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Gender Differences in Learning Environment and Student Attitudes in High School Chemistry Classrooms in South Africa

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Abstract

This study reports on the research findings on associations between student's gender and their perception of their chemistry classroom environment and their attitude towards chemistry, in the Ximhungwe circuit of the Bohlabela district in the Mpumalanga province of South Africa. A sample of 210 grade 12 physical sciences students from all the ten public high schools in the circuit was selected to complete a survey on Chemistry Classroom Environment Questionnaire (CCEQ) and Attitude Towards Chemistry Questionnaire (ATCQ). One-way multivariate analysis of variance (MANOVA) and a follow-up between group analysis of variance (ANOVA) conducted showed that male and female students had a high perception of their CCEQ inventory, which was influenced by all the five sub-scales. Mean scores and Independent samples t-tests showed that both genders had a positive attitude towards chemistry. Spearman's Correlation revealed that there is a relationship among the sub-scales of chemistry classroom environment but there was no relationship between physical sciences students' perception of their classroom environment and their attitude towards chemistry by gender.

***Keywords**: attitude, chemistry, gender, learning environment, perceptions*

INTRODUCTION

Numerous studies in mathematics, physics, chemistry, and biology education have shown that student perceptions of the classroom environment account for appreciable amounts of variance in learning outcomes, often beyond that attributable to background student characteristics. This assertion stems from the fact that research conducted over the past 40 years has shown that the quality of the classroom environment

is a significant determinant of student learning (Fraser, 1994, 1998). This is to say that, students perform better and have more positive attitudes toward the subject taught when they perceive the classroom environment positively and vice versa.

Accordingly, Fraser (1998), conducted a research on students' perceptions of their classroom environment and indicated that the following goals should be focused on: (a) establishing associations between student outcomes and perceptions of the classroom environment; (b) investigating differences between and within teacher and student perceptions; (c) investigating if students perform better in their preferred classroom environment than in other environments; and (d) studying the effects of student characteristics on classroom environments and of classroom environments on curriculum development. The present study contributes to the fourth aim mentioned by Fraser by considering the effect of gender on students' perceptions of classroom environment and their attitude towards chemistry and whether such variables are associated with decidedly different views of the classroom.

Theoretical Framework

The What Is Happening In this Class? (WIHIC) Questionnaire

Developed by Fraser, Fisher, and McRobbie (1996), the WIHIC measures high school students' perceptions of their classroom environment. The WIHIC measures a wide range of dimensions that are important to the current situation in classrooms. The WIHIC includes relevant dimensions from past questionnaires and combines these with dimensions that measure particular aspects of constructivism and other relevant factors operating in contemporary classrooms. It was designed to bring parsimony in the field of learning environments research (Dorman, 2003). One important consideration that has been part of classroom environment theory since the early 1970s has been Moos' (1979) conceptual framework for human environments that characterises environments as having relationship, personal growth, and system maintenance and change dimensions. Whereas relationship dimensions are concerned with the nature and intensity of personal relationships, personal growth dimensions focus on opportunities for personal development and self-enhancement. System maintenance and system change dimensions assess the extent to which the environment is orderly, clear in expectations, maintains control, and is responsive to change.

A description of each scale in the WIHIC as well as the classification of each WIHIC scale according to Moos' scheme is presented in Table 1. The original version of the WIHIC contained 90 items and nine scales, but was refined by both statistical analysis of data from 355 high school science students, and extensive interviewing of students about their views of their classroom environments in general, the wording and salience of individual items and their questionnaire responses (Fraser et al., 1996). Only 56 items in seven scales survived these procedures, although this set of items was expanded to 80 items in eight scales for the field-testing of the second version of the WIHIC, which involved high school science classes in Australia and Taiwan. The Australian sample consisted of 1,081 students in 50 classes who responded to the original English version. The Taiwanese sample of 1,879 students in 50 classes responded to a Chinese version that had undergone careful procedures of translation and back translation (Huang & Fraser, 1997).

Table 2: Scale Description for each Scale and Example of Items in the What Is Happening In This Class? (WIHIC) Questionnaire

Scale	Description	Item	Moos Dimension
Student Cohesiveness [SC]	Extent to which students know, help and are supportive of one another.	I make friendship among students in this class	Relationship
Teacher Support [TS]	Extent to which teacher helps, befriends, trusts, and shows interest in students.	The teacher takes a personal interest in me.	Relationship
Involvement [IV]	Extent to which students have attentive interest, participate in discussions, perform additional work and enjoy the class.	I discuss ideas in class.	Relationship
Investigation [IN]	Extent to which there is emphasis on the skills and their use in problem solving	I am asked to think about the evidence for statements.	Personal growth
Task Orientation [TO]	Extent to which it is important to complete activities planned and to stay on the subject matter.	Getting a certain amount of work done is important.	Personal growth
Cooperation [CO]	Extent to which students cooperate rather than compete with one another on learning tasks.	I cooperate with other students when doing assignment work.	Personal growth
Equity [EQ]	Extent to which the teacher treats students equally.	The teacher gives as much attention to my questions as to other students' questions.	System maintenance and change

This led to a final form of the WIHIC containing the seven 8-item scales. The WIHIC has been reported as useful and valid across a number of countries and subjects (Den Brok, Fisher, Rickards, and Bull, 2006, pp7-8). In some research, the questionnaire has been used without any modifications, and in others the questionnaire was adapted to suit the specific context.

Most of the studies reported above have provided information with respect to both validity and reliability of the WIHIC. Research seems to indicate that the reliability of the scales (Cronbach's alpha) of the instrument is usually above .70 at the student level and above .85 at the class level. Exploratory and confirmatory factor analyses indicate that the items of the WIHIC usually have factor loadings above .40 on their apriori scales and lower

loadings on other scales (Dorman, 2003). Moreover, Dorman (2003) has also indicated that the factor structure has been shown to be invariant across grade levels, countries, cultures, and gender which suggests that it is useful in studying gender issues, as is the case in the present study. Average correlations between the scales of the WIHIC, a convenient measure of discriminant validity, have been reported between approximately .20 and .50, indicating that each of the seven scales measures distinct, though partly overlapping elements of the classroom environment (Fraser, 1998).

Previous Studies Investigating Differences in Students' Perceptions on the WIHIC

Several studies involving the WIHIC were conducted outside the South Africa. For example, gender-related differences in students' perceptions of their learning environment and teacher behaviour were explored by Kim, Fisher, and Fraser (2000). The study involved 543 eighth-grade students in 12 different secondary schools in metropolitan and rural areas of Korea. Statistically significant differences were found between boys and girls on all seven scales and therefore might be suitable for a study on gender differences, as is the case for the sample used in the present study. It was reported that boys perceived more Teacher Support, Involvement, Investigation, Task Orientation, and Equity than did girls.

Other studies were also conducted in the USA but the majority of these studies were conducted in primary education. But three WIHIC studies were found that actually pertained to secondary education. Hoffner, Moss and Fraser (2002) investigated biology classes in North Carolina. Their results indicated that boys perceived more involvement and investigation than girls, and that students from higher grade levels perceived more cooperation than students from lower grade levels. Taylor and Fraser (2004) focused on secondary mathematics classes in Southern California. Their results indicated that girls perceived more student cohesiveness, task orientation, cooperation, and equity than boys. According to the authors, these findings are consistent with other WIHIC studies. Den Brok, Fisher, Rickards, and Bull (2006) used multilevel analysis and showed that, in the USA, student gender appears to be related to four scales: Student Cohesiveness, Teacher Support, Task Orientation, and Cooperation. For all of these scales, girls have statistically significant higher ratings than boys, indicating that they have a more favourable perception of the learning environment.

The review presented in this article, however, shows a mixed picture with respect to the effects of gender on students' perceptions of their learning environment and their attitude toward science or specific science subjects. There is one known study using the WIHIC carried out in South Africa. Aldridge et al. (2004) compared students' perceptions on the WIHIC between South Africa and Australia. Their study showed that students in South Africa perceived a greater degree of investigation opportunities in their science classrooms than Australian students, while students perceived less cooperation and equity in South Africa than students in Australia. This result is surprising since laboratories are non-existent in most rural high schools in South Africa. In the Ximhungwe circuit for instance only three out of the ten high schools have science laboratories, which unfortunately are not very functional. Thus investigation opportunities are limited in these settings.

In summary, it seems that in most studies conducted outside the South Africa, boys have a consistently more positive view of their classroom environments than girls. The only exception is the Equity dimension, where mixed results have been found with respect to gender differences. However, none of these studies investigated associations between gender and students' perceptions of their learning environment and attitude towards chemistry in a deprived area.

Attitude towards chemistry

An attitude may be defined as "a personal inclination - idiosyncratic, present in all individuals, directed to objects, events or people - that takes on a different direction and intensity according to the experiences each individual has had...it presents components from the affective, cognitive and motor domains" (Dewey, 1933). Such a personal inclination may or may not be overtly acknowledged, but is generally well established and closely held. Students, who are unable to cultivate positive attitudes, may not be able to persist to valid solutions for problems and, therefore, may not experience success in chemistry. The attitudes survey for this study consists of 12 statements, for each of which the student was asked to indicate how strongly he or she agrees or disagrees. In literature generally male students' attitude toward science is higher than female students (Catsambis, 1995; Jones, Howe, & Rua, 2000; Piburn & Baker, 1993; Greenfield, 1996), but Arisoy (2007) and Mandina (2012) have indicated that girls' perceptions of their learning environment, and their attitude toward science were higher than boys.

Null Hypotheses

The following hypotheses were formulated to guide the study.

1. There is no significant difference between physical sciences students' perception of their chemistry classroom environment among males and females.
2. There is no significant difference between physical sciences students' attitude towards chemistry among males and females.
3. There is no significant association between physical sciences students' perception of their classroom environment and their attitude towards chemistry in both genders.
4. There is no significant relationship among the sub-scales of chemistry classroom environment among males and females.

METHODOLOGY

Research Design: A cross-sectional survey was used in carrying out the study. This design was used in order to test the four hypotheses formulated to guide the study. The design made it possible for comparison to be made among the two different groups of students (Leedy & Ormrod , 2010). To accomplish this, all the ten high schools in the Ximhungwe circuit of the Bohlabela district in the 2013 academic year were used (DEMP, 2013). All the schools have one intact physical sciences class except one which has two intact classes.

The target population for the study comprised all grade 12 physical sciences students in the Bohlabela district in the 2013 academic year but the accessible population was all the 10 high schools in the Ximhungwe circuit in the 2013 academic year. All the schools were co-educational and were located in rural South Africa. In all, 210 physical sciences students participated in the study of which 102 males (48.5%) and 108 (51.5%) females.

Development and Validation of the Questionnaire: Chemistry Classroom Environment Questionnaire (CCEQ) and Attitudes Towards Chemistry Questionnaire (ATCQ) were the main instruments used for data collection. In constructing the CCEQ, "What Is Happening In This Class?" (WIHIC) instrument developed by Fraser, McRobbie and Fisher (1996) to measure high school students' perception of their science classroom environment served as a guide. This is because it has been internationally validated through several statistical procedures and has reported acceptable reliabilities in all these studies (Fraser, 2000). It was assumed that the five sub-scales of student cohesiveness, teacher support, involvement, cooperation, and equity of the original WIHIC exist in rural South African classrooms (see Table 1). The reliabilities recorded for each sub-scale under the Chemistry Classroom

Environment Questionnaire confirmed that the sub-scales exist in the chemistry classrooms. The inter item correlation coefficient between the items under the Cronbach alpha coefficients analyses were all above 0.30, which meant that the items were highly consistent and a good measure of a particular sub-scale (Fraser, 2000).

The Attitude towards Chemistry Questionnaire was constructed using the Test of Science Related Attitude (TOSRA) developed by Fraser (1982) as a guide. The TOSRA was used because it has been used in a number of cross-national studies to measure secondary school students' attitude to science and it has recorded acceptable reliabilities in all these investigations. In developing the ATCQ it was assumed that attitude towards chemistry was one-dimensional and since the items on the original TOSRA did not reflect the South African context, 12 items were wrote under the attitude one-dimensional instrument. They were then subjected to inter item correlation coefficient analyses and reported inter item correlation coefficients of above 0.30 making it suitable for the study in South Africa.

Thus, with such a wide use and applicability of the WIHIC, its applicability was also validated in South Africa to get an insight into its use as well as insight into the South African classroom learning environment, especially in the rural areas.

Data Analysis

Responses to test the differences in physical sciences students' perception of their chemistry classroom environment for males and females was obtained from grade 12 physical sciences students in the ten schools using the CCEQ. The items in the CCEQ were assigned values on a five-point Likert-type format (5-very often, 4-often, 3-sometimes, 2-seldom, 1-almost never). Negative statements had their values reversed. The mean and standard deviation scores for each dimension of the CCEQ were estimated, and physical sciences students' perception of their chemistry classroom environment was measured using the mean and standard deviation scores. One-way multivariate analysis of variance (MANOVA) was conducted to determine gender differences in physical sciences students' perception of their chemistry classroom environment with the five chemistry classroom environment sub-scales as the dependent variable and the gender as the independent variable. A corresponding one-way analysis of variance (ANOVA) with gender as the independent variable was conducted for each of the sub-scales of CCEQ individually as a follow-up test to the MANOVA to determine where the significant differences that existed between the school categories of their chemistry classroom environment existed.

Similarly, the ATCQ was used to obtain information to test the gender differences in physical sciences students' attitude towards chemistry. The items on the ATCQ were assigned values on a five-point Likert-type scale format (5-strongly agree, 4-agree, 3-undecided, 2-disagree, 1-strongly disagree). Negative values of items were also reversed just like in the CCEQ. Since the scale was in a five-point Likert-type scale format, three being the mid-value was chosen as an average value to which scores above it was considered to be positive attitude and those below it were also considered to be negative attitude. Mean and Standard Deviation scores of the responses on the attitude instrument for both genders were calculated to measure physical sciences students' attitude towards chemistry. Independent samples t-tests were also conducted on the items in the attitude instrument to determine those that showed significant difference between the students.

RESULTS AND DISCUSSION

Physical sciences Students' Perception of their Chemistry Classroom Environment

The first hypothesis states that there is no significant difference in physical sciences students' perception of their chemistry classroom environment in both genders. The scores obtained from their responses are presented in table 2.

Table 2: Mean (M) and Standard Deviation (SD) Responses for Males and Females on Chemistry Classroom Environment (CCE) Sub-scales

CCE Sub-Scale	Gender			
	Males		Females	
	Mean	SD	Mean	SD
Student Cohesiveness [SC]	4.04	0.55	4.04	0.59
Teacher Support [TS]	3.83	0.97	4.00	0.95
Involvement [IV]	3.81	0.63	3.69	0.77
Cooperation [CO]	3.80	0.66	4.12	1.06
Equity [EQ]	4.14	0.66	3.90	0.94

N=102 (Males); N=108 (Females)

Table 2 indicated that, both male and female physical sciences students had a high perception of their chemistry classroom environment but in favour of males on the involvement and equity scales and in favour of females on the teacher support and cooperation scales. For further analysis, one-way Multivariate Analysis of Variance (MANOVA) was used to determine the sub-scale(s) which contributed to the differences. The results are presented in Table 3.

Table 3: One-way MANOVA on CCE scales and gender

Effect	Value	F	Hypothesis df	Error df	p-values
Gender	0.87	3.067	5.00	198	0.013

Significant P<.05

The MANOVA test presented in Table 4 showed that Wilks' lambda (λ) value of 0.87 was statistically significant, $F(5,210) = 3.067$, $p<0.05$; partial eta squared=0.134, indicating that the population mean scores on the five sub-scales of chemistry classroom environment are the same for both genders cannot be supported and was therefore rejected. As a follow-up test to the MANOVA, the results of one way ANOVA with gender as independent variable was conducted for each of the five sub-scales of chemistry classroom environment. As shown in Table 4, all five sub-scales of chemistry classroom environment were not statistically significant using a Bonferroni adjusted alpha level of 0.05: student cohesiveness: $F(2,210)=0.007$, $p =0.985$, partial eta squared=0.000; teacher support: $F(2,210)=0.80$, $p =0.374$, partial eta squared=0.008; involvement: $F(2,210)=0.81$, $p =0.371$, partial eta squared=0.008; cooperation $F(2,210)=3.48$, $p = 0.065$, partial eta square=0.033; and equity: $F(2,210) =2.13$, $p= 0.147$; partial eta squared =0.020.

Table 4: Results of ANOVA as a follow up to the one –way MANOVA on the five sub-scales of chemistry classroom environment

CCE Sub-Scales	df	Mean Squared	F	p-values	Partial Eta Squared
Student Cohesiveness	1	0.007	0.00	0.985	0.000
Teacher support	1	46.7	0.80	0.374	0.008
Involvement	1	25.7	0.81	0.371	0.008
Cooperation	1	176.0	3.48	0.065	0.033
Equity	1	90.5	2.13	0.147	0.020

**Bonferroni Adjusted significant at P<0.05.*

The partial eta squared values recorded for the five sub-scales indicate that all the five sub-scales do not account for the variances in physical sciences students' perception of their chemistry classroom environment among males and females. An inspection of the mean scores as presented in Table 2 indicated that male physical sciences students had slightly higher means on the involvement and equity scales whereas female physical sciences students had slightly higher means on the teacher support and cooperation scales. However, the results of the ANOVA indicate that the differences are not significant.

Generally, from the analysis conducted on the first hypothesis, even though physical sciences students in both genders had a high perception of their chemistry classroom environment, students in both genders showed significant differences in how they perceive their chemistry classroom environment. The differences were in the areas of teacher support, involvement, cooperation, and equity sub-scales. This results confirms what Riah (2003), Chui-Seng (2004) and Mucherah (2008) found in their study with science students in Taiwan, Brunei and Kenya respectively. Riah (2003), Chui-Seng (2004) and Mucherah, (2008) reported that science students in these countries had a high perception across all the sub-subscales except the involvement sub-scale of their biology classrooms. However, students in the current study had a high perception of their chemistry classroom on all the subscales including the involvement sub-scale. This current study contradicts what Otami et al (2012) found in their study with elective science students in Ghana, which indicated a low perception of their biology classroom on all the sub-scales.

Physical sciences Students' Attitude towards Chemistry

The second hypothesis sought to test the differences in attitude towards chemistry between physical sciences students by gender. The results are presented in Table 5. This was done by considering attitude towards chemistry as one-dimensional. From table 5 male and female physical sciences students had mean scores greater than the average mean score of three (3). These therefore suggest that both male and female physical sciences students have a positive attitude towards chemistry but slightly in favour of male students in some cases and females in other instances. As a follow up test, independent samples t-test, $\underline{t}$ (210) = 1.96, P =0.436 conducted to determine whether there is significant difference between male and female students with regard to their attitude towards chemistry showed that there is no significant difference between the students by gender.

Table 5: Mean (M) and Standard Deviation (SD) scores of items Constituting, Attitude towards Chemistry by Gender

No	Statements	Gender	M	SD
1	It is best to find out why something is true by checking it from Chemistry textbooks than being told.	Males	4.31	1.010
		Females	4.19	1.065
2	The topics covered in Chemistry are not interesting.	Males	1.80	1.114
		Females	1.85	1.123
3	There should be more Chemistry lesson every week.	Males	4.53	0.987
		Females	4.46	0.926
4	Chemistry is one of the most interesting science subjects	Males	4.57	0.922
		Females	4.48	0.818
5	I am always prepared for chemistry lessons.	Males	4.18	0.974
		Females	4.24	0.889
6	Chemistry lessons are boring.	Males	1.35	0.796
		Females	1.41	0.901
7	It is important to study Chemistry at school.	Males	4.43	0.855
		Females	4.46	0.794
8	I would like to study Chemistry related course at the highest level of my education.	Males	4.29	0.923
		Females	4.02	0.157
9	Doing well in Chemistry is important to me.	Males	4.75	0.483
		Females	4.80	1.528
10	I enjoy Chemistry lessons.	Males	4.57	0.855
		Females	4.48	0.746
11	I enjoy science more if there were no Chemistry lessons.	Males	2.31	1.407
		Females	2.43	1.525
12	Chemistry is the most difficult of all the science subjects.	Males	1.55	0.986
		Females	1.78	1.144

**Significant at P>0.05; Degree of freedom (df) = 208*

The results from the analysis of the second hypothesis is similar to Coleman (2004) who reported that science students in low and high achieving schools in Singapore have a positive attitude towards science. The results of the second hypothesis however contradict a similar work by Coleman in South Korea where science students in low achieving schools had a negative attitude while those from high achieving schools had a positive attitude towards science.

Association between students' attitude toward chemistry and perception of chemistry classroom environment

Hypothesis three states that there is no significant association between physical sciences students' perception of their classroom environment and their attitude towards chemistry by gender. Table 6 shows a simple bivariate association between attitude and perception measures. An examination of simple correlation coefficient (Spearman's rank order correlation coefficient, r) reported in Table 6 shows that there were no statistically significant relationships between attitude and perception measures for students by gender ($r = 0.04$, $n = 210$, $P > 0.05$).

Table 6: Spearman's correlation between students' perception of their chemistry classroom environment and their attitude towards chemistry by gender

CCE Sub-Scales	N	r	significance
Attitude versus perception (Males)	102	0.026	0.858
Attitude versus perception (Females)	108	0.016	0.908

*Not significant, P >.05

Association among the Sub-scales of Chemistry Classroom Environment between Males and Females

The fourth hypothesis states that there is no significant relationship among the five sub-scales of chemistry classroom environment between males and females. Table 7 presents the results of correlations among the sub-scales of chemistry classroom environment for males.

Table 7: Results of Spearman's correlation among the sub-scales of chemistry classroom environment in Males

CCE Sub-Scales	Student Cohesiveness	Teacher support	Involvement	Cooperation	Equity
Student Cohesiveness		0.48	0.72	0.58	0.42
Teacher support			0.42	0.40	0.58
Involvement				0.57	0.43
Cooperation					0.39
Equity					

*r values significant at P < 0.05; N = 102

The results of the correlational analyses as shown in Table 7 for the sub-scales of chemistry classroom environment in males indicate that, there is positive relationships among the sub-scales which were statistically significant at P < 0.05. This therefore means that, as a particular sub-scale in the chemistry classroom environment increases, it results in an increase in a corresponding subscale of the same environment. Hence the null hypothesis that there is no significant relationship among the five chemistry classroom environment sub-scales for males was rejected.

On the relationship among the five sub-scales of chemistry classroom environment among females, the correlational analyses as shown in Table 8 indicates that, there is also a positive statistically significant relationship among all the sub scales. Hence the null hypothesis that there is no significant relationship among the five chemistry classroom environment sub-scales among females was rejected. From the analyses, the hypothesis that there is no significant relationship among the five sub-scales of chemistry classroom environment by gender was tested with Spearman's rank order correlation. It was however revealed from the correlational analyses that, there are significant positive relationships among all the five sub-scales of chemistry classroom environment. Hence the null hypothesis that there is no significant relationship among the five chemistry classroom environment sub-scales was rejected.

Table 8: Results of Spearman's correlation among the sub-scales of chemistry classroom environment in Females

CCE Sub-Scales	Student Cohesiveness	Teacher support	Involvement	Cooperation	Equity
Student Cohesiveness		0.37	0.56	0.46	0.39
Teacher support			0.49	0.43	0.74
Involvement				0.53	0.55
Cooperation					0.40
Equity					

*r values significant at $P < 0.05$; $N = 108$

Conclusion

The results from the study indicate that male and female physical sciences students had a high perception of their chemistry classroom environment but in favour of males on the involvement and equity scales and in favour of females on the teacher support and cooperation scales. This was confirmed by the mean scores which indicated that male physical sciences students had slightly higher means on the involvement and equity scales whereas female physical sciences students had slightly higher means on the teacher support and cooperation scales. However, the results of the ANOVA indicated that the differences were not significant.

The physical students' perception of their chemistry classroom environment was therefore not influenced by gender. The differences were in four of the five sub-scales, which are teacher support, involvement, cooperation, and equity scales.

Also, generally, both male and female physical sciences students have a positive attitude towards chemistry but slightly in favour of male students in some cases and females in other instances. In spite of this the results showed that there is no significant difference in attitude towards chemistry between the students by gender. This seems to suggest that physical sciences students' attitude towards chemistry was not also influenced by gender.

The fact that no relationship was established between physical sciences students' perception of their chemistry classroom environment and their attitude towards chemistry seem to suggest that one's perception may not necessarily influence one's attitude. This was also not influenced by gender.

The relationship among the sub-scales of chemistry classroom environment with respect to males and females indicates that students' perception of their chemistry classroom environment was influenced by all the sub-scales.

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