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Functional scientific literacy among prospective teachers: A comparative study

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Abstract
Functional scientific literacy is currently considered the core aim for development of the citizens of the current century. Ability of making functional to the scientific literacy is determined as an important factor for fostering the performance of teachers in teaching and of students in learning. Many science studies have reported that gender influenced the teachers' functional scientific literacy (FSL) and understanding of science. However there are not much investigation in the field of the interaction between gender and functional scientific literacy. With the intention of attain more understanding on issue, this study aims to examine the functional scientific literacy among prospective science teachers and the influence of their gender (comparison of gender). A total 500 prospective science teachers were chosen as a sample across Chhattisgarh, a state of India. A self-made functional scientific literacy test (FSLT) was administered to investigate the prospective teachers' functional scientific literacy with three main domains of FSL namely (i) nature of science (NOS), (ii) science process skills (SPS), and (iii) Use of science understanding in daily life. The result indicates that the gender influence prospective science teachers' functional scientific literacy on each domain. In addition, Male prospective teachers' mean scores indicate that they are having high FSL than the female counterpart. The finding of the study indicate that there is critical area for improvement of female prospective teachers' FSL. This implies that pedagogy during training must be more emphasized on the way of teaching that how to make functional to the science knowledge which has been learned in the classroom, how to design the curriculum for implication in their daily life to solve the personal and social problems.

Keywords: prospective science teachers, Functional scientific literacy, nature of science, science process skill, science understanding

Introduction

Educational reform in the India emphasis on the need for functional scientific literacy (FSL) to prepare rational and scientifically tempered teaching staff and learner of 21st century (NCF, 2005) [1] . To become functionally scientific literate citizen is currently considered as a central goal and critical learning outcome for science education standard in Indian (Kumar and Singh 2017, NCF, 2005) [2, 1] and in several other countries (Dani, 2009; Bybee, 2008; and Dahsah & coll, 2007) [3, 4, 5]. FSL is determined as an important factor for fostering prospective teacher science teaching. Many science education researchers have reported that gender influenced the science understanding and attitudes towards science.

Functional scientific literacy can referred as practical knowledge and understanding of basic science concepts related to individuals' life in order to improve their standard of living by means of solving their problem of daily matters. Science content in functional scientific literacy would not make emphasis on theoretical and scientific principles that are unrelated to student's daily life, but rather, the emphasis would be placed on the application of scientific knowledge to the improvement of living conditions and other aspects of daily life. Teachers are the major input in attainment functional scientific literacy (Chin, 2005) [6] and promoting it at all levels of education. Due to the significant role of science teachers in preparing future scientifically literate citizens, they must be well equipped in science subjects and related skills. Studies on teachers' knowledge advocates that both teachers' subject knowledge and pedagogical knowledge are essential for good science teaching and student understanding (Shulman, 1987) [7]. Moreover, they must be trained to have a well-founded understanding of science and be up-to-dated of the current scientific issues affecting society every day. So teacher should use science education as functional tool in schools and society. This study, therefore, attempt to investigate whether gender of pre-service science teachers of Chhattisgarh state in India affect the functional scientific literacy. For this comparison tests have been carried out.

Review of literature

Studies have revealed that cognitive level of achievement in science related activities and attainment of skills can be influenced by gender in favour of boys (Ige and Arowolo, 2003) [8]. Yang (2004) [9] reported that males were found to be better than females in constructing and using theories of science. Likewise, a study done by Valanides (1997) [10] revealed that males had significantly better performance than females on scientific reasoning. Further, Catsambis (1995) [11] also found in a study that some female students have higher probabilities of enrolling in high-ability classes than males.

Yet, female students have less positive attitudes toward science, play a part in fewer relevant extracurricular activities, and seek less often to science careers than males. Scientific attitude of students and their career interests vary according to students' gender as well as their racial or ethnic background.
In contrast to the above findings Nwosu and Ebere Ibe (2014) [12] observed that if equal opportunities are given in science and technology curriculum and instruction, every student would perform well in terms of achievement of a reasonable scientific literacy levels irrespective of gender. In some other studies, Female PSTs makes a significant difference in terms of understanding of NOS and comprehension of basic science concepts (Cavas, Ozdem, Cavas, Cakiroglu, & Ertepinar, 2013) [13]. Similarly, Altun, Sibel, and Turgutm (2011) [14] reported that Gender has no effect on scientific literacy levels.

Objective of the study
The current study aimed to find out answer to the question:
Is there a gender difference among prospective science teachers with functional scientific literacy as a whole?
Is there a gender difference among prospective science teachers with functional scientific literacy as a part (Domains of FSL)?

Hypotheses
Null hypotheses that guided the study were:
1. There will be significant difference between mean score of Functional scientific literacy as whole of male and female prospective science teachers.
2. There will be significant difference between mean score of Functional scientific literacy as part of male and female prospective science teachers.

Method of the study
Research Design
This Research was conducted to explore the functional scientific literacy of the prospective science teachers with respect to gender by using survey research.

Participants/ Sample
The participants for this study were 500 prospective science teachers (250 Male and 250 Female) taken as a sample across Chhattisgarh state of India. This study was administered on the prospective teachers of third semester (year 2017) of teacher training programme and they had completed their 3 month practice teaching schools. These participants had opted either Physical or Biological science discipline as a teaching method.

Instrument
Functional Scientific literacy Test (FSLT) was developed by investigator. The FSLT consists of 38 items of three main dimension that is Nature of science (13), Science process skills (12) and Use of science understanding in daily life (13). Each dimension has three tier of question from the knowledge, understanding and Application level. Each item having multiple choice question. Correct responses were awarded one point and zero mark given for wrong answer.
This instrument had been established validity and reliability. Reliability of the test was found to be .86 by calculating internal consistency using Cronbach's alpha which is considered sound for use in the study. Discrimination index and difficulty level were also established.

Domain of Functional Scientific literacy (FSL)
Functional scientific literacy has unification of three main components includes (1) Nature of Science (2) science process skills and (3) Use of science understanding in daily life.

Nature of Science (NOS)
Nature of science describes how science functions (Martin-Dunlop, 2013 and Mc Comas, 1998) [15, 16]. Includes *knowledge, process, society & community, the scientific community, and interrelationship* between these components. It prepares students for socio-scientific decision-making and scientific problem-solving, enhancing functional scientific literacy (Shamos, 1995) [17], or multi-dimensional scientific literacy (Bybee, 1997) [18].

Science process skills (SPS)
Science process skill is the event involves a series of scientific questions or tasks that contain the use of one or more process skills. These skills include *Observing, hypothesis formulation or inferring, influencing, identifying variables, design experiment or experimenting, graphical representation*. This set of skills yield developing organising possible solutions for dealing with the problems of human life and society in any step and domain of life.

Use of science understanding in daily life
It deals with the use of the principles and findings of sciences in everyday life, rather limited to universities or laboratories**.** It rejects a school science which is disconnected from their own lives and circumstances, a depersonalized science, where there is no space for themselves and their ideas (UNESCO, 2010) [19]. This implicates rationality & novelty, critical & creative thinking, use of science beyond classroom, personal & social relevancies, & solving daily life problem.

Data collection and analysis
For investigating functional scientific literacy among prospective science teachers, the FSLT was administered to the prospective teachers at the training instructions. For analysis of functional scientific literacy, significance of gender differences was analysed using mean, standard deviation, t-test between gender scores.

Result
The assumption of homogeneity of variance was tested using the Levene's test and its results are shown in Table 1. Levene's test result p-value > 0.05 showed the homogeneity of the variances between groups.

Table 1: Levene's Test for Equality of Variances

FSL	F	df1	df2	Sig. (p>.005)
Nature of science (NOS)	2.452	1	498	.118
Science process skills	1.151	1	498	.284
Use science understanding in daily life	.301	1	498	.583

The comparison of prospective teachers' functional scientific literacy scores using mean, standard deviation, and t-test explored that male and female prospective science teachers differs significantly in their functional scientific literacy as a whole (p<.05). The independent t-test, and p-value for prospective science teachers' functional scientific literacy are display in table 2.

$H_{0\ 1.}$ There is no significant difference between the mean scores of FSL (as a whole) of male and female prospective science teachers.

Table 2: t- test result for significance of mean difference of FSL on gender

Variable	Gender	N	Mean	SD	t-value	Sig.(2-tailed)
Functional scientific literacy (FSL)	Male	250	24.39	5.271	6.359	001* p < 0.05
	Female	250	21.62	4.409		

*****Significant at 0.05 level (df = 498)

On the basis of result (given in table 1) it can be assumed that the t-value is 6.359 having p- value less than 0.05, indicates that the mean Score of FSL of male and female prospective teachers differ significantly. Thus the Null hypothesis (H_0) that there is no significant difference in mean Scores of FSL (as a whole) of male and female prospective teachers is rejected. Therefore, it may be said that both male and female prospective teachers were found to have different levels of FSL.

Additionally, the mean score (24.39) of male prospective teachers showing higher than the mean score (21.62) of female counterpart. This indicates that male prospective teachers are more functionally scientific literate than the female prospective teachers.

When the dimension of FSL were considered, it found that male and female prospective science teachers differs significantly on their domain of FSL too, viz. it shows difference also on Nature of science, Science process skills, and use of science understanding in daily life. The independent t-test, and p-value for prospective science teachers' functional scientific literacy are display in table 3.

Table 3: t-test results for mean difference on FSL domain based on gender

Functional scientific literacy (FSL) domain	Gender	N	Mean	SD	t	Sig.(2 tailed) p-value
Nature of science (NOS)	Male	250	8.42	1.933	6.120	.001*
	Female	250	7.32	2.083		
Science process skills (SPS)	Male	250	7.46	2.020	6.849	.001*
	Female	250	6.24	1.989		
Use of science understanding in daily life	Male	250	8.40	1.933	3.876	.001*
	Female	250	7.72	2.012		

*****Significant at 0.05 level (df = 498), p<.05.

On the basis of the result (see table 3), it can be seen that the t-values of NOS, SPS, and 'Use of science understating in daily life' are 6.120, 6.849, & 3.876 respectively and p- values (p< 0.05), indicates that the mean Score on each domain as a part of FSL of male and female prospective science teachers differ significantly. Thus the Null hypothesis (H_0) that there is no significant difference between mean Scores FSL as a part (domain wise) of male and female prospective teachers, is rejected. So, it may be assumed that both male and female prospective teachers were found to have different levels on Nature of science, Science process skills, and use of science understanding in daily life.

Furthermore, the mean score of male prospective science teachers showing higher than the mean score of female counterpart on all of those three domains of FSL. This indicates that male prospective teachers are more functionally scientific literate on each part of FSL than the female prospective science teachers.

Discussion

Research related to functional scientific literacy shows that teacher is one of the most important component in the process of learning. Therefore, a lot of studies have been dedicated to understand the teachers' knowledge, attitude, beliefs, skills, competence etc. in the field of science teaching. The main reason underlying these intense research is the belief that teachers' cognition, views and actions would be important in shaping future generations. So, they must be trained well during their training programme. This study is also conducted on the belief that the science teachers' functional scientific knowledge is significant in the achievement of functional scientific literacy at all levels of education (Chin, 2005) [6].

The results overall showed that there are differences between genders in respect to FSL and it domain. The evidence is consistent with the research finding of Nwosu and Ebere Ibe (2014) [20] who found that the functional scientific literacy of students differ significantly in respect to gender with a better

performance of male students. almost same result had been found in studies of Yang (2004) [9]; Ige and Arowolo (2003) [8]; Valanides (1997) [10] and Catsambis (1995) [11] in favour of male that they are better in constructing and using theories of science, had significantly better performance scientific reasoning than female.

In contrast to the result of present study, Nikam (2013) [21] who found equal level of functional scientific literacy among male and female prospective teachers which was enhanced by teaching strategies. Likewise, Bacank and Gokdere (2009) [22], and Beaumont-Walters and Kola (2001) [23] have examined the relation between gender and effectiveness of the teaching strategies for functional scientific literacy and science process skills (as it is the part of FSL) among prospective teachers, and concluded that there is no much difference in the level of scientific literacy among male and female prospective teachers. The similar pattern was observed by Nwosu and Ibe (2014) [12]; Cavas, et al. (2013) [13] and Altun, Sibel, and Turgutm (2011) [14] that there would not be gap between gender if equal opportunities are given in science exposer and environment in terms of understanding, using, comprehending the NOS and science concepts.

As studies revealed that functional scientific literacy depends on some factor like understanding nature of science, science process skills, students' capability to acquire relevant and required knowledge, skills and attitudes that will enable them develop their full capacities to solve everyday life problems, improve their lives and their environment, participate entirely in decision making relating to their community progress, and be able to compete favourably are lacking. This condition may be attributed to poor student background in science and technology related tasks, ineffective science education due to teachers' lack of sufficient execution of functional scientific literacy, poor content knowledge as well as use of poor pedagogical strategies (Ibe, Nwosu, Obi, and Nwoye, 2016) [24]. So, finding in the present study, may be due having negligible amount of these factors influencing the female prospective teachers of Chhattisgarh and showing incompetent to become a functionally scientific literate and that's why differing from male prospective teachers.

Conclusion

Functional scientific literacy has significant implication for enhancing prospective science teachers' capability of scientific, useful, and meaningful teaching. Although previous studies indicated that there is no effect of gender on scientific ability and FSL (Piraksa, Srisawasdi, & Koul, 2014) [25]. The results of the present study revealed that the functional scientific literacy does depend on gender i.e. there is an effect of gender on FSL of prospective teachers. This finding highlights the importance of the need for minimising the gender gap in terms of FSL. It is essential to give a special attention to the female prospective science teachers in order to make them skilled teachers. Besides, it is suggested that training of science curriculum transaction should be given by inquiry-based methods (Johnson & Lawson, 1998; Weld, Stier, & Birren, 2011; Zimmerman, 2007) [26, 27, 28], and laboratory method (Friedler et al., 1990; Gunhaart & Srisawasdi, 2012; Liao & She, 2009; She & Liao, 2009) [29, 30, 31, 32] and other learner centric scientific methods which foster prospective science teachers' ability as the core of functional scientific literacy.

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