 2

	Experimental Group	Control Group
Mean	7.9 (M_1)	5.5 (M_2)
Standard Deviation	0.4	1.1
Sample size	57(N_1)	57 (N_2)
Critical Ratio = 15.4 (t)		

The t-value of 15.4 is much greater than the critical level(viz.t=2.58).This leads us to conclude that EIS had a greater influence on EG1 than that of CG1.

b. *Statistical Data used for the Comparison of the performance of EG1 andCG1 for 'ComprehensionComponent 'of Terminal Behavior of the Two Experimental Groups*.

Table 3

	Experimental Group	Control Group
Mean	6.0 (M_1)	3.4 (M_2)
Standard Deviation	0.1	1.0
Sample size	57(N_1)	57 (N_2)
Critical Ratio = 19.47 (t)		

The statistical test of significance for difference between means of the EG1 and CG1 shows a high t-value of 19.47. This clearly proves the effectiveness of the EIS in developing the comprehension component.

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c. *Statistical Data used for the Comparison of the performance of EG1 and CG1 for the 'Application Component 'of Terminal Behavior of the Two Experimental Groups.*

Table 4

	Experimental Group	Control Group
Mean	3.6 (M_1)	1.6 (M_2)
Standard Deviation	0.5	0.7
Sample size	57(N_1)	57 (N_2)
Critical Ratio = 17.87 (t)		

The high t-value of 17.87 is a clear proof of the effectiveness of the EIS in developing the comprehension component as against the conventional teaching strategy used for the CG1.

d. *Statistical Data used for the Comparison of the performance of EG1 and CG1 for the 'Analysis Component 'ofTerminal Behavior of the Two Experimental Groups.*

Table 5

	Experimental Group	Control Group
Mean	4.9 (M_1)	1.7(M_2)
Standard Deviation	0.3	0.8
Sample size	57(N_1)	57 (N_2)
Critical Ratio = 30.45 (t)		

The very high t-value helps us to conclude that EIS used for the EG1 is more effective than the strategy used for the CG1.

e. *Statistical Data used for the Comparison of the performance of EG1 and CG1 for the 'SynthesisComponent 'ofTerminal Behavior of the Two Experimental Groups.*

Table 6

	Experimental Group	Control Group
Mean	3.0 (M_1)	1.3(M_2)
Standard Deviation	0.2	0.6
Sample size	57(N_1)	57 (N_2)
Critical Ratio = 17.65 (t)		

The advantage of the superior learning efficacy created by the EIS has resulted in the observed differences.

f. *Comparison of the performance of EG1 and CG1 for the '**Evaluation Component**'of Terminal Behavior of the Two Experimental Groups.*

Table 7

	Experimental Group	Control Group
Mean	3.8 (M_1)	1.1(M_2)
Standard Deviation	0.4	0.8
Sample size	57(N_1)	57 (N_2)
Critical Ratio = 24.75 (t)		

The statistical test of significance for difference between means of theEG1 andCG1 has yielded a high t-value of 24.75, which is far greater than the critical level set for difference at the 0.01 level, viz., t=2.58.

IV. Discussion

The Total Cognitive Terminal Behavior of the two experimental groups equated for their entering behavior has yielded a very high t-value of 38.2, showing that differing levels of entering behavior when equated tends to increase the t-value. This would also mean that partialing the effect of entering behavior increases the level of learning of the experimental group. When it comes to the six components of cognitive learning (Knowledge, Comprehension, Application, Analysis, Synthesis, and Evaluation), the strategy is still effective, but to a lesser extent than for total cognitive learning. This helps us to infer that EIS is most effective for augmenting total cognitive learning. The high t-value obtained for the 'Analysis component' of cognitive outcomes is a clear proof that EIS has a special advantage in respect of meeting the analysis component.

The above analysis provides dependable evidence of the fact that the experimental strategy for teaching the select topic in geography yields far better results in achieving higher levels of geography learning than the practicing class room pedagogy adopted by the control group for teaching the same content. The fact that the two original groups were made equal in

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respect of their entering behavior helps us to draw more dependable conclusions about the role of the new strategy to be tested. The fact the Test of Terminal Behavior, in which cognitive outcomes are measured using more sharp -focused and technically constructed tests of learning outcomes, which measure the students deeper level of cognitive functioning like 'analysis, synthesis and evaluation, not normally done in routine class tests,also must have contributed to the noticed differences. The topic selected was also one that demanded sharper concept-oriented and skill oriented methodologies for teaching, as compared with the routine teaching areas in geography like economic geography, human geography which constitutes a major portion of school geography.

V. Conclusions

This study proved beyond doubt the superiority of the EIS viz.,'The Scaffold- Supported Inquiry Method'for teaching secondary school geography.The highly significant differences noticed for each of the seven cognitive outcomes(Total cognitive outcome and six sub-components) used in the study support the fact that the experimental instructional strategy is a highly effective procedure for teaching complex and abstract areas of geography which demands mental manipulation of three-dimensional concepts and constructs like longitudes and latitudes, uses of angular measurements for fixing the location of places on a sphere. The highest critical differences were evident for total cognitive outcomes as compared with the corresponding differences obtained for the six component cognitive outcomes. This indicates the fact that although the EIS is more useful for developing total cognitive outcomes, as defined in Blooms Taxonomy ,it is not equally efficient in producing each of the six component cognitive outcomes separately ,even when we know that the EIS succeeded in creating highly significant t-differences for each of the component cognitive outcomes, although to a slightly lesser extent than for total cognitive outcomes.

All the seven cognitive outcomes (six component cognitive outcomes and their total) were all seen to show highly significant and relatively high positive correlations with each other. The inter correlations among the six component cognitive outcomes are much higher than the similar correlations of the component cognitive outcomes with total cognitive outcome. These R-values are in the range 0.761 to 0.925. This is to be interpreted as due to the presence of a possible common ability component running through all the six component outcomes.

VI. Implications

- A teaching method with a proper balancing of real 'learner involvement in learning'coupled with 'properly conceived and effectively operated teacher support' will help to augment the quality of cognitive learning of students, as compared with the methodologies normally used in present-day classrooms.
- The twin principles, the first intended to 'make the learner responsible for his / her learning', and the second 'the need for professional intervention of the teacher at appropriate points' are to be borne in mind by teachers of geography (or teachers of every subject for that matter) especially when teachers want to teach complex areas of physical geography or its equivalent content in different subjects.
- Partialing the effect of entering behaviour increases the level of learning of the experimental group.
- The success of the EIS in the present study probably indicates the need to evolve parallel methodologies for teaching other areas of physical geography which overlap with physics, mathematics and other life sciences, using the same strategy.
- Topics in geography like layers of the atmosphere, pressure belts, rainfall, wind movements, soil erosion, salinity of the sea, environmental pollution, population migration, etc. are some of the possible areas in geography which are best taught using the new instructional strategy validated in the present study.
- It will be most beneficial if the state curriculum committees in the country make specific references to areas in social-science teaching which can be taught most effectively using the present strategy (EIS) with proper adaptations.

The present study is only an attempt to open a new instructional approach for adoption by the teaching community for teaching science-based areas in social sciences in a big way, if the spirit of 'scientific inquiry' and 'self-discovery' are the preferred teaching approaches for improving the depth of geography learning.

VII. Future Research

A study of the relative efficacy of the present instructional strategy in producing the crucial cognitive and affective outcomes using factor analysis of the relevant cognitive and affective outcomes indicated among select experimental and control groups, like what has been used in the study. A comprehensive study for validating the present methodology (Scaffold-Supported Inquiry Method) for teaching geography in secondary schools, with several other causal / intervening variables for testing its effectiveness for producing several crucial affective outcomes in the other significant domains of human behaviour – affective and psychomotor dimensions, and the more specialized dimensions of cognitive behaviour.

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