

**BOTSWANA STUDENT TEACHERS' VIEWS ON THE  
NATURE OF SCIENCE AND SCIENTIFIC METHOD:  
A CRITICAL REFLECTION**

by

**APARNA KADIYALA**

Submitted in part fulfillment of the requirements for  
the degree of

**MASTER OF EDUCATION –WITH SPECIALISATION IN  
NATURAL SCIENCE EDUCATION**

at the

**UNIVERSITY OF SOUTH AFRICA**

**SUPERVISOR: PROF P HIGGS**

**JOINT SUPERVISOR: PROF E O MASHILE**

**JUNE 2005**

Student number : 3306-121-1

## **DECLARATION**

I, Aparna Kadiyala, declare that **BOTSWANA STUDENT TEACHERS' VIEWS ON THE NATURE OF SCIENCE AND THE SCIENTIFIC METHOD: A CRITICAL REFLECTION** is my own work and that all the sources that I have used or quoted have been indicated and acknowledged by means of complete references.

**SIGNATURE**\_\_\_\_\_

**DATE**\_\_\_\_\_

**(MRS A KADIYALA)**

## **ABSTRACT**

The assumption of the present study is that teachers should possess an adequate understanding of the nature of science and scientific method and hence this aspect was investigated. The empirical research carried out with Secondary School teacher trainees at Botswana colleges of education showed the following:

Subjects possess an adequate understanding of some aspects of the nature of science and several aspects of the scientific method. They however do not have an adequate understanding on certain aspects of the nature of science. An association was found between the nature of science, type of educational institution attended, years of study and majoring in science. A positive association was found between scientific method and years spent studying. The present study recommended the inclusion of history, philosophy and sociology of science in the curriculum of teacher education.

## **ACKNOWLEDGEMENTS**

I take this opportunity to express my gratitude to my supervisors **Professor P. HIGGS and Professor E.O. MASHILE, UNISA** for their guidance, suggestions, criticism, and constant encouragement in my completion of this study.

I am also thankful to **Mrs. B . MODONGO**, principal of Tonota College of Education in Botswana, and colleagues of the Science Department at Tonota and Molepolele Colleges of Education who provided me with the time, space and facilities to pursue this research.

I would also like to extend my thanks to **Mr. Gerber** for his valuable suggestions on the analysis of the results and to **Mrs. Jane Smith**, who edited the final draft.

My heartfelt thanks to all the **science student teachers** of Tonota and Molepolele Colleges of Education for their cooperation.

Finally, my heartiest thanks to my husband **Mr. Benarji** and my son **Sree Nikesh** and, indeed, to all my family members, for sharing my joy and problems as I worked on this study.

**Aparna Kadiyala**

## **KEY WORDS**

Student teachers, pre-service teachers, pre-service teacher education, nature of science, scientific method, scientific knowledge, scientific observations, scientific theories, scientific laws, scientific models, scientists' work, gender, type of educational institution, years spent in study, science major / minor teaching subject and post –positivist views /non-traditional views.

## **TABLE OF CONTENTS**

### **CHAPTER 1: ORIENTATION**

	<b>PAGE NO</b>
<b>1.1</b> Introduction	<b>1-4</b>
<b>1.2</b> The significance of the present study	<b>5-6</b>
<b>1.3</b> Statement of the problem and background information	<b>7-11</b>
<b>1.4</b> Objectives	<b>11</b>
<b>1.5</b> Clarification of concepts used in the research project	<b>12</b>
<b>1.6</b> Theoretical framework and research design	<b>13-18</b>
<b>1.6.1</b> Theoretical framework	<b>13-16</b>
<b>1.6.2</b> Research design	<b>17-18</b>
<b>1.7</b> Programme of study	<b>19</b>

### **CHAPTER 2: VIEWS ON THE NATURE OF SCIENCE AND THE SCIENTIFIC METHOD: AN INTERNATIONAL PERSPECTIVE**

<b>2.1</b> Introduction	<b>20- 22</b>
<b>2.2</b> Pre-service teachers' views on the nature of science and scientific method	<b>22-43</b>
<b>2.2.1</b> Pre - service teachers' views on the nature of science	<b>23-39</b>

2.2.1.1	Pre-service teachers' views of scientific observations	24-26
2.2.1.2	Pre-service teachers' views on the status, role and validation of scientific theories	26-30
2.2.1.3	Pre-service teachers' views on the status and role of scientific laws	30-32
2.2.1.4	Pre-service teachers' views on the status of the scientific models	33
2.2.1.5	Pre-service teachers' views on the nature, generation, development and progression of scientific knowledge	34- 36
2.2.1.6	Pre-service teachers' views on the nature of scientists work	37-39
2.2.2	Pre-service teachers' views on the scientific method	40-42
2.2.3	Summary of pre-service teachers' views on the nature of science and the scientific method	42- 43
2.2.4	Possible reasons for discrepancy in previous research findings	44- 50
2.2.5	Factors that influence Pre-service teachers' understanding of science and scientific method	50-57
2.2.6	Data-collection instruments used in previous research studies	58-61
2.3	Summary of chapter 2	62-63

## **CHAPTER 3: RESEARCH METHODOLOGY AND PRESENTATION, ANALYSIS AND DISCUSSION OF RESULTS**

<b>3.1</b>	<b>Introduction</b>	<b>64</b>
<b>3.2</b>	<b>Research methodology</b>	<b>64 - 84</b>
<b>3.2.1</b>	<b>The main research questions</b>	<b>65</b>
<b>3.2.2</b>	<b>The methods of study</b>	<b>66</b>
<b>3.2.2.1</b>	<b>Variables used in the study</b>	<b>67-68</b>
<b>3.2.3</b>	<b>Research design</b>	<b>69-84</b>
<b>3.2.3.1</b>	<b>Description of instrument: Questionnaire</b>	<b>69- 74</b>
<b>3.2.4</b>	<b>Validity and reliability of instruments, procedure and content</b>	<b>74- 75</b>
<b>3.2.5</b>	<b>Description of population and sample</b>	<b>76-79</b>
<b>3.2.5.1</b>	<b>Diagrammatic representation and analysis of sample</b>	<b>80-82</b>
<b>3.2.6</b>	<b>Data collection</b>	<b>82</b>
<b>3.2.7</b>	<b>Hypotheses</b>	<b>83-84</b>
<b>3. 2.8</b>	<b>Data analysis</b>	<b>84</b>
<b>3.3</b>	<b>Analysis and discussion of the research results</b>	<b>85-120</b>
<b>3.3.1</b>	<b>Presentation and analysis of collected data</b>	<b>85-90</b>
<b>3.3.2</b>	<b>Item analysis</b>	<b>91-94</b>
<b>3.3.3</b>	<b>Presentation of results</b>	<b>94-96</b>
<b>3.3.4</b>	<b>Analysis and discussion of results for research question and objective one</b>	<b>97-106</b>
<b>3.3.4.1</b>	<b>The nature of science</b>	<b>97-103</b>
<b>3.3.4.2</b>	<b>Scientific method</b>	<b>104</b>
<b>3.3.5</b>	<b>Summary of student teachers' views on the nature of science and the scientific method</b>	<b>105-106</b>

<b>3.3.5.1</b>	Student teachers' views on the nature of science	<b>105</b>
<b>3.3.5.2</b>	Summary of student teachers' views on the scientific method	<b>106</b>
<b>3.3.6</b>	Analysis and discussion of results for research question and objective 2	<b>107-120</b>
<b>3.3.6.1</b>	Nature of science, scientific method and gender	<b>108-109</b>
<b>3.3.6.2</b>	The nature of science, the scientific method and type of educational institution attended	<b>110-112</b>
<b>3.3.6.3</b>	The nature of science, the scientific method and years spent in studying	<b>112-114</b>
<b>3.3.6.4</b>	The nature of science, the scientific method and science as a major/minor teaching subject	<b>115-117</b>
<b>3.3.7</b>	Summary of results based on research question and objective 2	<b>118-120</b>
<b>3.3.7.1</b>	The nature of science, the scientific method and gender	<b>119</b>
<b>3.3.7.2</b>	The nature of science, the scientific method and type of institution attended	<b>119</b>
<b>3.3.7.3</b>	The nature of science, the scientific method and years spent in studying	<b>119</b>
<b>3.3.7.4</b>	The nature of science, the scientific method and whether science is offered as a major or minor teaching subject	<b>120</b>
<b>3.4</b>	Summary of chapter 3	<b>120</b>

## **CHAPTER4:**

### **CONCLUSIONS AND RECOMMENDATIONS**

<b>4.1</b>	Introduction	<b>121-122</b>
<b>4.2</b>	Summary of the research	<b>122-129</b>
<b>4.2.1</b>	Conclusions from literature review	<b>123-126</b>
<b>4.2.2</b>	Conclusions from present empirical research	<b>126-129</b>
<b>4.3</b>	Implications and recommendations for improvement of student teachers' understanding of the nature of science and the scientific method	<b>130-133</b>
<b>4.3.1</b>	The implications of, and recommendations for, future curricular development teacher education	<b>131-132</b>
<b>4.3.2</b>	Suggestions and recommendations to teacher trainers	<b>132-133</b>
<b>4.4</b>	Limitations of the present study	<b>134</b>
<b>4.5</b>	Further research	<b>135-136</b>
<b>4.6</b>	Summary of chapter 4	<b>137</b>

<b>BIBLIOGRAPHY</b>	<b>138-143</b>
---------------------	----------------

<b>APPENDIX A – QUESTIONNAIRE TO STUDENT TEACHERS</b>	<b>144-150</b>
---	----------------

## LIST OF FIGURES

<b>Figure 1:</b>	Diagrammatic representation of percentage of male and female student teachers in the sample	<b>80</b>
<b>Figure 2:</b>	Diagrammatic representation of percentage of Tonota and Molepolele student teachers in the sample	<b>80</b>
<b>Figure 3:</b>	Percentage of 1 <sup>st</sup> , 2 <sup>nd</sup> and 3 <sup>rd</sup> year student teachers in the sample	<b>81</b>
<b>Figure 4:</b>	Percentage of major and minor student teachers in the sample	<b>81</b>
<b>Figure 5:</b>	Percentage of responded and non-responded male student teachers in the sample	<b>86</b>
<b>Figure 6:</b>	Percentage of responded and non-responded female student teachers in the sample	<b>87</b>
<b>Figure 7:</b>	Percentage of responded and non-responded Tonota college student teachers in the sample	<b>87</b>
<b>Figure 8:</b>	Percentage of responded and non-responded Molepolele college student teachers in the sample	<b>88</b>
<b>Figure 9:</b>	Percentage of responded and non-responded major student teachers in the sample	<b>88</b>
<b>Figure 10:</b>	Percentage of responded and non-responded minor student teachers in the sample	<b>89</b>
<b>Figure 11:</b>	Percentage of responded and non-responded first-year student teachers in the sample	<b>89</b>
<b>Figure 12:</b>	Percentage of responded and non-responded second-year student teachers in the sample	<b>90</b>
<b>Figure 13:</b>	Percentage of responded and non-responded third-year student teachers in the sample	<b>90</b>

## LIST OF TABLES

<b>TABLE 1:</b>	Description of latent factor and observed variables	<b>67</b>
<b>TABLE 2:</b>	Description of factors, variables and number statements and rationale for each statement	<b>71-72</b>
<b>TABLE 3:</b>	Description of factors, variables, statements and pattern of scoring	<b>73</b>
<b>TABLE 4:</b>	Distribution of sample according to gender, type of institution, years of study and science major/ minor teaching subject	<b>79</b>
<b>TABLE 5:</b>	Analysis of the questionnaire responses according to gender, type of educational institute, science as major / minor teaching subject and years spent in studying	<b>85</b>
<b>TABLE 6 :</b>	Item analysis	<b>92</b>
<b>TABLE 7:</b>	Frequency and percentage of responses to questionnaire statements	<b>95-96</b>
<b>TABLE 8:</b>	Chi –square values and probability based on nature of science and gender	<b>108</b>
<b>TABLE 9:</b>	Chi –square values and probability based on scientific method and gender	<b>109</b>
<b>TABLE 10:</b>	Chi- Square values and probability based on nature of science and type of educational institution attended	<b>110</b>

<b>TABLE 11:</b>	Chi – square values and probability based on the scientific method and type of institution attended	<b>111</b>
<b>TABLE 12:</b>	Chi- square values and probability based on the nature of science and years spent in studying	<b>113</b>
<b>TABLE 13:</b>	Chi- square values, probabilities based on the scientific method and years spent in studying	<b>114</b>
<b>TABLE 14:</b>	Chi- square values and probabilities based on the nature of science and science as a major / minor teaching subject	<b>115</b>
<b>TABLE 15:</b>	Chi- square values and probabilities based on scientific method and science as a major / minor teaching subject.	<b>116</b>
<b>TABLE 16:</b>	Probability values smaller than 0.05	<b>118</b>

