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Comparison of level of inventive thinking among Science and Arts Students

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Abstract

This study was to review and compare the extent of the inventive thinking of form four students of science and arts stream in national secondary schools. The level of inventive thinking surveyed in this study involved 660 students who were selected from five national secondary schools from the area of Machang, Kelantan. Seven inventive thinking sub-constructs reviewed were flexibility, higher-order thinking, self-regulation, curiosity, creativity, willingness to take risks and spiritual norms and values. Data were analysed using descriptive and inferential statistic. The descriptive analysis found that six out of seven sub-constructs of inventive thinking studied showed a high level among the respondents as a whole. Those sub-constructs were flexibility, higher-order thinking, self-regulation, curiosity, creativity and spiritual norms and values. Meanwhile, one sub-construct, willingness to take risks, showed a medium level of min value interpretation. The findings of two-way ANOVA inference shows that variables of stream, location and gender affect the determination of the level of most inventive thinking sub-constructs studied.

Keywords: Creativity; curiosity; flexibility; higher-order thinking; inventive thinking; self-regulation; spiritual norms and values; science; willingness to take the risk

1. Introduction

The idea of becoming a developed nation by 2020, is the largest project to crown Malaysia as a world-class country in various fields, especially economy. Therefore, Third Outline Perspective Plan (OPP3) (2001) clearly outlines the necessary knowledge and skills needed in the people of our country so that Malaysia can compete with other countries in the new millennium.

OPP3 demand that the school curriculum be revised to promote thinking and inventive skills among students. According to the Prime Minister, Datuk Seri Najib (2012), the transformation of education must be implemented to produce young people who can think and have the advantage of adapting the knowledge to face the challenges in the future. Mahalel (2003) also stated that creative and analytical thinking skills are the main qualities in developing individuals that can compete in the global market. This shows the importance of thinking skills in producing a

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generation with creative, critical and innovative thinking, able to solve complex problems, has a brilliant mind and thinks out of the box.

Education reformation recommends that the development of students of high-order thinking and innovative is very important in primary and secondary school level. This awareness was delayed due to the emphasis on the education system that prioritize the 'ability to think' but less emphasis on the ‘ability to design and experimentation’ (Mohd. Azhar, 2004). The best way to implement is to start this at the school level by nurturing the inventive thinking culture. Therefore, research on the level of inventive thinking among students of science and arts stream is essential to ensure our national aspiration to be a developed nation by 2020 can be achieved.

2. Inventive Thinking

Inventive thinking is a cognitive skill that is critical in making certain tasks easier and simple with the aid of technology. In this study, inventive thinking skills refer to the skills listed in the enGauge 21st Century Skills (2003). The elements of values were included in the framework of this study in line with the aspiration of national education to produce individuals who are not only knowledgeable and skilled but they also have good manners and values (Osman & Marimuthu 2010; Osman, Tuan Soh & Arsad 2010; Tuan Soh 2011).

Based on the above rational, the skills listed in the inventive thinking skills are described as in Table 1.

| Elements                     | Description                                                                 |
|------------------------------|----------------------------------------------------------------------------|
| Flexibility                  | The ability of students to modify the thinking, attitudes and action in dealing with an assignment within limited time and resources while learning. |
| Higher-order thinking        | Cognitive processes such as analysing, comparing, evaluating and synthesizing a problem during learning. |
| Self-regulation              | The students' ability to set learning goals, make plans to achieve those learning goals, manage time and evaluate the quality of learning independently. |
| Curiosity                    | Curiosity of students in learning something and make inquiries during learning. |
| Creativity                   | The ability of students to produce a new idea or product, genuine and worthy, to make judgments on the ideas presented, energetic, and generative, imaginative, sensitive to the environment and examine own self independently. |
| Willingness to take risk     | The desire of students to make mistakes and willingness to accept challenging assignments while learning. |
| Norms and spiritual values   | A holistic teaching approach or comprehensive in terms of mental, physical, emotional and spiritual as well as serving as the pillar of religion and guidance in shaping a person into someone with good values and moral. |

Source: NCREL & Metiri Group (2003)

3. Purpose of the Study

The main purpose of this study was to compare the level of inventive thinking among form four students of science and arts stream in national secondary schools in Malaysia and to determine whether there are significant differences between the level of inventive thinking of form four students of science and arts stream based on the location and gender.
4. Methodology

This study is a quantitative survey study using questionnaire instrument to compare the level of inventive thinking of form four students in science and arts stream during teaching and learning in schools. The instrument was a set of questionnaires developed based on the elements identified by enGauge 21st Century Science Skills.

5. Findings and Discussions

Based on Table 3, the significant value of Levene test for each of the sub-constructs is between the range of 0.016 and 0.484. Four sub-constructs, namely flexibility, high-order thinking, curiosity and creativity, scored values greater than 0.05. Thus for these four sub-constructs, the variance of scores of each group is homogeneous at 0.05 significant level. For the other two sub-constructs, namely self-regulation and risk-taking, the significance ranged between 0.01 and 0.05, therefore the variance score of each group is homogeneous at significance level of 0.01. For the sub-construct of values, the significance value is less than 0.01. This means that the variance findings for each group of sub-constructs on this sub-construct are not homogeneous. However, two-way ANOVA analysis was still conducted in this study because, according to Jackson (2006), two-way ANOVA analysis can still be continued even if the variance of each group is not homogeneous as it is believed to have no impact on the findings of the study and it is a statistical robust test.

Table 2. Descriptive analysis on the level of inventive thinking of form four students of science and arts stream

| No. | Sub-Constructs                  | Mean | Standard Deviation | Level |
|-----|---------------------------------|------|--------------------|-------|
| 1.  | Flexibility                     | 3.83 | 0.46               | High  |
| 2.  | Higher-order thinking           | 3.88 | 0.62               | High  |
| 3.  | Self-regulation                 | 3.78 | 0.63               | High  |
| 4.  | Curiosity                       | 3.74 | 0.53               | High  |
| 5.  | Creativity                      | 3.67 | 0.47               | High  |
| 6.  | Willingness to take risk        | 3.43 | 0.90               | Moderate |
| 7.  | Spiritual norms and values      | 4.33 | 0.44               | High  |

Table 3. Levene test

| Sub Constructs          | F     | df1 | df2 | Sig. |
|-------------------------|-------|-----|-----|------|
| Flexibility             | 1.749 | 7   | 652 | .095 |
| Higher-order thinking   | 1.260 | 7   | 652 | .268 |
| Self-regulation         | 2.206 | 7   | 652 | .032 |
| Curiosity               | 1.736 | 7   | 652 | .098 |
| Creativity              | .928  | 7   | 652 | .484 |
| Willingness to take risk| 2.047 | 7   | 652 | .047 |
| Spiritual values        | 2.880 | 7   | 652 | .006 |

5.1. Flexibility

Based on Table 4, it was found that female science stream students of city school and female arts stream students from rural school have the highest level of flexibility with the mean value of 3.93 (SD=0.04) respectively. While the lowest level of flexibility recorded by the male art stream students of rural areas (mean=3.74, SD=0.05).

Table 4. Descriptive analysis of level of flexibility comparison

| Stream | Location | Gender | Mean | Standard deviation (SD) |
|--------|----------|--------|------|-------------------------|
| Science| Urban    | Male   | 3.79 | 0.06                    |
|        |          | Female | 3.93 | 0.04                    |
|        | Rural    | Male   | 3.77 | 0.06                    |
Table 4.1 shows that there is a significant effect only between the male and female \[F (1.660)=4.87, p=0.028\]. However, the effect is very small in size based on the eta squared value; the 0.007 only explained 0.7% variance of gender effect on the level of flexibility in learning. This shows that there are significant differences in mean scores of adaptability and flexibility of students based on gender.

Table 4.1. Two-way ANOVA analysis on the flexibility of the respondents

| Sources            | Sum of squares | df | Mean square | F     | Sig.    | Eta squared |
|--------------------|----------------|----|-------------|-------|---------|-------------|
| Stream             | .036           | 1  | .036        | .177  | .674    | .000        |
| Location           | .015           | 1  | .015        | .076  | .784    | .000        |
| Gender             | .998           | 1  | .998        | 4.868 | .028*   | .007        |
| Stream * Location  | .358           | 1  | .358        | 1.746 | .187    | .003        |
| Stream * Gender    | .030           | 1  | .030        | .147  | .701    | .000        |
| Location * Gender  | .182           | 1  | .182        | .888  | .346    | .001        |
| Stream * Location  | .966           | 1  | .966        | 4.715 | .030*   | .007        |
| Gender             | .578           | 1  | .578        | 1.524 | .217    | .002        |
| Error              | 1.104          | 1  | 1.104       | 2.910 | .089    | .004        |

*significant at 0.05 level

5.2. Higher-order thinking

Table 5 shows the female arts stream students of rural areas has the highest level of thinking compared to other respondents (M=4.00; SD=0.05). Whereas, the lowest level of thinking was recorded by the male arts stream students of rural areas (M=3.71; SD=0.06).

Table 5. Descriptive analysis of level of high-order thinking comparison

| Stream | Location | Gender | Mean | Standard Deviation |
|--------|----------|--------|------|--------------------|
| Science | Urban    | Male   | 3.89 | 0.08               |
|        |          | Female | 3.99 | 0.06               |
|        | Rural    | Male   | 3.88 | 0.08               |
|        |          | Female | 3.87 | 0.06               |
| Arts   | Urban    | Male   | 3.83 | 0.11               |
|        |          | Female | 3.72 | 0.08               |
|        | Rural    | Male   | 3.71 | 0.06               |
|        |          | Female | 4.00 | 0.05               |

Table 5.1 shows that although the value of the difference between the highest and lowest mean is 0.29 but there are no significant effects on these three variables which are stream, location and gender.

Table 5.1. Two-way ANOVA analysis on the level of high-order thinking of the respondents

| Sources             | Sum of squares | df | Mean square | F     | Sig.    | Eta squared |
|---------------------|----------------|----|-------------|-------|---------|-------------|
| Stream              | 1.104          | 1  | 1.104       | 2.910 | .089    | .004        |
| Location            | .007           | 1  | .007        | .018  | .893    | .000        |
| Gender              | .578           | 1  | .578        | 1.524 | .217    | .002        |
| Stream * Location   | .739           | 1  | .739        | 1.947 | .163    | .003        |
| Stream * Gender     | .084           | 1  | .084        | .222  | .637    | .000        |
| Location * Gender   | .729           | 1  | .729        | 1.921 | .166    | .003        |
5.3. Self-Regulation

Based on Table 6, it was found that the female science stream students of city schools had the highest mean value for this sub-construct (M=4.01, SD=0.06).

Table 6. Descriptive analysis of level of self-regulation comparison

| Stream  | Location | Gender | Mean   | Standard Deviation(SD) |
|---------|----------|--------|--------|------------------------|
| Science | Urban    | Male   | 3.72   | 0.08                   |
|         |          | Female | 4.01   | 0.06                   |
|         | Rural    | Male   | 3.73   | 0.08                   |
|         |          | Female | 3.80   | 0.06                   |
| Arts    | Urban    | Male   | 3.81   | 0.11                   |
|         |          | Female | 3.76   | 0.08                   |
|         | Rural    | Male   | 3.56   | 0.06                   |
|         |          | Female | 3.82   | 0.05                   |

Table 6.1 shows that there was a significant main effect of self-regulation of students based on gender [F (1,652) = 7.28, p=0.007]. This finding is also similar to the findings of the sub-construct of flexibility. However, the gender effect size of self-regulation is greater, which is 0.011, or in other words, only by 0.011% to the variance effect of gender variance of form four students’ self-regulation. This finding indicates that there is no significant difference in terms of mean score of self-regulation based on gender.

Table 6.1. Two-way ANOVA analysis on the level of self-regulation of the respondents

| Sources                | Sum of squares | Df | Mean square | F    | Sig. | Eta squared |
|------------------------|----------------|----|-------------|------|------|-------------|
| Stream                 | .830           | 1  | .830        | 2.174| .141 | .003        |
| Location               | 1.382          | 1  | 1.382       | 3.618| .058 | .006        |
| Gender                 | 2.779          | 1  | 2.779       | 7.276| .007*| .011        |
| Stream * Location      | .003           | 1  | .003        | .007 | .935 | .000        |
| Stream * Gender        | .183           | 1  | .183        | .480 | .489 | .001        |
| Location * Gender      | .079           | 1  | .079        | .207 | .649 | .000        |
| Stream * Location * Gender | 2.583 | 1 | 2.583 | 6.763 | .010* | .010       |
| Error                  | 249.019        | 652| .382        |      |      |             |
| Total                  | 9712.319       | 660|             |      |      |             |

*significant at 0.01 level

5.4. Curiosity

Table 7 shows that two groups of respondents recorded the lowest mean value for curiosity, whom are male arts stream students. This means, both the urban and rural schools recorded the lowest mean value for curiosity. Highest mean value was recorded by female science stream respondents who attended urban schools.

Table 7. Descriptive analysis of level of curiosity comparison

| Stream  | Location | Gender | Mean | Standard Deviation(SD) |
|---------|----------|--------|------|------------------------|
| Science | Urban    | Male   | 3.70 | .07                     |
|         |          | Female | 3.90 | .05                     |
| Rural   | Male     | 3.70   | .07  |
|         | Female   | 3.78   | .05  |
Table 7.1 shows that the two variables, stream and gender, has a significant effect on the level of curiosity of form four students. The findings for the effect of stream on curiosity is \([F(1,652)=4.923, \ p=0.027]\), while the finding the effect of gender is \([F(1,652)=6.902, \ p=0.009]\). This indicates a significant difference in mean score of curiosity of form four students based on stream and gender, but not by location.

Table 7.1. Two-way ANOVA analysis on the level of curiosity of the respondents

| Sources          | Sum of squares | df | Mean square | F     | Sig. | Eta squared |
|------------------|----------------|----|-------------|-------|------|-------------|
| Stream           | 1.368          | 1  | 1.368       | 4.923 | .027*| .007        |
| Location         | .009           | 1  | .009        | .031  | .860 | .000        |
| Gender           | 1.918          | 1  | 1.918       | 6.902 | .009*| .010        |
| Stream * Location| .388           | 1  | .388        | 1.396 | .238 | .002        |
| Stream * Gender  | .075           | 1  | .075        | .272  | .602 | .000        |
| Location * Gender| .006           | 1  | .006        | .021  | .886 | .000        |
| Stream * Location* | .385         | 1  | .385        | 1.384 | .240 | .002        |
| Gender           |                |    |             |       |      |             |
| Error            | 181.177        | 652| .278        |       |      |             |
| Total            | 9398.438       | 660|             |       |      |             |

*significant at 0.05 level

5.5. Creativity

Table 8 shows the group of respondents who had the highest mean value is the female science stream respondents from urban schools. The mean value for the group was 3.83(SD=0.05). This means that the group had a higher level of creativity than the other respondents. While the respondents with the lowest level of creativity is the male science and arts stream respondents of rural areas (M=3.58; SD=0.06) and also male science stream from urban schools (M=3.58; SD=0.06).

Table 8. Descriptive analysis of level of creativity comparison

| Stream | Location | Gender | Mean | Standard Deviation(SD) |
|--------|----------|--------|------|------------------------|
| Science | Urban    | Male   | 3.58 | 0.06                   |
|        |          | Female | 3.83 | 0.05                   |
|        | Rural    | Male   | 3.58 | 0.06                   |
|        |          | Female | 3.64 | 0.05                   |
| Arts   | Urban    | Male   | 3.62 | 0.08                   |
|        |          | Female | 3.74 | 0.06                   |
|        | Rural    | Male   | 3.58 | 0.05                   |
|        |          | Female | 3.70 | 0.04                   |

Based on Table 8.1, the stream and the location had no significant impact on the determination of the respondents’ level of creativity. Only gender was found to be the factor affecting the level of creativity, when two-way ANOVA test results indicate the significance of these variables is less than the 0.05 level \([F(1,652)=12.008, \ p=0.001]\). However, its effect size is very small (Eta squared=0.018) which only explains 1.8% variance of the gender effect on the level of creativity. This indicates that there are no significant differences between the location of the school and mean score of creativity of science and arts form four students.

Table 8.1. Two-way ANOVA analysis on the level of creativity of the respondents

| Sources | Sum of squares | df | Mean square | F     | Sig. | Eta squared |
|---------|----------------|----|-------------|-------|------|-------------|
| Stream  |                |    |             |       |      |             |
| Location|                |    |             |       |      |             |
| Gender  |                |    |             |       |      |             |
5.6. Willingness to take risks

There is a difference between the readiness to take risks among the form four students based on stream, school location and gender. Based on Table 9, the highest level of willingness to take risks was recorded by male science stream students of urban schools with a mean value of 3.58 and standard deviation of 0.11. Lowest level of readiness to take risks was recorded by the female arts stream group in urban schools (M=3.12; SD=0.11).

Table 9. Descriptive analysis of level of willingness to take risk comparison

| Stream   | Location | Gender | Mean  | Standard Deviation(SD) |
|----------|----------|--------|-------|------------------------|
| Science  | Urban    | Male   | 3.58  | 0.11                   |
|          |          | Female | 3.45  | 0.09                   |
|          | Rural    | Male   | 3.50  | 0.11                   |
|          |          | Female | 3.44  | 0.09                   |
| Arts     | Urban    | Male   | 3.57  | 0.16                   |
|          |          | Female | 3.12  | 0.11                   |
|          | Rural    | Male   | 3.53  | 0.09                   |
|          |          | Female | 3.35  | 0.08                   |

Based on Table 9.1, the variable that gives a significant impact on the different levels of willingness to take risks is the gender variable with the significant value of 0.007(p<0.001)[F(1,652)=7.255, p=0.007]. However, the impact is very small, being only 1.1% explained variance of the difference effect. Therefore, there is no difference for the streams and locations variables.

Table 9.1. Two-way ANOVA analysis on the level of willingness to take risk of the respondents

| Sources                  | Sum of squares | Df | Mean square | F     | Sig. | Eta squared |
|--------------------------|----------------|----|-------------|-------|------|-------------|
| Stream                   | 1.313          | 1  | 1.313       | 1.631 | .202 | .002        |
| Location                 | .072           | 1  | .072        | .090  | .765 | .000        |
| Gender                   | 5.839          | 1  | 5.839       | 7.255 | .007*| .11         |
| Stream * Location        | .669           | 1  | .669        | .831  | .362 | .001        |
| Stream * Gender          | 1.660          | 1  | 1.660       | 2.062 | .151 | .003        |
| Location * Gender        | 1.100          | 1  | 1.100       | 1.367 | .243 | .002        |
| Stream * Location * Gender| .306           | 1  | .306        | .380  | .538 | .001        |
| Error                    | 524.753        | 652| .805        |       |      |             |
| Total                    | 8294.778       | 660|             |       |      |             |

5.7. Spiritual Norms and Values

Table 10 shows that the female arts stream students from rural schools scored the highest mean value (M=4.45; SD=0.037) while the lowest mean value recorded by the male arts stream students in rural areas (M=4.11; SD=0.777).
Table 10. Descriptive analysis of level of spiritual norms and values comparison

| Stream | Location | Gender | Mean  | Standard Deviation(SD) |
|--------|----------|--------|-------|------------------------|
| Science | Urban    | Male   | 4.28  | .054                   |
|        |          | Female | 4.41  | .042                   |
|        | Rural    | Male   | 4.27  | .055                   |
|        |          | Female | 4.33  | .044                   |
| Arts   | Urban    | Male   | 4.11  | .077                   |
|        |          | Female | 4.36  | .052                   |
|        | Rural    | Male   | 4.21  | .044                   |
|        |          | Female | 4.45  | .037                   |

Based on Table 10.1 shows that there was no significant difference effects in terms of mean value based on the location of the school. On the other hand, there was a significant difference in the students' inventive thinking based on gender. This is explained by the significant value for the variable location being the only one with lesser confidence level of p<0.01[F(1,652)=20.815, p=0.000]. Indirectly, explained that there were only differences for the stream and locations variables.

Table 10.1. Two-way ANOVA analysis on the level of spiritual norms and values of the respondents

| Sources               | Sum of squares | df | Mean square | F     | Sig.  | Eta squared |
|-----------------------|----------------|----|-------------|-------|-------|-------------|
| Stream                | .213           | 1  | .213        | 1.140 | .286  | .002        |
| Location              | .083           | 1  | .083        | .443  | .506  | .001        |
| Gender                | 3.899          | 1  | 3.899       | 20.815| .000* | .031        |
| Stream * Location     | .655           | 1  | .655        | 3.496 | .062  | .005        |
| Stream * Gender       | .718           | 1  | .718        | 3.834 | .051  | .006        |
| Location * Gender     | .063           | 1  | .063        | .336  | .562  | .001        |
| Stream * Location *   | .026           | 1  | .026        | .141  | .708  | .000        |
| Gender                |                |    |             |       |       |             |
| Error                 | 122.125        | 652| .187        |       |       |             |
| Total                 | 12511.453      | 660|             |       |       |             |

*significant at 0.01 level

6. Conclusion

The descriptive analysis found that six out of seven sub-constructs of inventive thinking studied showed a high level among the respondents as a whole. Those sub-constructs were flexibility, higher-order thinking, self-regulation, curiosity, creativity and spiritual norms and values. Meanwhile, one sub-construct, willingness to take risks, showed a medium level of min value interpretation. The findings of two-way ANOVA inference shows that variables of stream, location and gender affect the determination of the level of most inventive thinking sub-constructs studied.

A different level of inventive thinking based on learning stream has been detected on the findings of the curiosity sub-constructs. For science stream respondents, the high level of curiosity shows the ability to build their knowledge and understand the scientific ideas such as the method performed by scientists who investigate the universe (National Research Council, 1996). While the arts stream respondents, the high level of curiosity shows that they can analyse materials from the premier source that can be used to explain and understand the events in history and how it can related to things happening on nowadays.

Finally, the study showed that the location does not affect any of the sub-constructs of inventive thinking studied. This means that the level of inventive thinking is not limited to be developed among the students in the city alone. Majority opinion that the exposure of urban students on the current needs of nation and the world is higher than the rural students is proven wrong. Rural students in this study showed their potential to compete with students from urban schools in terms of building inventive thinking in themselves.
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