

## CHAPTER 6 — CONCLUSIONS

### a. Introduction

In this final chapter, I will attempt to draw implications from the behavior described in the previous chapter, and then I will attempt to make certain recommendations for mathematics teaching as well as for further research. The most important recommendation at this point is that this report be studied thoroughly and that each person draw conclusions for himself. This final chapter should be written by each person for himself as he considers the problem and the evidence presented. I intend to do much study myself before I will be satisfied with my conclusions. Only then can a satisfactory final chapter replace this hasty and inadequately prepared statement.

The first part of this chapter dealing with the implications of the data will consider educational, social and epistemological implications. The second part will try to outline some steps to be followed in developing mathematics teaching in Africa, as well as in pursuing research related to this project. These implications and recommendations are, of course, tentative, and will thus be brief and general. As this report is studied and the research amplified, more specific conclusions can and should be drawn.

### b. Implications of the Project

#### (1) Educational

In the first place, the tribal languages should be observed carefully and used where they reinforce the concepts to be taught in school. The use of pre-mathematical and pre-logical language by children in their homes can provide a useful foundation for teaching in the school. We are not necessarily recommending that the first years of school be in the tribal language, since this is not

always possible or desirable. But isolated concepts and terms and features from the language can be used very effectively. Thus, in the Kpelle language, the terms for set and group can be put to good use in teaching elementary mathematics. It is probable that such terms are known in most African languages and these should be sought for and used.

Terms for other important concepts should also be isolated and drawn upon. Mathematics has to do with the presentation, aspect, measure and value words, whether in English or in any other language. We must build on these words in our classes. We should know what measures are used, and we should use those measures in the classroom to teach precise measurement. We should study carefully the structure of the number names in the language known by the children and build the English number names in parallel. We should know how objects and material are organized into fields of attention, and how their presentation is named, so that when we teach the relation of numbers to objects and material, we can build upon previous knowledge. We should know what general aspects are considered by persons within the society, and we should use them. The scheme presented in this report will prove useful in organizing that knowledge in any culture.

Then we must know properly how to form propositions. Mathematics depends in many ways upon the proper organization of statements so that these statements make sense. Not only must the terms used be culturally relevant, but the form of the statement made up of the terms must be a familiar form. English syntax which has no parallel in the tribal language will prove a barrier to effective learning. The scheme for the analysis of proposition-formation presented in this report should prove useful for that analysis in any language.

Finally, we must study how arguments are constructed in the language, so

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that we can give convincing proofs of mathematical facts. Proofs which are not convincing to the students, for cultural or linguistic reasons, are almost worse than no proofs at all. Of course, where proofs in the tribal culture depend solely on authority and tradition, it may be necessary to introduce some new procedures. But this must be done cautiously and carefully, so that the students are fully aware that something new is happening. Otherwise, the mathematics class will be a class in memorizing elaborate nonsense, as it so often unfortunately is at the present.

Tribal concepts, materials and experiences must be used throughout as illustrations of mathematical structures, concepts and facts. If this is not done, mathematics will remain a foreign discipline, "full of sound and fury, signifying nothing". The analysis given in this report for the Kpelle culture should suggest a procedure for analyzing the culture of any other society, and particularly mathematical behavior within that culture.

All this information should guide the writing of mathematics textbooks. However, it is likely that there is considerable variation in mathematical behavior between the different tribal groups. Thus the teachers' guides for textbooks should include instructions for finding the relevant concepts in the culture within which the teacher is working. This activity should be a cooperative venture between teacher and student. If the teacher knows precisely what he is looking for in order to prepare the student's way to learn a certain concept, then he can question the students for this information. In answering the questions, the students will learn more about their own society, and will by the very process begin to learn what the teacher wishes to teach them.

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It may result from further study that some of the behavior discovered within the Kpelle culture is true on a wide scale in African tribes. If that is the case, this behavior should be incorporated into the textbooks, and the teacher instructed how to apply it. Wherever possible, such behavioral patterns should replace patterns which draw on western culture.

The last implication to be drawn about the educational process is that a pre-school kindergarten program, along intelligently organized lines, will probably aid mathematics learning. We have not yet done research in this area, but the research is necessary and will probably bear out our initial opinions. The children are very inadequately prepared for school, particularly so compared with children who come from educated homes, and it may be that this preparation can take place in a school or nursery or kindergarten.

(2) Social

We should be able to help ease the difficulties of transition from the tribal to the western culture with the knowledge we are gaining from this project. Not only will the education that children receive be more meaningful, but we can see those areas wherein the two cultures differ most radically. We can make suggestions for adult literacy and vocational training, based on the mathematical deficiencies uncovered in this report. There have already been some attempts by myself and others here in Liberia to develop an adult literacy program in mathematics, and it is hoped that the value of these classes can be studied and reported by next year. In this way we should be able to make recommendations to employers of tribal persons, so that they can see, in a controlled way, the potential weaknesses and deficiencies of their employees.

From this information, we can develop suggestions for in-service training programs for companies hiring substantial numbers of illiterate or semi-literate employees.

Another area where this information can be used is that of public health and town planning. It is evident that a tremendous job is needed in improving health and living facilities in tribal and especially in transitional communities. An extension of this study into the areas of health and welfare should prove important and significant. These problems are in many cases very closely related to problems in learning basic science and mathematics.

(3) Epistemological

We are not ready at this point to draw firm inferences from our data concerning possible universal aspects of human knowing and learning, and likewise those areas wherein cultures may differ. However, we can hazard a few tentative guesses from a comparative analysis of Kpelle and English behavior.

In the first place, the analysis of descriptions of fields of attention fits Kpelle and English structure so well, that it may possibly be a universally applicable analysis. If that is the case, we have learned something important about the way people think and present their thoughts. In particular, it is important to observe the split in a given language between countable and non-countable fields of attention, and notice the ways in which both cultures describe singular, plural, generic and individualized fields of attention. Both Kpelle and English recognize the difference between discrete objects and continuous material, although they put different contents in different categories, and use different formal techniques for expressing the qualities of existing things. It may be that all languages mark this distinction between discrete

and continuous.

In the second place, our analysis of the organization of propositions may be applicable to a wide variety of languages. Grammar and syntax vary widely from language to language, but doubtless there are elements in common. It is possible that one common element is the separation of propositions into atomic and molecular, and the construction of atomic propositions from subject and predicate. Moreover, certain of the logical connectives may be universal in character, although this is less likely, since certain English logical connectives are not found in simple form in Kpelle and vice versa.

In the third place, it may be that argumentation is always of the same form, namely, a series of propositions followed by a marker indicating implication. This seems to be true in both English and Kpelle, and might be true of all languages and cultures. However, the sort of evidence that justifies an implication seems to differ from culture to culture, and thus we are not yet ready to draw conclusions. The types of evidence used are probably small in number, and these types should eventually be listed and categorized.

In the fourth place, it seems that learning by imitation is common to many societies. It appears that almost all learning within the Kpelle culture, certainly all learning relevant to mathematics, takes place when children observe and imitate the adults in the culture. However, there does not appear to be any learning procedure analogous to our scientific method which is common to many cultures. Kpelle culture in particular does not seem to make use of this procedure, but relies on authority and tradition for its responses to problems. It can perhaps be said that the Kpelle man lives within an environment which he accepts without making an effort to change it.

c. Recommendations

(1) Mathematics teaching

In the first place, there are several areas where the tribal culture offers useful analogies to what is to be taught in mathematics. These analogies must be used in the ways mentioned above. All teaching requires that bridges be built from what is known to what is to be learned. Each bridge, moreover, must be constructed from materials already familiar to the learner. In this way, he moves in easy steps from the familiar to the unfamiliar. The specific topics which can provide bridge material from the traditional culture to the incoming western culture are to be found for each society by careful study. The method outlined in this report should prove useful, and the specific areas of strength discovered in the Kpelle society should be suggestive for similar areas of strength in other cultures.

In the second place, stress must be placed on those areas where the tribal culture is particularly weak, in order to overcome the deficiency. For example, the Kpelle culture is weak in the recognition and use of geometrical shapes and figures. Thus an elementary mathematics program must try to overcome that deficiency, and develop a vocabulary and working knowledge of shapes that many western children knew before they entered school. The systematic use of materials such as puzzles and games, as well as careful surveys of customary village life for geometrical shapes, should prove helpful in this regard.

The Kpelle culture is also weak in the area of formal logic. Much work is needed to overcome this weakness, and thus the elementary mathematics curriculum should stress logical puzzles and games. Word problems are well<sup>known</sup> to be a great source of difficulty in Liberian schools, and this is probably due as much to the deficiency in logical reasoning as it is to the language barrier. People are

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unaccustomed to use reasoning to reach a conclusion in mathematical operations, and thus this form of argumentation needs to be stressed from the earliest days of school. In particular, the child should be encouraged to ask questions so that he can see the difficulties and begin to suggest ways to overcome them.

This leads to the third area of weakness in Kpelle culture. There seems to be no use made of the scientific method in problem solving. Thus when children come to school, they expect to receive traditional lore, handed down as if from on high. They are not familiar with the exercise of unprejudiced curiosity, but rather expect to be told to memorize something. Thus we need to put much more stress on discovery in mathematics than on rote learning. Kpelle children are excellent at rote learning and imitation of adults. What they need is to be put on their own to discover truths and answers to new problems. In this way, they will understand better what mathematics really is, namely, "the deductive investigation, with predictive consequences, of quantitative models representing human fields of attention."

A fourth weakness in Kpelle culture is its lack of abstract mathematical operations and terminology. For instance, nominal aspect names are largely absent from the language, except for artificial words made up by foreigners. Likewise, abstract arithmetic is not known, and thus when it is encountered in school it is treated as something purely formal and mechanical—and meaningless. The gap between concrete statements of qualities, measures and values, on the one hand, and abstract mathematics on the other, must be bridged, and special attention must be paid to it in writing textbooks and teaching classes.

A fifth weakness in the Kpelle culture is its lack of precision. This precision is, of course, not needed in the society, where the tradition has created a

way of life which is approximate and qualitative in the extreme. Thus the schools should from the earliest grades stress mathematical precision and rigor. Statements should be exact and precise, and the student should neither hear nor be allowed to say anything vague and indefinite. However, this cannot be done without reference to the cultural situation. There are some areas in tribal life where precision is valued, and these must be used in building the bridge from the traditional way to the new way.

There are, of course, many other areas where mathematical weakness in the Kpelle society contributed to inadequate education. Several of these are stated in detail in the body of this report, and others will be discovered as the research proceeds. It is to be hoped that further research will show how these weaknesses affect other tribes and other cultures. There may be some which are peculiar to the Kpelle tribe, while there may be some which are common to wide areas of Africa and even of the world.

The third area of study concerns modifications in teaching method, based on the differences in observed learning procedure between the Kpelle and western cultures. We do not know enough, however, about the Kpelle society to make detailed suggestions. From what we know thus far, it seems that we have an open road to experiment with new procedures, since little is done in Kpelle society to further the intellectual development of children. The only thing to beware of is the tendency Kpelle children have to accept and learn their elders' modes of behavior as authoritative. They have not been trained to be critical and curious, approaching a new problem with an open and analytical mind. Whatever procedure we follow in teaching, the inculcation of the scientific method must be an important part of it.

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We also feel that it would be useful to have pre-school instruction to prepare the children for the school experience. The Kpelle home is barren of anything which would promote arithmetic or reading readiness. Thus, if these materials could be put in the children's hands in a kindergarten situation, their education might be improved radically. But research needs to be done in this area before any definite conclusions can be drawn.

(2) Research

This report is in its very incompleteness a recommendation for further study. The final chapter has been brief and tentative, not only because of lack of time to prepare it, but also because the data is insufficient to make firm recommendations. Thus the first demand for further research is that the present project be completed. At various points throughout the report, there have been statements to the effect that a particular point has not been explored properly, or that no data is available from which to draw conclusions. Thus it is necessary first to follow up all these points, and bring this phase of the study to a close.

Specifically, the following areas need further study. The conclusions drawn concerning the description of fields of attention and the construction of propositions need to be formalized, and then checked in a new setting, to determine their validity. If possible, tests should be designed which would verify specific implications derived from these conclusions. The construction of arguments must be examined in much more detail, so that conclusions can be drawn, and their implications tested in a new setting.

Our study of the anthropological setting of mathematics needs to be verified in a different town, where we have not already so thoroughly tested the people that their usefulness as informants is seriously reduced. We must formalize

and clarify our statement of the role of mathematics in the culture, draw implications from it, and test these implications in the new town.

Our work in psychological experimentation is most incomplete at the present. We need more subjects for many of the tests administered. We need a full statistical analysis of those data. And we need to design tests which will show the strength of the presence of other concepts, particularly geometrical and logical. Finally, we need to devise a procedure to show the emotional underlying factors, which influence mathematics learning and teaching.

The study of learning procedures within the culture has barely been started. We do not yet have a procedure by which to study the way Kpelle children learn mathematical and logical concepts. We must give serious thought to this question and attempt to find a way to learn what we wish to know. We then must carry out the tests or observations, draw implications from them, and test these implications. We also need to learn more about patterns of cultural change, so that we can be precise and exact in speaking of them, instead of vague, indefinite and subjective.

The next area for work after the completion of the Kpelle study is, of course, the preparation of the final report of that study. And on the basis of that report we must draw up a systematic statement of the research procedure so that other persons can follow that procedure in studying other cultures. The method must be so well worked out, and so explicitly stated, that persons without elaborate training in linguistics, anthropology, mathematics, philosophy and education can follow the steps and organize the data. Thus it is hoped that the procedure will be of the questionnaire type. One of the reasons, of course, for the extensive support provided to the present project is that such support need not be supplied for similar future projects. The groundwork will have been laid, and

the remainder of the construction should be much easier.

Thus we recommend that, using this standardized procedure, a study similar to the present one be carried out in a series of widely divergent cultures. For example, there should be cultures chosen from each of the major language and culture groups in tropical Africa, in order to get a clear picture of the mathematical situation across the continent. There should be studies done in the major creole and pidgin languages in tropical Africa, e.g., Sierra Leone Krio, Portugese Creole, Liberian English, Nigerian and Cameroon pidgin, the French Patois, Congo Swahili, Tanganyika Swahili, and other pidgins and creoles as they are discovered. Some comparative studies should also be made on other continents, so that any features peculiar to Africa can be isolated for further study. And, finally, a comparative study should be undertaken in developed nations, to provide standards for analyzing the data. These comparative studies should, of course, treat the four aspects considered in this project: linguistics, anthropology, psychology and education.

Then, using this data, a general study should be made by persons competent in these fields of cross-cultural differences and similarities, in the hopes of arriving at general conclusions concerning pre-mathematical and pre-logical behavior in human society in general. This inquiry should then lead to a broad statement concerning human knowing and learning in mathematics and logic and related fields, itself a significant contribution to the discipline of philosophy.

The final important area to be the subject of further research concerns related concepts in the other sciences. Such an inquiry should begin with an analysis of the behavior which is relevant to the physical sciences in non-western culture. An inventory of concepts and behavior related to these sciences should be made, in parallel with the findings of this present study of pre-mathematical

and pre-logical behavior. Likewise, a survey of biological science should be made within these cultures. Another science to be studied is the technology of the tribal peoples, as related to technology in more developed cultures. From this information an entire survey of technical activities in these cultures can be made.

This general comprehension of technical behavior can then provide information for understanding the more complex disciplines of history, religion, the arts, and philosophical speculation. Finally, it is to be hoped that this project will lead to a general philosophy of human knowing, an object which has been sought for years, but only within the context of developed cultures. This is a massive undertaking, but the conclusions should be worth the effort.