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Effects of cooperative learning plus inquiry method on student learning and attitudes: a comparative study for engineering economic classrooms

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In the Iranian higher education system, including engineering education, effective implementation of cooperative learning is difficult because classrooms are usually crowded and the students never had a formal group working background in their previous education. In order to achieve the benefits of cooperative learning in this condition, this paper proposes a combination of cooperative learning and inquiry method. The method is implemented by grouping students in a way that the learning procedure is done in non-official class sessions by each group, while the inquiry method is done in the regular programmed class sessions. The study is performed in Islamic Azad University and the methods are implemented in two engineering economic classes with different numbers of students in each working group. The results are compared with a control class in which traditional teaching style is implemented. The results of analysis show simultaneous improvement of learning and behavioural attitudes of the students with cooperative learning plus inquiry method in the classroom with a fewer number of students in each working group.

Keywords: active learning; cooperative strategy; inquiry method; grouping; attitudes; engineering economic course

1. Introduction

This paper proposes a combination of cooperative learning and inquiry method which lies within the active learning category for teaching in engineering economic classes. The study has been implemented in the fall semester of 2010 in the Fars Science and Research Branch, Islamic Azad University.

In general, active learning refers to the teaching styles that engage students actively in the learning procedure (Prince 2004). Cooperative learning is one of the most important active learning techniques which could be implemented by ‘grouping’ of the students to enhance the incentive for cooperation rather than competition (Prince 2004). In spite of the benefits brought about by the recent successful experience of cooperative learning for engineering education at an international level (Abdulaal et al. 2011; Maceiras et al. 2011; Pinho-Lopes, Macedo, and Bonito 2011), a lack of willingness to implement cooperative learning strategy in engineering classrooms in the Iranian higher education system is observed. According to the inquiry made by...
M.R. Salehizadeh and N. Behin-Aein

the authors, unfamiliarity of the instructors and students with the method and its benefits, concerns about lack of time as well as crowding of classes are mentioned as the major obstacles in front of adopting the cooperative strategy in engineering courses. As well, in the Iranian higher education system, including engineering education, students had no chance to work and learn together and critic each other in their previous education. In order to overcome the mentioned difficulties and take the advantages of cooperative strategy in crowded classrooms, a combination of cooperative learning and inquiry method is proposed in this paper. In the proposed strategy, group learning is done in students’ free time before attending the class. Afterwards, the results of cooperation through the students’ pre-class questions about the content are reflected through the inquiry process between the groups in the classroom. The study is performed in Islamic Azad University by considering three engineering economic classrooms. Traditional method is applied as the teaching method in one of them as control group and cooperative learning plus inquiry method is used for teaching in the others as experimental groups. Cooperative learning in two recent classrooms is implemented by grouping the students with different numbers in each group.

Previous studies at an international level show that as a result of cooperation, students’ psychological, social abilities and educational performances are enhanced (Cohen 1994; Yang and Zheng 2010). Also, teamwork has the capability to enhance the ‘social skilfulness’ of the students (Kern, Moore, and Akillioglu 2007; Smith 1989) and group activities should be performed in such a way that the students believe that their success is mutually dependent on the others. This enriches cooperative learning with ‘positive interdependency’ features (Erdem 2009; Smith 1989). Evaluation of the student groups should be carried out in a way that the performance of all students can be considered. This helps to enhance the students’ ‘individual accountability’ (Smith 1989, 1995). When the students’ activities are accounted in the final evaluation, each of the students would be aware of the worth of their own activity, which could improve individual ‘self-respect’. Improving these attributes, i.e. social skilfulness, positive interdependency, individual accountability, self-respect as well as curiosity, inventiveness, critical thinking and persistency is not only beneficial for the students’ personal and professional life, but is also effective for exercising democratic behaviour which is an important and essential skill, especially in developing societies (Cottell and Millis 1992). This importance is highlighted for the engineering students who are trained to deal directly with society through involvement in industrial projects. In this study, we select the latest four attributes and evaluate the students’ behavioural attitudes besides evaluating the students’ learning.

As a whole, the research questions to be answered are as follows: (1) ‘Are there any significant differences in students’ learning instructed by cooperative learning plus inquiry method compared to the using traditional method?’ (2) ‘Are there any significant differences in students’ behavioural attitudes instructed by cooperative learning plus inquiry method compared to the using traditional method?’

The main contributions of this paper are: (1) Implementing a cooperative study for engineering classrooms in the Iranian educational system, (2) Implementation of a cooperative learning combined with inquiry method for crowded classrooms and (3) To study the effect of different numbers of grouping in the cooperative learning procedure.

The rest of this paper is as follows: in Section 2, a brief overview of the comparative approach is presented. In Section 3, a general background of the students is described. In Section 4, the learning and teaching approach is presented: The traditional teaching method that is used in one of the classrooms is presented in Section 4.1 and a combinatory cooperative learning with inquiry method which is applied in two experimental classrooms in Islamic Azad University is presented in Section 4.2. Section 5 includes results and discussion on implementation of cooperative learning plus inquiry technique in comparison with the traditional method. Two-way analysis of variance (ANOVA) is used for comparison among data. Section 6 concludes the paper.
2. Approach overview

In order to compare the impact of a cooperative learning plus inquiry method on student learning and attitude in comparison with the traditional teaching style, three engineering economic classrooms each with 60 students are selected. The first classroom (Class A) is devoted to traditional learning, the second and the third (Classes B and C) are devoted to cooperative learning. Figure 1 depicts the flowchart of the comparative study procedure.

The effect of different numbers of groups for cooperative strategy is studied in this paper as grouping of the students is an essential factor for implementing cooperative learning (Chan et al. 2007). As shown in Figure 1, the students of Classes B and C are clustered in 3 and 6 groups, respectively. The quantitative and qualitative analysis is performed in order to elaborate this comparative study.

The reason for selecting engineering economic among the electrical engineering courses is that it is an optional course in the syllabus of electrical engineering in the Iranian higher education system and, if in anyway the method cannot be continued during the semester, the instructor can compensate any deficits during the remaining time without any problem in continuity. It is mentioned that the course topics for the three classrooms are the same and cover:

- Time value of money.
- Rate of return vs. interest rate.
- Annual equivalent cash flow.
- Present, uniform annual and future worth factors.
- Special cases of cash flows.
- Effective interest rate.
- Present worth evaluation method.
- Uniform annual evaluation method.
- Extra investment analysis.
- Benefit-cost ratio.
- Payback period method.
- Depreciation techniques.

Figure 1. Flow chart of the comparative study.
• Cash flow after tax.
• Replacement analysis.
• Sensitivity analysis.
• Inflation.

The comparative study was implemented for the first time in the fall semester of 2010 in the Fars Science and Research Branch, Islamic Azad University. The students’ learning is evaluated by taking five exams during the semester and the significance of the results is examined by utilising two-way ANOVA. The students’ attitudes such as curiosity, inventiveness, critical thinking and persistency are evaluated through a closed questionnaire. The questionnaire includes 23 statements in 4 domains. The students are asked to express their level of agreement or disagreement with the provided statements. The answers are transformed into quantitative values using the five-level Likert scale. Also in order to qualitatively analyse the results, a scientific competition between the selected groups from the three classrooms is organised.

3. General background of the students

In the following, we list general backgrounds of the students to clarify the context of the comparative study:

• All of the students in this research study in Islamic Azad University.
• Iranian educational system is the same for all of the students. The final exam at the end of the high school period as well as the university entrance exam is the same for all of them.
• Enrolment of the students in each class is random.
• The age range of the students is 18–22.
• None of the students have experienced academic cooperative learning before.
• The same teacher (first author) is responsible for teaching in each of the three classrooms.
• Course topics for the three classrooms are the same and cover the items mentioned in Section 2.
• Students of these three classrooms were not informed about the pedagogical approach before enrolment.
• The learning and teaching approach of the students in each class remains constant for 1 semester, i.e. 16 class sessions.

It is observed that the general background of the students, across the three separate classes, is relatively homogeneous; allowing for the implementation of a comparative study.

4. Learning and teaching approach

4.1. Traditional teaching

A traditional teaching approach is considered for instruction of the students in Class A. Generally, traditional teaching is concerned with teacher-centred classes in which students are considered as the ‘knowledge holes’ that are to be filled with information (Novak 2010). In traditional teaching style, sometimes the speed of transferring information from the teacher to the students is so quick that the students are not able to analyse the information simultaneously in the classroom. In this teaching style, the interaction of the students is not significant. Mostly, instead of cooperation and interaction, students compete to get better scores in the exams. In traditional teaching classrooms, the students are passive (Wright, Bittner, and Zeithaml 1994) and class participation is limited to asking a few questions from the teacher. In this teaching style, the students mostly focus on
note-taking rather than learning information (Lunsford and Herzog 1997; Peterson 2001) and the students mostly concentrate on superficial indicators, hence disregarding deep learning (Jaques and Salmon 2007; McCarthy and Anderson 2000). Moreover, this teaching style is not able to draw teachers’ attention to the psychological and behavioural attitudes of the students. Traditional teaching technique is the normal teaching method used in the Iranian engineering educational system and the students from preliminary school to college are taught using this teaching style.

4.2. Cooperative learning plus inquiry method

In order to make it possible to implement cooperative learning for crowded classrooms, we have combined cooperative learning (Millis and Cottell Jr 1997) and inquiry method (Evans 2012; Özdilek and Bulunuz 2009). In cooperative learning, students are grouped and learning is realised by means of group activities (Millis and Cottell Jr 1997). Inquiry method or question and answer method is focused on asking questions. The students are encouraged to ask questions in class and attempt to find the answers (Rutherford 1964). Also, the teacher could pose some questions and the students attempt to answer (Evans 2012). In the presented method of this paper, as it is observed from Figure 2, cooperative learning starts with grouping the students, which is considered an essential factor for implementing cooperative learning (Chan et al. 2007). The topics for each class session and the references are introduced in the first session of the class. Based on that, before a class session, each of the groups should study the materials and prepare some questions in such a way as to cover the content completely. During the class session, each of the groups asks their questions from the other groups’ members. After listening to the answer, all class members participate in a discussion about the answer. This procedure is continued until the predetermined content is covered. The instructor is responsible for leading the questions and answers in such a way that all concepts of the content are completely covered by means of complementary descriptions and also to guarantee the participation of all the students in the class discussion. The effect of different numbers of groups for cooperative study is studied in this paper. Therefore, the students of Classes B and C are clustered in 3 and 6 groups, respectively. The teacher imposes no obligation on the students for grouping but they themselves are clustered into groups. The main differences between cooperative learning plus inquiry method and traditional teaching style are as follows:

- Traditional teaching style is ‘centralised’ by the teacher but the proposed teaching style is ‘decentralised’ and all the students participate in its management.
- The role of the teacher in traditional teaching style is to instruct the course, manage the class and answer any questions. However, in the classrooms with the proposed teaching style, this role changes to supervising class discussions, providing complementary descriptions and guaranteeing the participation of all students in the class activities.
- In the classrooms with the proposed teaching style, the teacher should be more concerned about time management. The teacher should assure time is fairly devoted to each group while the topic is being covered and the class reaches the pre-determined session schedule. A teaching assistant could help in this regard, but is not specifically used in our case study.

In addition to managing the class, the teacher should be careful of the emotional and behavioural attitudes of the students by putting focus on guiding the students’ interactions. Figures 3 and 4 show that the student interactions increase much more in comparison with the traditional teaching style.

One of the most important features of the implemented teaching style in classes B and C is its combination with the inquiry method. Before the class session, all of the students of each group
5. Results and discussion

The results of implementation of cooperative learning plus inquiry method in comparison with traditional teaching style including exam results, science attitudes and descriptive analysis are presented in this section. Evaluation of the students’ learning is performed by taking five exams during the semester. The data are analysed by SPSS and MATLAB. The average values of the students’ scores in each class that are related to each exam are depicted in Figure 5. It should be noted that the exams’ scores scale in the Iranian educational system is from 0 to 20.
Evaluation of students’ learning in cooperative learning plus inquiry method classes (i.e. Class B and Class C) has shown that the students’ average scores in Class C have improved after the first exam. However, for Class B, no promising results are observed, which is because of the high number of students of each group in this class. The descriptive statistics of the scores are presented in Table 1. In order to examine the significance of the results, two-way ANOVA is utilised. Here, there are two factors: teaching and learning approach and exam. It is mentioned that these factors have no interactions. Table 2 shows the ANOVA results. The \( p \)-value for teaching
Table 1. Descriptive statistics of the scores.

<table>
<thead>
<tr>
<th>Class</th>
<th>Exam</th>
<th>Mean</th>
<th>SD</th>
<th>N</th>
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<tr>
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<td>14.5</td>
<td>3.25863</td>
<td>60</td>
</tr>
<tr>
<td></td>
<td>2</td>
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<td>3.23841</td>
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<td>15</td>
<td>3.33306</td>
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<td>4</td>
<td>16</td>
<td>4.06358</td>
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<td></td>
<td>5</td>
<td>15</td>
<td>3.1956</td>
<td>60</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>15.3</td>
<td>3.50454</td>
<td>300</td>
</tr>
<tr>
<td>B</td>
<td>1</td>
<td>12</td>
<td>3.02181</td>
<td>60</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>15</td>
<td>3.98142</td>
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<td>3</td>
<td>14</td>
<td>2.95051</td>
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<td></td>
<td>5</td>
<td>14</td>
<td>4.36303</td>
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<td>Total</td>
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<td>14</td>
<td>3.75343</td>
<td>300</td>
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<tr>
<td>C</td>
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<td>60</td>
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<td></td>
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<td>Total</td>
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<td>3.29984</td>
<td>300</td>
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<tr>
<td>Total</td>
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<td>13.667</td>
<td>3.31431</td>
<td>180</td>
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<td></td>
<td>2</td>
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<td>180</td>
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<td></td>
<td>5</td>
<td>15.1667</td>
<td>3.66758</td>
<td>180</td>
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<tr>
<td>Total</td>
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<td>15.166</td>
<td>3.54246</td>
<td>900</td>
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</table>

Table 2. ANOVA table of the scores.

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<tr>
<th>Source</th>
<th>SS</th>
<th>df</th>
<th>MS</th>
<th>F-statistics</th>
<th>p-value</th>
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</thead>
<tbody>
<tr>
<td>Learning style</td>
<td>566</td>
<td>2</td>
<td>283</td>
<td>26.42</td>
<td>0</td>
</tr>
<tr>
<td>Exams</td>
<td>2251.7</td>
<td>99</td>
<td>23.74</td>
<td>2.12</td>
<td>0</td>
</tr>
<tr>
<td>Interaction</td>
<td>2309</td>
<td>198</td>
<td>11.6615</td>
<td>1.09</td>
<td>0.2248</td>
</tr>
<tr>
<td>Error</td>
<td>6427.8</td>
<td>600</td>
<td>10.7131</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>11554.5</td>
<td>899</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

and learning approaches effect is approximately zero. This is a strong indication that the students’ scores vary in all three learning styles. It is concluded from the results shown in Tables 1 and 2 that the cooperative strategy plus inquiry method has a positive effect on learning of the students in the class with a fewer number of students. The $p$-value of 0.2248 in Table 2 indicates that there is no strong interaction between the exams and the learning styles, i.e. these factors are approximately decoupled. Table 2 also provides other information extracted from the two-way ANOVA procedure.

In addition to learning, the students’ science attitudes are evaluated based on a questionnaire which covers items to evaluate the effect of cooperative strategy plus inquiry method on student attitudes including: (1) curiosity, (2) persistence, (3) inventiveness and (4) critical thinking (Kratochvil and Crawford 1971). The questionnaire contents are presented in the appendix. The students are asked to assign one of these answers to each of the questions: strongly agree, agree, neither agree nor disagree, disagree and strongly disagree. The students’ responses are quantified using Likert scale in such a way that 5, 4, 3, 2 and 1 are assigned to the response strongly agree, agree, neither agree nor disagree, disagree and strongly disagree, respectively. Afterwards, the data gathered from the students of Classes B and C are compared by using ANOVA. The ANOVA
results are depicted in Tables 3–6 and the average of the data for Classes B and C is also depicted in Table 7.

It is observed from the results of Table 7 that the average related to the attitudes of Class C is better than that of Class B. However, as it is depicted in Table 3, for the curiosity the difference is not significant and for the inventiveness, as it is depicted in Table 5, the difference is, for the most part, significant. Moreover, the percentage of the students who agree or strongly agree that cooperative learning plus inquiry method affects positively on their attitudes is calculated and depicted in Figure 6. The results show that a high percentage of the students in both Classes B and C is satisfied with the cooperative strategy plus inquiry method.

In addition, a descriptive analysis of the implemented cooperative strategy and its impacts on learning and attitudes of the students are presented. It is observed that the cooperative strategy plus inquiry method has an equal influence on learning and attitudes of all the students regardless of their courses’ scores average, i.e. all of them benefited from this learning strategy equally.

Besides the exams and evaluation of attitudes that are performed through the questionnaire, a scientific competition is organised between the selected groups from the three classrooms. The
The purpose of this competition is to evaluate the same attitudes which have been asked through the questionnaire evaluation. Three types of questions have been designed:

- Questions for evaluation of the students’ persistency: These questions are similar to the materials taught in class and need slight computational efforts.
- Questions for evaluation of the students’ curiosity: These questions are incorporated with some points that require the students’ to search through new materials. For this purpose, students are allowed to use the internet during the exam.
- Questions for evaluation of the students’ critical thinking: An evaluated engineering economic design is considered and the students are asked to re-evaluate it and do the necessary corrections.

The time of this scientific competition is considered 5 hours. It is observed that the students of Classes A, B and C leave the competition after 2.5, 3 and 4.5 hours. This shows the persistency of both cooperative learning classes is more than traditional learning class. We also observe that the students of Classes B and C attempt to do the exercise together, but the students of Class A are not able to work together co-ordinately. The students of Class C show more success in criticism of the evaluated engineering economic design. Fear of mistake is reduced in the students of Classes B and C in comparison to the students of Class A. Finally, the score of the students of Class C is higher than Classes B and A. However, the average of the students’ scores in Class B is less than Class A. As depicted in Figure 5, in this competition the students of Class B are more prosperous in comparison to the students of Class A. In other words, Class B is more prosperous in comparison to Class A in ‘elitism evaluation’ but not in the general evaluation.
It should be noted that this study is considered as a very early attempt for implementing active learning methods in engineering classrooms in the Iranian educational system, in which learning from K-12 is solely performed as an individualised task. With this very traditional background, the students have never experienced any cooperation in class activities in a formal way at the university level. In this study, because of unfamiliarity of the students with active learning methods, crowded classes, assigned exams through the semester, university restricted regulations, the implementation of cooperative learning plus inquiry method wholly in classrooms might be very time-consuming and causes the contents of the course not to be covered completely. Hence, the cooperative learning is performed before class in unofficial times and the inquiry method is done in the class. This implementation method is different from what has been performed in previous cooperative learning researches (Abdulaal et al. 2011; Chan et al. 2007; Kern, Moore, and Akillioglu 2007). The implementation method makes this learning strategy suitable to be adapted for use in crowded classrooms at the university level, whereas most of the previous studies on cooperative learning are performed for a class with a lower number of students (Abdulaal et al. 2011; Chan et al. 2007; Kern, Moore, and Akillioglu 2007; Maceiras et al. 2011).

Finally, it is promising that the cooperative strategy plus inquiry method through its positive mentioned effects on the students’ learning and attitudes may guarantee our hope for promotion of the important features such as self-respect, social skillfulness, positive interdependency and individual accountability, which have been cited from previous researchers (Erdem 2009; Kern et al. 2007; Smith 1989, 1995) in the Introduction section, in the long term.

6. Conclusions

In this paper, a cooperative learning plus inquiry method was presented for crowded engineering classrooms. For effective engagement of the students in class activities, the students were grouped. Cooperation was performed before a class session and the results of cooperation were reflected through inquiry method in the class session. The case study was three engineering economic classrooms in Islamic Azad University each with 60 students. The students have been unfamiliar with cooperative strategy in their previous educational experience, the class time was fixed and the main concern was covering the course content. The first class (Class A) was devoted to traditional learning while the second and the third classes (Classes B and C) were devoted to cooperative learning plus inquiry method. The effect of different numbers of groups for cooperative study was studied in this paper. Therefore, the students of Class B and C were clustered in 3 and 6 groups, respectively. It was strongly indicated that the students’ learning varied in all three classrooms. Learning performance of the students in Class C was better than Class A and Class A was better than Class B. In order to find out the effect of the presented strategy on the students’ behavioural attitudes, four attitudes including curiosity, persistence, inventiveness and critical thinking were considered. It was observed that the presented strategy had a positive effect not only on learning, but also on the attitudes of the students. The results of this study showed that the average related to the attitudes of Class C is better than that of Class B. However, for the curiosity the difference was not significant and for the inventiveness, the difference was, for the most part, significant. Moreover, a high percentage of the students in both Classes B and C agreed or strongly agreed that cooperative learning plus inquiry method affected positively on their attitudes. Qualitative analysis showed that Class B was more prosperous in comparison to Class A in ‘elitism evaluation’, but not in the general evaluation as the quantitative analysis showed, and also performance of Class C in both elitism and general evaluation was better than Classes B and A.

By means of the above mentioned findings, the research questions could be answered: there are significant differences in students’ learning and attitudes instructed by cooperative learning plus inquiry method compared to the using of traditional method. However, the positive effectiveness
will be revealed when the presented strategy is implemented in Classes with a fewer number of students in each group.

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Appendix. Questionnaire contents

After finishing the course, the students were asked about the effects of the cooperative learning plus inquiry method on
their attitudes. The assessment of the students’ attitudes was performed by a questionnaire with the following contents
using Likert scale. Four attitude areas that are a part of scientific literacy used in this research are as follows:

A. Curiosity

- I usually use several senses to explore organisms and materials.
- I always ask questions about objects and events.
- I am very interested in the outcomes of experiments.
- I pay particular attention to an event or object.
- I am interested to learn more and more about events and objects.

B. Inventiveness

- I like to generate new ideas about any scientific concept.
- I usually use equipment and ideas in unusual but constructive ways.
- I am eager to suggest new experiences or experiments.
- I am able to describe novel conclusions from my observations.

C. Critical thinking

- I can provide sound reasons for my suggestions.
- I can provide sound reasons for my conclusions.
- I can provide sound reasons for my predictions.
- I give evidence to justify my conclusions.
- I like to predict the outcome of untried experiences.
- I change my ideas in response to evidence or logical reasons.
- I point out contradictions in reports by my classmates.
- I am interested in investigating the effects of selected variables.
- I can solve brain teasers and provide explanations.

D. Persistence

- I am not easily distracted from my activity.
- I maintain active interest in a problem or event for a longer period than my classmates.
- I continue to investigate materials after their novelty has worn off.
- I like to repeat an experiment in spite of apparent failure.
- I complete an activity even though my classmates have finished earlier.