The Impact of Individual and Group Work in Students' Performance on Laboratory Work with Argument-Based Inquiry Instructional Strategy

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Abstract:*This preliminary study aims to investigate the impact of individual and group work on the argumentation discourse and performance of students' laboratory work of chemistry in a Form 6 school centre in Kota Kinabalu, Sabah. An analysis type of investigation work with argument-based inquiry strategy was set to a group of 6 students. Three of them were doing investigation work individually, while the rest were in a group work. Data was collected from students' argumentation discourse and their performance on the task. This data was triangulated by written documents of the students. The students' quality of argumentation discourse and performance on the task were compared between individual work and group work. Observation data showed that the students in group work have better quality of argumentation discourse and performance on the task given than the students with individual work. Students' assumption of role was observed in the group work, therefore it is suggested that only two of students is much preferred compared to three students in a group work. This study is to suggest the usage of laboratory work with argument-based inquiry instructional strategy as a guide module for Form Six Chemistry teachers who want to reflect on their teaching methods in laboratory.*

Index Terms:*Argumentation discourse, Students' performance, Laboratory work.*

I. INTRODUCTION

The Malaysian Chemistry Curriculum has been designed to produce active learners with skills and capabilities to learn through hands-on activities and experimentations (Curriculum Development Centre, 2005). Laboratory work is part of chemistry learning and its intention is to relate chemical theory of practice in the laboratory. But the main objectives in the syllabus of Malaysian Higher School Certificate (STPM) Chemistry Coursework are to improve the practical skills and the quality of the practical work of students where individual work is implemented the most in the syllabus and is parallel to Cronin and McCabe (2017) findings. The findings state working alone is better in terms of quality of techniques. Individual work is a superior approach especially when it means that the student works solely on his/her own and focuses on the completion of their projects without relying on others. The STPM Chemistry Coursework is a continuous school-based assessment and most of the time the teachers are able to facilitate and do direct assessment on the desired practical and scientific skills performed by students. Therefore the individual work in the STPM Chemistry Coursework is not really a "working alone" task because as students are allowed to ask for help and advice from their teacher. However working in group is also implemented in the STPM Chemistry Coursework for guided inquiry instruction, and synthesis technique that require students to handle corrosive chemicals.

The small-group activities have become most accepted in the laboratory that consists of two to five members (Cooper, 2005)and is widely studied in the STEM disciplines (Micari, Pazos, Streitwieser and Light, 2010; Cooper and Robinson, 1998) and chemistry (Robinson and Nurrenbern, 1997). In chemistry courses, collaborative groups have been used in a wide variety of situations ranging from lecture classes to upper-level laboratory classes. It is clear that this method has given positive impact in promoting deeper level of understanding, higher level of reasoning and critical thinking.

Whether working alone or in group work is necessary in the laboratory, most of the time the aim in the context of school laboratory work is to get the task done in order to fullfill the syllabus requirement rather thangoing through the learning process while solving problems (Jiménez-Aleixandre and Reigosa, 2006).When all the procedures are uniform to all the students, with similar data, and the claims match the expected outcomes, then the reporting of results and conclusion often lack of students deeper understanding for the topic and scientific reasoning skills (Greenbowe & Brian Hand, 2005). This is also happen in the STPM Chemistry Coursework where the students only focus in completing the task rather than understanding the process of the laboratory work. . Repetition of work if often carried out when something happen not according to their plan or large percentage error occur in their data when compared to the "literature value". Comparing findings with the "literature value" is rather normal atthe laboratory work inMalaysian schools as laboratory learning environment isstill focussing on 'teacher centered' and 'confirmatory' activity (TIMSS, 2011; Lilia, 2009; Effandy and Zanaton, 2007 ;Zakaria and Iksan, 2007)which limits the students' potential in learning through open ended investigation (Lilia, 2009; Effandy and Zanaton, 2007).

Most chemistry teachers assume that if students carry out a chemistry laboratory activity with direct instructions given in the manual, they will learn laboratory techniques and

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related concepts. But there is increasing evidence proving traditional cookbook laboratories are not effective for majority students. Researchers have consistent findings that student may learn more on laboratory techniques rather than the related concepts (Newton, Driver, and Osborne, 1999;Greenbowe and Brian Hand, 2005), and they are unable to relate their experiences of activities in the laboratory with students' learning process (Hofstein and Lunetta, 2003) as less time is allotted for discussion, argumentation and reconciliation of meaning (Kim and Song, 2006). This traditional method is encouraging students to adopt the role of passive listeners and followers abandoning scientific reasoning skills (Kenneth, 2009).One way of developing scientific reasoning skills is through argumentation. It is the acquisition of knowledge by encouraging learner's ability to think and solve problems and generate argumentative discourse.

Eventhough questioning can increase thinking skills among students (Marzano, Pickering and Pollock, 2001) but some reports claimed that the discourse in the confirmatory laboratories lacks arguments (Abi-El-Mona and Abd-El-Khalick 2006) and this does not help in the students understanding of the topic or processes. Findings from the previous studies show that the students experiencing the argument-based instruction in an inquiry-type laboratory are able to generate significantly better arguments(Grooms, Sampson and Golden, 2014;Walker, Sampson, Grooms, Anderson and Zimmerman, 2012 ; Sampson and Clark, 2009).

STPM is an exam-oriented system and because of this, the primary goal for students' performance in school is to increase their content knowledge in the discipline and ability to learn successfully from traditional content delivery tools such as textbooks, lectures, laboratory manuals and multimedia presentations (Cracolice, 2005).The report on Trends in International Mathematics and Science Study (2011)claimed that Malaysian students spent less time doing laboratory activities compared to students in other countries and the teachers are preferably to use textbooks rather than science equipment materials for their teaching instructions. This method promotes majority students to loose interest in open ended laboratory instruction (Lilia, 2009) and makes them think that activities in laboratory is not important (Noor Akmar 2007).

Chemistry laboratory with inquisitive activities offers many possibilities in giving meaningful learning. Researchers suggest that students' participation in inquiry-type laboratory work, that involves identifying research questions, forming hypothesis, designing and conducting scientific investigations, formulating scientific explanations by coordinate evidence in support of claims, and then justify their choices is important in developing a scientific literate individual (Grooms, Sampson and Golden, 2014;Lilia, 2009; Jimenez-Aleix-andre and Erduran, 2008; Ozkan, Carikoglu and Tekkaya, 2006)

Chemistry Education Curriculum has a valuable contribution to counter the 4^{th} Industrial Revolution and plays a crucial role in Malaysia's aspiration to become a developed nation. It is important to nurture the students with skills and capabilities to learn chemistry ideas with appropriate technique of pedagogy. There is a need to introduce appropriate guided inquiry laboratory instruction in Malaysian learning environment to improve the achievement of high and low academic ability level students in their learning process. Therefore it is vital for us to investigate the students' performance within individual and group work in the STPM Chemistry instructional laboratory with Argument-Based Inquiry Instructional strategy and select the most suitable instruction before setting it in a larger series of laboratory work. The steps in doing the laboratory work has added values from the Argument-Driven Inquiry (ADI) instructional model(Sampson and Gleim, 2009) and compliance with Malaysian learning environment.

II. LITERATURE REVIEW

A. Sociocultural Theory and the Zone of Proximal Development

The assumption of sociocultural theory is that all higher-level human development is socially mediated. The relation between social mediation and development appears in a discussion of the zone of proximal development (ZPD). Vygotsky (1978) proposed learning perspective is within the context of social interaction which involves a series of processes that interact with the social surroundings. He identified a person's development as in two levels: actual development, a person that can perform actions independently without support or assistance; and potential development as determined through the performance of tasks in collaboration or under supervision with more able person or less mature and more mature person. The difference between this two levels is the ZPD.

When members of small group are exposed to scientific tasks, it provides opportunities for them to get involved in debatable arguments that will be supported or rejected by the other groups. Sometimes with teacher's intervention, the group has the opportunity to construct knowledge. This manner of generating knowledge is an example of constructivist socio-cultural knowledge, as described by Vygotsky (1978).

B. Learning in the Laboratory

Laboratory learning strategies in connecting theory and practice have been successfully implemented in chemistry courses. Particularly, the Science Writing Heuristic (SWH), which highlight on claims and evidence(Schroeder and Greenbowe, 2008) and Argument-Driven Inquiry (ADI), which forefronts student construction of or a land written scientific arguments (Walker et al., 2012; Grooms, 2011) have shown positive student learning outcomes. SWH has been implemented together with Process-Oriented Guided Inquiry Learning (POGIL) to help connect theory and practice.

However, implementing of SWH or ADI requires significant changes to laboratory curriculum to include the inquiry-based experiments. An investment in resources and professional development needed for the adoption to be successful and this often end up continuing the traditional

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teaching because of time constraints for preparing and learning about new course materials. This large scale modifications may be difficult to achieve and can be overwhelming to be implemented.

Therefore for this study, the researcher forms a laboratory work with Argument-Based Inquiry that is compliance with the STPM Coursework syllabus and instruction. This instructional strategy is based on social constructivist theories of learning and from the learning framework of instructional model, Argument-Driven Inquiry (Sampson and Gleim, 2009) to create more authentic and educational laboratory activities. It closely resembles science research laboratories and is more educative for students as they may receive feedback and have an opportunity to learn from their mistakes throughout the process.

C. Argumentative Discourse in the Laboratory

Argumentative discourse is a dialogic event carried out among two or more individuals where they have to construct an argument that justifies the claims that support the evidence (Duschl and Osborne, 2008), a way to talk about scientific information, ideas or practices, scientific methods and reasoning (Lee and Irving, 2018).

It will support the social construction of knowledge during the activity, exposing student thinking and enabling its critical evaluation by the teacher, the student and his or her peers (Duschl and Osborne, 2008).

III. OBJECTIVE

The focus of this study was to explore the students' performance on scientific research tasks individually and in group throughout the laboratory instruction.

IV. METHODOLOGY

This is a small-scale study, qualitative method with careful observation and mine data from discourse and documents. An experiment using Qualitative Analysis technique specific for Inorganic Chemistry is used in this study. In order to create the Argument-Based Inquiry instruction strategy to be compatible with the instruction of STPM Coursework Syllabus, individual work instruction was implemented and have the same instruction with the small group work. The goal of this study was to investigate the performance of the students in both individual and group work during the laboratory instruction.

A. Research Samples

A small-scale study was conducted in a classroom of 6 students from the same school (Form 6 Centre at the West Coast Division of Sabah, Malaysia). These students were selected using purposive sampling – same age (18)with similar cognitive level and had just sat for their first semester examination. They were expected to have sufficient literacy levels to be involved in the argumentation session where the tentative arguments were shared and critiqued.

B. Research Samples

The main sources of data were audio and video recordings of the teacher and students' discourse and physical actions. The written work was also documented in the argumentation session and their reports. The teacher organized the students into individual and small group. They were required to plan and carry out tests to identify the anions in an unknown solid mixture. They were required to deduce as much as they could about the anions. The teacher and students' discourse were audio-taped from the beginning of the first stage of identifying the task and designing their investigations. The teacher encouraged the students to ask questions as they designed their investigation using a "hint" diagram given by the teacher. The teacher showed techniques to do the test as most of the students could not recall some of proper techniques needed in the experiment. Safety precautions were continuously remindedto the students because some of the materials were corrosive and released toxic fumes and the tests needed to be done in the fume cupboard.

The students' process skills were observed and video-taped. Their discourse through the process were audio-taped. Their argumentative discourse aimed to elucidate the students' understanding about several aspects in the qualitative analysis technique and their understanding in the theory of practice. The assumption of responsibility from the teacher to the students and the role as leader and follower between the students were observed. The students' written work were also documented. Their argumentation session between the individuals and small group were audio and video-taped. This aimed to find the differences in their production of evidence in support of claims, and justification of their choices.

C. Data Analysis

The transcripts of discourse were analysed using inductive analysis (Lincoln and Guba, 1985) to interpret social situations, focusing on emerging of theory in the data. The situations that relevant to the study were grouped in categories and the interpretations were explained carefully with proposed meaning. The situation were corresponded to the problem solving in the laboratory work instruction. The laboratory report from each students were analysed using the STPM assessment rubric and their written arguments were analysed.

Below is the phases in the Argument-Based Inquiry instruction. Only five stages were used from the model instruction of Argument-Driven Inquiry (ADI) because of the time constraint in the STPM Coursework Laboratory Instruction.

Table 1: Phases Performed by the Students

Phases	**Individual**	**Small Group**
Identification of Task and Design Method	+	+
Data Analysis	+	+
Tentative Argument	+	+
Argumentation Session	+	+
Investigation Report	+	+

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V. RESULT

A. Students' Performance

The small group has completed their task in a less time compared to the individuals. Almost no error was observed in their investigations results. Their argumentative discourse were detected in almost all of the laboratory activities, except Sue, the silent member. Their reasoning skills were detected more in their arguments in the argumentation session phase compared to the individuals. Their written work in laboratory report has no significant difference compared to the individuals except on their written arguments in the additional instruction of the laboratory activity. However, the written arguments of Sue, Anne and Nina were all identical. Three of them were copying each other's work. They have not shown deep understanding in the process of their investigation activity and they could not write proper good arguments about their investigation work. Darren was taken a very long time to hand in his laboratory report and did not write any arguments about his investigation work.

B. Social Interaction and Group Roles

The small group were consist of three students named as Rose, Sue and Lenny. Sue was a shy, silent and passive listener in the group and always follow the instructions from her fellow members. She neither talk in group discussions nor in the argumentation session. At first, Lenny was assuming leadership eagerly sharing her knowledge and decision making to her members.

Lenny: Let see, the instruction need us to find the anions, so I guess we can start by looking at this one.

Rose: Hmm, yeah…that's right.

Rose was at the start following Lenny's ideas but eventually sharing more of her ideas to improve their design of the investigation. The discourse in the group was only between Lenny and Rose. Sue was not involving herself in the planning of the investigation and was waiting for the instruction of her members. Sue's understanding in the process of investigation work was not detected in the discourse because she did not involve herself in the group discussion.

The individuals were also three students named Darren, Anne and Nina. They were first assigned in a group for designing the task for their investigation. Darren was assuming leadership and sharing his decision making and his knowledge of the specific tests to his members. The other two, Anne and Nina was following Darren ideas and always focusing on the procedures rather than the ideas of the processes.

Darren: Let us start by checking all the materials. Both of you can do that.

Nina: What are we going to do now? …

Anne was keep on telling the shortcomings of their designs but never give solutions to their problems. Nina also never give solution to their shortcomings of investigation design. She was following the instruction given by Darren.

Anne: But this one need to find nitrate right? I couldn't find which one we need here.

Nina: Okay. Wait for his idea.

Their discourse on the ideas of their investigation design were only detected when they were assigned together as a group at the first stage of the laboratory instruction. Later when they were assigned to do the laboratory work individually, all of them were doing their task without discussing on their work together. Unfortunately, all of them were doing the same mistakes in one of their test in the investigation. They were too concentrated to get the task done and did not mind to repeat the procedures. Finally they asked for the teacher's advice on their problem. Most of their discussion were about managing the procedures in their investigation.

VI. DISCUSSION

This section discusses about students performing laboratory activity. The researcher has identified problem arose in the instruction All the students were taken a very long time designing their investigation. Therefore it is appropriate for the planning to be done earlier, not on the same day of the laboratory activity. The support provided by the teacher in this study was intended as scaffolding according to the Vygotskian zone of proximal development. The transfer of responsibility from the teacher to students in completing task is essential in the conceptualization of scaffolding.

By means of inductive analysis with proposed interpretations, this study finds that placing students in groups does not guarantee negotiation of meaning takes place between them. This was seen in the group of three students, when one of them was a passive listener and left out from the group discussion. It shows that not all students with different Zone of Proximal Development in groups will be rewarded in the learning intervention. Some will not have the benefit from it because of their social interactions and roles (Reigosa and Jiménez-Aleixandre, 2007). The understanding required for an experiment has to be in the ZPD so that during group discussion, the students can discuss the subject and foster the knowledge and understanding of its members (Vygotsky 1978).

The students must see each person in the group benefits from the others' efforts. This should be the positive interdependence and individual accountability (Cooper, 2005). Students' with poor content knowledge (Sadler and Fowler, 2006) is also a factor in leading Sue to be passive and left out from her group. Students will enter into argumentative discourse when they have much knowledge of the content that supports the scientific background of the experiment.

The other two students were collaborating well in the group, therefore the result suggest that working in two as a group is well better than three in a group. It had significantly improved understanding in the investigation activity compared to students working individually. But this is contrast to Cronin and McCabe (2017) findings where both individual and working with partner has similar contribution to the improvement of understanding of the subject. Individual work is still significant for investigations with specific purposes (Cooper, 2005).

Students used to have little understanding on the purpose behind each step of the experiment and the urgency to complete the task is always a priority to them. This is why the individual students could not counter the shortcomings of their investigation design. They were too focused on their work and did not make time to discuss on their findings, even though they did the tests on the same work table. However their lack of content knowledge in the process of investigation may also be the factor of their weaknesses in designing the investigation.

Sue, Anne and Nina were also could not write proper arguments on their investigation. According to researchers, the ability to argue or understanding of arguments and argumentation will support their ability to write arguments (Kuhn and Udell, 2003; Nussbaum and Sinatra, 2003). This result suggest additional instrument to promote argumentative writing to be implemented in the laboratory instruction.

VII. CONCLUSION

Based on the findings, it was clear that Argument-Based inquiry can be implemented in the instruction of STPM Coursework Syllabus with Malaysian learning environment. The experiment served as a potential platform for an argumentative discourse. As a conclusion, the performance of students in a small group is significantly better compared to individual work. It is suggested that two students in a group will perform best in the Argument-Based Inquiry strategy.

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