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STUDENTS ARGUMENTATION IN SCIENCE LESSONS: A STORY OF TWO RESEARCH PROJECTS

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ABSTRACT

The study analysed profiles of students' argumentation and how lessons may develop students' argumentation skills. The study was conducted at two Indonesian progressive private schools and a school located in Australian low socio-economic community. This study explored possibilities to draw together results from two different research approaches typical to each country. The Indonesian research project used paper and pencil tests and interviews to investigate students' argumentation skills, while the Australian research project analysed videos of the lessons. The Indonesian study finds that there is no significant different between two types of schools and gender. The Australian classroom showed shifts in creative dispositions that include the argumentation processes but not a consistent pattern between classes. The Australian teachers actively required students to make claims, explore the robustness of these claims, transferred these claims to new settings and to think of alternative explanations that encouraged students to construct more coherent arguments. This study finds that interpreting and re-interpreting two different research approaches can produce insights that benefit both sides as it can account for the context and needs of each country. In addition, combining of two different methodologies provided perspectives often not collected through single methodologies.

Keywords: argumentation skills, Australia, Indonesia, science education

INTRODUCTION

Internationally, governments are concerned about the outcomes of international comparative studies on students' achievement in science, such as TIMMS and PISA that involved both Australia and Indonesia. A number of educational policies are formulated in response to the findings, such as programs to improve teachers' qualification that are expected to give impact on the improvement of students' achievement. In both Australia and Indonesia, there were similarities in terms of strategy to improve the quality of education. While Indonesia introduces teacher certification (Jalal, Samani, Chang, Stevenson, Ragatz, & Negara, 2009; Republik Indonesia, 2005), researchers and government organizations in Australia have conducted numerous national surveys and reviews on teacher education programs in relation to the competency levels of teachers, certification procedures, and their employment status (Australian Institute for Teaching and School Leadership, 2013; Harris, Jensz & Baldwin, 2005). There is a relatively common perception in both countries that changing the teacher education programs will improve learning. In both Australia and Indonesia, the focus is on changing the quality of teachers rather than how the students learn. While focusing on improving teachers' competencies that can be important, however, it should not be ignored how the students learn since education is about students' learning rather than teachers' teaching. Comparatively, approaches to improve education put much more

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emphasis on what the teacher do, not on what and how the students echieve.

Some researchers (Osborne, 2010; Hand, Norton-Meier, Staker, & Bintz, 2009) claim that reasoning skills can contribute to the quality of student learning. This paper will describe two studies in Australia and Indonesia that attempt to address some of the issues around the students' argumentation and reasoning. Kuhn (2010) argues, "Skills of argument are fundamental intellectual skills, worthy of attention in their own right." Argumentation requires students to think clearly and critically as well as provide evidence to support claims. Hornikx & Hahn (2012) identify the notion "argument" as refers to reason, a structured sequence of reasons and claims, and a social exchange. All these three are integral to understand the human reasoning and cognition. These suggest that argumentation skills are closely related to reasoning and in this paper; the two terms are used interchangeably.

Hammer & Sikorski (2015) argue that a student learning is complex and that it needs to take into account the complexity reasoning of the learners. In addition, students learning can often be lack a degree of coherency in their reasoning processes and it is important to address this. Student learning is enhanced when they are actively involved in the learning process. Engagement in learning can be facilitated when students develop good reasoning skills that can be achieved by demanding students to make a claim and to support their claim by giving strong evidences. Students achieve better conceptual understanding and reasoning skills when they are supported to generate their own representations and justify their understanding.

This process of utilizing representations provides insights into how students reason. As Lehrer & Schauble (2015) said, learning is a coordinated, on-going enterprise of working together to build coherent accounts and not a kind of static hypothesis to be tested, affirmed, and reified. There are students who cannot develop coherent accounts and to address the different ways that they endeavor to reason and understand the concepts. There are two possible ways for students to make meaning of science concepts (Zembal-Saul, 2008). In the first pathway, students may start with scientific phenomena and pursue it with formulating testable questions and followed by collecting and analyzing data. Alternatively, students may also make meaning by looking at the existing scientific knowledge and scrutinizing the knowledge in terms of the evidence and the justification. Toulmin's (1958) formal model of argumentation processes has been the dominant model in studies on student argumentation in science. According to Toulmin, a strong argument consists of a claim (a statement of position), data/ground (facts and evidence to prove the claim), warrant (logical statements that serve as bridges between the claim and the data), backing (statements to support the warrants), qualifier (statements that limit the strength of the argument), and rebuttal (statements indicating circumstances when the argument does not apply).

As suggested by Nielsen (2013), one of the advantages of Toulmin's model is the applicability to analyze large-scale quantitative data. It focuses on the identification of claims, assertions, connecting evidence or data, warrants for claims, and backings for warrants (Brown, Nagashima, Fu, Timms, & Wilson, 2010; Osborne, 2010). Toulmin's models allow researchers to analyze an argument into its component and conduct quantitative analyses.

While we see the value in Toulmin's taxonomy, we also believe that the actual process is not so reductive as Toulmin's model suggests. Dolan & Grady (2010) who claimed that the highest level of reasoning in inquiry entailed students thoughtfully representing data in multiple ways including tables, drawings, graphs, or statistical representations note the complexity of reasoning processes. The different nature of Indonesia and Australia in terms of the methods to teach science at schools as well as research methods employed by science education researchers, it is interesting to see how Indonesian and Australian schools facilitate students reasoning. The following are questions that guide this research: How is the profile of students' argumentation?; How do lessons facilitate students' argumentation?; How is the significance of the research design?

METHODS

This study was designed to explore possibilities to integrate findings from two different research traditions of two countries (quantitative in Indonesia and qualitative in Australia). Although traditionally both countries have a long history of bilateral relationship, however, the number of educational research collaboration is very limited. It seems that different research traditions in both countries have been shaping research-funding bodies to favor different research approach. As a result, researchers in both countries adjusted their research approach to the preference of the awarding bodies.

In this study, we attempt to collaborate at data analyses and interpretation level (Figure 1). We believe that interpreting and re-interpreting two different research approaches can produce insights that benefit both sides as it can account for the context and needs of each country.

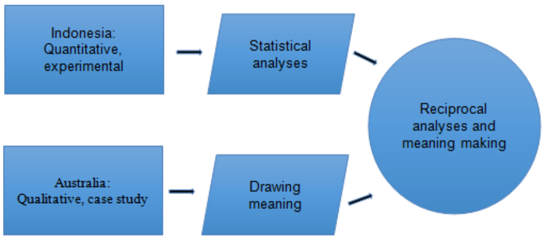

Figure 1. Research design

For the Indonesian setting, a pre and post intervention of the data collection using written tests and interviews were conducted to measure students' reasoning. Interviews to the school principal were conducted to collect data about the school philosophy and policies. Teachers' views about how lessons may contribute to students' argumentation skills were collected through interviews to the science teachers. At the Australian setting, data were collected through interpretive analyses of the videos and interviews to the teachers and the students. The Australian study focuses on instances where argumentation appears in class and deeply analyzes them to draw meanings from such instances. Based on the data collected at each country, we conduct reciprocal analyses and draw meanings from the data. We tried to understand and draw meanings of findings from both countries. Finally, we tried to draw common and more general accounts from both studies.

The study was conducted at two Indonesian schools and an Australian school. The Indonesian schools are two readily accessible private schools. For the purpose of anonymity, the Indonesian schools are identified as School A and School B. The schools were purposely selected since they were considered as progressive schools that ready to adopt innovation. Both schools implemented the national curriculum but they also modified it to fit the philosophy of the schools. Unlike most schools, enrolment rate at both schools was relatively low as they were relatively expensive schools. All students in School A and School B participated in the study.

The Australian school consists of a school whose teachers have been involved in our work on student-generated representations (Prain & Waldrip, 2006; Sutopo, Liliasari, Waldrip, 2013; Waldrip & Prain, 2012; Waldrip, Prain, & Sellings, 2013). The school was a high school located in low socio economic community. The number of the students in the classroom was about 25 students. A science topic on genetics taught by a science teacher was chosen as an exemplary lesson. Students were accustomed to traditional classes that were didactic and teacher focused. We focused on a teacher (Wendy) who was perceived as excellent by their peers. The teacher was committed to improving the student learning and took risks to try new approaches that were likely to improve learning for students. One would identify the teacher as a 'risk taker'.

The levels of students' argument were analyzed based on a modified rubric based on Toulmin's framework. Based on Toulmin's framework Choi, Notebaert, Diaz, & Hand (2010) developed a matrix to the analyzed argumentation. The matrix, however, is a bit complicated that we decided to simplify for the purpose of our study (Table 1).

Secondly, the students' responses were analyzed based on the coherence and comprehensiveness of the components of their answers (Table 2). We felt that it was important to examine whether the students related components of arguments together to build a coherent argument. We were interested if the students' answers provided and related data, evidences or warrant that in meaningful and logically made sense. To analyze the coherence of the reasoning, we developed the following rubric. Students' interviews were used to clarify the students' answers and to explore the students' deeper reasoning.

Analyses of the Australian data were mainly based on the videos of the lessons. All videos were carefully watched to find incidents of argumentations. We initially analyzed the videos based on Lucas, Claxton and Spencer's (2012) creative disposition including inquisitiveness, persistence, imaginativeness, collaborativeness and disciplined. When there were parts of lessons that showed such incidents, we carefully analyzed them to see how argumentation was used to develop the students' thinking. In addition, the teacher – student interaction and the student-student interactions were examined to explore their reasoning processes.

RESULTS AND DISCUSSION

Level of the arguments

In general, both schools (Figure 2) show similar patterns of Toulmin's levels. Most of the students are predominantly at level 2. This means that students are able to make a claim and present some data or warrant to support the claim

Table 1. Level of students' argument

Level	Description
1	Present a claim only. Example: I am going to use pesticide **(*claim*)**.
2	Present a claim and data and/or warrant. Example: I am going to use pesticide **(*claim*)** because pesticide contains chemicals that will kill the insects **(*data*)**, so that the number of the pests will decrease **(*warrant*)**.
3	Present *claim, data, warrant,* and *backing/ qualifier/ rebuttal.* Example: I am going to use pesticide **(*claim*)**, but I will choose only natural pesticide **(*qualifier*)** because pesticide contains chemicals that kills pests **(*data*)** The number of the pests will decrease **(*warrant*)**.
4	Presents *claim, data, warrant, backing,* and *qualifier/ rebuttal.* Example: I am going to use pesticide **(*claim*)**, but I will choose only natural pesticide **(*qualifier*)** It is because pesticide contains chemicals that kills pests **(*data*)** The number of the pests will decrease **(*warrant*)** because pesticides kills pests **(*backing*)**.
5	Presents all components of argumentations*: claim, data, warrant, backing, qualifier,* and *rebuttal.* Example: I am going to use pesticide **(*claim*)** although I know that pesticide is not good for the environment (**rebuttal**) It is better to use natural pesticide **(*qualifier*)** because pesticide contains chemicals that kills pests **(*data*)** The number of the pests will decrease **(*warrant*)** because pesticides kills pests **(*backing*)**.

Table 2. Level of coherency and relationship between components in the examination scripts

Category	Description of the rubric
Higher Coherency	*Claim* is logic and is supported by a correct and relevant *grounds* (*data, warrant, backing*) Example: To fights rice pests we can use controlled insecticide and natural predators of the insect Insecticide works by affecting the physiology of the insects while predators prey the insects
Reasonable coherency	*Claim is logically make sense and is supported by a sound ground.* Example: I am going to use insecticide because it will kill pests
Limited coherency	*Claim* logically make sense but no supporting grounds or the ground is incorrect or irrelevant *Claim doesn't logically make sense and provides no supporting grounds* Example: Building a wooden fence around the rice field to protect rice field from pests.

but only few of them can provide rebuttal. A study conducted by Garcia-Mila, Gilabert, Erduran and Felton (2013) suggests that giving students tasks that required them to reach consensus led them to produce rebuttals in their discourse. Since rebuttals represent an acknowledgment of the limitations to one's own claim, higher number of rebuttals indicates that the students are learn to look issues from different perspectives.

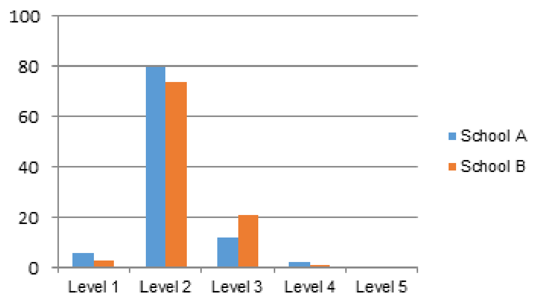

Figure 2. Percentage of students' argumentation

Figure 2 shows that neither Indonesian school's perspective resulted in higher levels of students' reasoning as compared to the other school. Although both schools adopted a very different philosophy, however, the results indicates that schools' philosophy does not reflected in the students' argumentation skills. It suggests that argumentation is not a product of the type of school. It is possible that the development of the students' argumentation seems to rely on the teaching-learning process, which reflects Hattie's (2012) claims that the teacher has much more impact on learning than does the school. This indicates that lessons do not significantly reflected school philosophy.

Indonesian teachers' interviews suggest that they did not completely aware of strategies to facilitate students' learning using argumentation and inquiry, such as Argument Driven Inquiry (Sampson & Gleim, 2009), or give tasks that require students to come to a justified agreement of other students and propose a consensus solution to the problem (Garcia-Mila et al., 2013). They described some strategies perceived that could promote students' reasoning. Some of these reasons were trivial, such as asking questions that do not require the students to think or asking the students to present an idea, that is, recall questions. Some teachers required their students to conduct field study that could appear to provide opportunities for reasoning. However, these experiences were designed more on giving students direct experience with the objects or nature rather than asking the students to collect and analyze data to support their ideas.

Results from the students' questionnaires show that teachers (43%) rarely present problems or issues that require the students to provide evidence to support their answers. The Students (58%) also report that laboratory classes are not aimed at collecting evidence to support the students' ideas. These suggest that laboratory classes are not designed to promote the students' reasoning. It is possible that students rely on their common sense rather than reflecting on laboratory evidence to support their claims.

Coherence of the arguments

Figure 3 shows that students at School A tend to be able to formulate more coherent arguments compare to School B. Our observation finds that lessons rarely demanded the students to formulate coherence arguments, such as by asking the students to provide more detail explanation and supporting evidence for their answers. Indeed, there were situations where teachers presented issues that required the students expressed their ideas, however, students were not demanded to provide more elaboration. To facilitate students' argumentation skills, teachers should involve the students in an argumentative situation that required them to think and justify their arguments (McDonald, 2014).

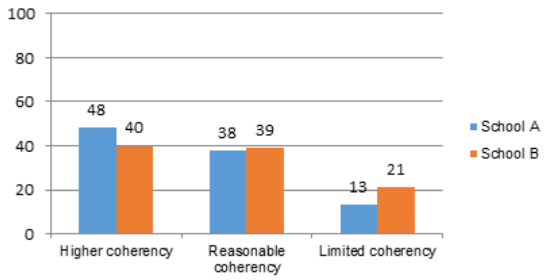

Figure 3. Coherence of students' argumentation

From grade 7 to grade 9, there is a shift (Figure 4) toward a more coherent reasoning but the gain is not significant. This result confirms the tendency for gaining over time (Choi, *et al.*, 2010; Kuhn, Katz & Dean, 2004). It is possible that this shift was due to the students' maturity or personal experience rather than the learning experience. Indeed, maturity may play important roles in facilitating the students' learning as people grow up they can argue better.

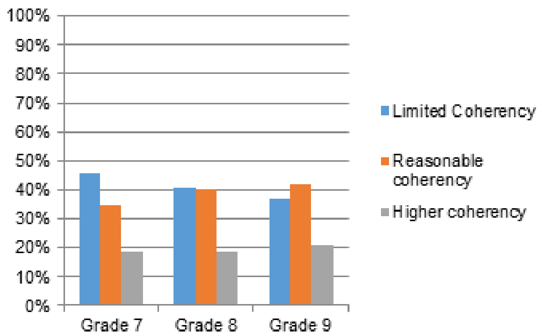

Figure 4. The development of students' arguments

As suggested by Choi *et al.*'s (2010) simple maturation is not sufficient for learning how to reason or to argue. This suggests that there are other factors affecting the students' ability to reason and they do not necessarily relate to the lessons in the classrooms. The survey results also show that the students made use of information from the news (25%) and their daily life experience (35%) as sources of evidence to support their claims. This data could suggest that the development of the students' reasoning depend more on students' individual efforts rather that the school programs.

Gender comparison

A comparison between boys and girls shows that girls tend to reach higher levels of reasoning as well as a more coherency in reasoning skills (Figure 5) but the difference was not statistically significant. Since schools and teachers seem to play very minimum roles in developing the students' reasoning, girls' achievement may relate to maturity or personal efforts. Teachers suggest that girls tend to be more focus in the lessons compare to boys.

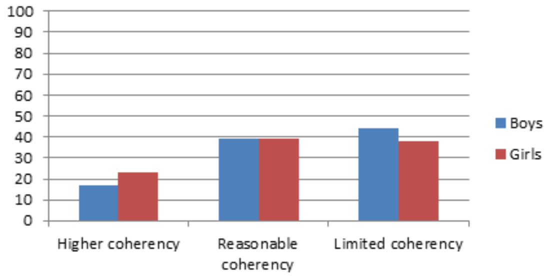

Figure 5. Comparison between boys' and girls' argumentation.

Statistical analyses of the levels and the coherence of the structure of the students' argumentation show that there is no significant difference in terms of types of schools, the grade levels, and gender. These suggest that difference philosophical backgrounds and school arrangement, give little contribution to the development of the students' argumentation skills. The fact that different grade levels did not lead to improvement of students' argumentation suggest that argumentation has not been given sufficient attention at both schools. In the interviews, the teachers said that their teaching strategies were predominantly lecturing. Here, the students are passive audiences with little opportunities to practice their argumentation skills. The interview suggests that the teachers did not value argumentation because their main focus was delivering that contents of the curriculum and practicing for examinations.

Argumentation in the classroom

Data on argumentation process in the classroom were taken from the Australian context. The initial analyses of the video recordings were based on Lucas, *et al.* (2012) Creative Dispositions (Table 3). It measures the extent lessons provide learning environments that allow the students to develop their argumentation and reasoning skills. Table 3 presents the time in the lessons that indicate creative dispositions.

Table 3 shows that there was no consistent pattern in the use of creative dispositions. Wendy

Table 3. Percentage of time on Creative Dispositions observed in Wendy's class

Aspect	Class 1	Class 2	Class 3
Inquisitive			
Wondering & questioning	11.1	6.3	7.8
Exploring & investigating	7.9	9.1	8.3
Challenging assumptions	5.5	4.4	7.7
Persistent			
Sticking with difficult	6.1	4.2	5.5
Daring to be different	3.1	4.1	4.3
Tolerating uncertainty	2.3	1.3	3.7
Imaginative			
Playing with possibilities	12.0	14.1	9.1
Making connections	8.0	8.8	8.7
Using intuition	4.3	2.9	2.5
Collaborative			
Sharing the product	3.9	7.9	8.7
Giving & receiving feedback	8.0	11.8	5.2
Cooperating appropriately	3.0	7.2	7.2
Disciplined			
Developed techniques	2.4	6.0	7.1
Reflecting critically	5.7	3.8	2.9
Crafting & improving	2.5	5.7	3.1

Student/ teacher	Conversation	Aspect of argument
Wendy:	We are going to look at the chances of inheriting a particular trait. When meiosis occurs, the breakup can be random. If we have two parents who can roll their tongue and they are heterozygous. We want to find out what is the chance of them having a child that cannot roll their tongue.	Invitation to make a claim
Ken:	Which one can't? Two big 'RR's can, two 'rr's cant.	Making a claim
Susan	1 in 4.	Making a claim
Steve:	50 : 50.	Making a claim
Kay:	It is 1 in 4 because the big 'R's dominate.	Justifying a claim
Ken:	Mothers give half the information, 'R', or 'r'. Dad's give 'R' or 'r'.	Justifying a claim
Wendy:	When the sperm with 'R' meets egg with 'r', it means they can roll their tongue. When the sperm with 'r' meets egg with 'R', it means they can roll their tongue. The Big 'R' dominates. Can 'r' and 'r' roll their tongue?	Asking for clarification
Susan:	Yes.	Making a claim
Steve:	What about your kids?	Asking for clarification
Kay:	It depends.	Refining a claim
Wendy:	Is it really important to know this? …….. Not really. For some people, this stuff matters. Say you want a child who is over 2.2 meters tall, have brilliant sporting ability, dark hair, green eyes.	Refining a claim
Ken:	That is like cheating. If they go to basketball as they were designed that way.	-
Wendy:	What happens if a teacher who influences the child not to like basketball and want to do something else?	Invitation to make a claim
Ellen:	What if the parents didn't want them to understand science?	Invitation to make a claim
Wendy:	They don't do one thing in tests, you choose what test you want. Women only have a certain number of eggs and so there is a limit to how many combinations of genes that one can have.	Refining a claim

often used collaborative group work to build understandings and this class had a high degree of observed the student- teacher and the student-student interactions. Wendy's classes were characterized by reasonably high levels of persistency, imaginative and discipline dispositions.

To understand how lessons may contribute to the students' argumentation, we analyzed classroom conversations that require the students to make claims, justifying claims, and refining claims. The following is an example of such conversation.

The excerpt shows that in the nature, arguments there is no sequence of making claim, providing data (evidence) warrant, backing, qualifier, and rebuttal. Rather argumentation flows in a random sequence that certain component of argument may appear more frequent than the others may do. In Wendy's class, the learning environment was good that the students did feel comfortable in making suggestions and challenging other comments. She did express the view that, even though these students normally avoided science, in this class they were heavily involved in the discussion and challenging other claims.

At the same time, Wendy had planned and led a particular line of questioning. Her teaching was focused on the group as a whole but she responded to individual responses and interests. Her initial approach was to teach them as a group but in practice, she modified her lesson according to student responses and to address the students' interests and understandings. She had developed and environment in which the students felt free to express their views and felt that it was important to allow the students to express their understanding in ways that reflected their interests. A feature of her teaching was the ability to coordinate the students' explanations (8%) and used their evidence to explain and clarify their understanding (8-9%). Wendy had the most consistent use of each creative disposition and this could be reflected in that the reasoning processes had higher level of making claims, coordinating explanations and justifying and communicating ideas than most of the other classes. She felt that was possible for the students in checking and refining claims result in a lower need for them to communicate their ideas publicly.

After the topic had been taught, both the teacher and the students were interviewed. The majority of the students, three months later, were able to recall their learning and explain their current understanding with more detail to the researchers than what the teacher reported were typical responses from the students. The students were asked whether their experience with this approach affected their understanding, ability to explain, and their perception of the class. The majority of the students reported that compared to traditional classes: The classes were more interesting and engaging resulting in more class engagement and more involvement in discussions, making claims, explaining and clarify that improved their learning; They felt that the necessity to explain their viewpoint enhanced their ability to communicate understanding to be more convincing; The need to explain their thinking helped many students to clarify their understanding; and The group and classroom discussions assisted in developing, clarifying and evaluating understanding of concepts.

Discussion

This study reported on argumentation using two studies that utilized quite different samples and methodology. We suggest that valuable lessons can be drawn from using different methods and different classes. Firstly, the Indonesian case study that used surveys and examination of the student script showed that most the students' argumentation skills were relatively immature in that most students were at the level 2 (of five levels) while only a small proportion of the students developed coherent arguments. While the shifts in the Indonesian sample were not significant, they did occur in the direction of more coherent argument as the students progressed through their schooling. We argue that teaching for reasoning requires more than just explaining the concepts, but letting the students develop claims, find supporting evidence, and identify possible counter arguments. The students reported that Indonesian teachers rarely asked the students to give evidence for their thinking or collect evidence for their views. Osborne (2010) states that teachers need to explicitly develop the reasoning skills with their students. In our view, there is a need for teachers to plan lessons that facilitate the students' ability to construct coherent arguments. These Australian teachers who were 'risk takers' planned lessons that required the students to make claims, explore the robustness of these claims, transferred these claims to new settings and to think of alterative explanations, which encouraged the students to construct more coherent arguments.

In Indonesia, it is very often believed that smaller size of class would allow students to have more quality discourse between teacher – students and student-students. This study shows that the size of the class does not necessarily lead to quality discourse unless the teacher is competent and in the position to do it. The larger Indonesian class is only slightly larger than the Australian classrooms indicating that class size is not a major issue in developing reasoning. This confirms that the class size is not the determinant factor (Berliner & Glass, 2014).

In 2013, Indonesia introduced new curriculum that put more emphasize on scientific process and scientific reasoning. The curriculum prescribes that teachers should teach lesson based on "scientific approach" model that requires teachers to give the students more opportunities to find evidence and to reason. Although the curriculum guides provide detail guidance on how to teach, improvement of the teachers' understanding of the curriculum and other additional supports are needed to ensure that teachers are competent to implement the curriculum. As documented in earlier research (Widodo & Riandi, 2013), previous Professional Development (PD) resulted in few changes to classroom teaching practice. Therefore, it seems reasonable to suggest that future PD about the implementation of the new curriculum should adopt new PD models to enhance the teaching and learning processes. In Australian classrooms, teachers are required to undertake a minimal amount of PD to maintain teacher registration but are less directed as to what PD is appropriate for them.

In the Australian cases, the students were asked to represent a claim, provided evidence for it, then after further representational manipulation, refinement, discussion, and critical thought, to reflect on and confirm or modify their original case. In this context, analogous to Mullis, Martin, Ruddock, O'Sullivan, & Preuschoff (2011) views of reasoning processes, the students were invited to be assessors of their own learning (mediators), and to function as an audience and sounding board for the other students, thereby co-operatively fostering scientific reasoning and literacy development aligned to scientific practice on a micro learning-community scale. As noted by Ford & Forman (2006), unless school students learn to construct and interpret accounts of their observations and reasoning, and become active in the learning process, then their learning can become constrained and superficial. The Indonesian students were asked to make a claim, justify their claim and to provide a rebuttal in their examination scripts but rarely in classroom practice. It is possible that students utilize reasons in classroom activities but do not do this in examinations, as they might not be able to provide coherent justification nor do they educated to see this as an essential a criteria for examination marking.

We suggest, like previous studies, the teaching process has the most impact on reasoning. Hence, the quality of the teacher does matter (Berliner & Glass, 2014). Teachers who have clear expectations as to what they want the students to develop and how to achieve this, can make a difference. The extent that the teachers' value reasoning and they know how to develop it can have an influence on students' learning.

Indonesian students reported that in their view, teachers rarely required them to make a claim, justify, and rebut challenges. The Australian case study focused on the pattern of creative dispositions and found that they varied from lesson to lesson but some components were more dominant. It also examined the class discussion and noted that students moved between ranges of creative dispositions (Tytler & Prain, 2010). It did not appear that any particular dispositions were precursors to other dispositions. The students engaged with dispositions as a tool to explore their understandings and the teacher could facilitate this process. The Indonesian sample indicated that the type of school was not a major factor in improving the student reasoning. It did suggest that there was an improvement over time in the level of coherency in reasoning. These results examined the analysis of examination scripts and students' perceptions of the process.

We argue that looking at the student reasoning from a range of perspectives, improved our understanding as to how reasoning was facilitated. The teachers played a critical role in helping the students explored their understanding and developed confidence to expose their views (Tytler, Prain, Hubber, & Waldrip, 2013). Sharing of understanding assisted students to explore their own personal views (Kuhn, 2015). It provided teachers with the opportunity to monitor the students understanding and to facilitate opportunities to check robust of understanding, and to plan the next crucial step in developing the students' understandings of topics. We do suggest that Indonesian teachers need to use classroom talk as a means of monitoring student understanding. We did not find evidence in Indonesian classrooms that this was prevalent.

CONCLUSION

This study combined researches from two different education cultures. The Indonesian sample investigated largely the quantitative data and did not find significant change in outcomes. Since the students appear to perceive that they were not taught how to reason very often in class, there is a need to re-conceptualize how this is achieved. The Australian data, largely qualitative, described the reasoning process and interviews revealed greater retention of learning compared to other classes. The teachers reported some subjective outcomes like perceived stress and improved the students' engagement.

The outcomes of this research can inform teacher education candidates in these countries. We recognize that there is a need to continue this study to investigate reasoning and describe learning in both countries. We recognize that it is not easy to combine data from different countries but it is definitely not impossible. It is important to recognize the limitations of doing this. We suggest that this research can produce insights that benefit both sides as it can account for the context and needs of each country. We recognize that culture can have an impact on the results, but in this case, the results are not largely explained by culture. This study appears to be the first investigation of reasoning that examines two quite different countries, that are, Indonesia and Australia. Indonesia has a very centralized education system while Australia is moving towards a more centralized system. Hence, the implications of this research are important for both countries.

REFERENCES

Australian Institute of Teaching and School Leadership. (2013). *Initial teacher education: Data report*

Carlton South, VIC: Education Services Australia.

Berliner, D.C., & Glass, G.V. (2014). *50 Myths & Lies that threaten America's public schools The real crisis in education* New York: Teachers College Press.

Brown, N. J. S. , Nagashima, S. O., Fu, A., Timms, M., & Wilson, M. (2010). A framework for analyzing scientific reasoning in assessment. *Educational Assessment, 15* (3), 142-174.

Choi, A., Notebaert, A., Diaz, J., & Hand, B. (2010). Examining arguments generated by year 5, 7, and 10 students in science classrooms. *Research in Science Education, 40*(2), 149-169.

Dolan, E., & Grady, J. (2010). Recognizing students' scientific reasoning: A tool for categorizing complexity of reasoning during teaching by inquiry. *Journal of Science Teacher Education*, *21*(1), 31-55.

Ford, M., & Forman, E (2006). Redefining literacy learning in classroom contexts. *Review of Research in Education, 30*, 1-32.

Garcia-Mila, M., Gilabert, S., Erduran, S., & Felton, M. (2013). The effect of argumentative task goal on the quality of argumentative discourse. *Science Education, 97*(4), 497–523.

Hammer, D., & Sikorski, T. (2015). Implications of complexity for research on learning progressions. *Science Education, 99*(3), 424-431.

Hand, B., Norton-Meier, L., Staker, J., & Bintz, J. (2009). *Negotiating science: The critical role of argument in student inquiry.* Portsmouth, NH: Heinemann.

Harris, K.-L., Jensz, F., & Baldwin, G. (2005). *Who's teaching science? Meeting the demand for qualified science teachers in Australian secondary schools* Melbourne: Centre for the Study of Higher Education, The University of Melbourne.

Hattie, J. (2012). *Visible Learning for Teachers: Maximising Impact on Learning.* New York: Routledge.

Hornikx, J & Hahn, U. (2012). Reasoning and argumentation: Towards an integrated psychology of argumentation. *Thinking and Reasoning, 18*(3), 225–243.

Jalal, F., Samani, M., Chang, M. C., Stevenson, R., Ragatz, A. B., & Negara, S. D. (2009). *Teacher certification in Indonesia: A strategy for teacher quality improvement*. Jakarta: Ministry of National Education.

Kuhn, D., Katz, J. B. & Dean, D. (2004). Developing reasoning. *Thinking & Reasoning, 10*(2), 197–219.

Kuhn, D. (2010). Teaching and learning science as argument. *Science Education, 94*(4), 810-824.

Kuhn, D. (2015). Thinking together and alone. *Educational Researcher, 44*(1), 46-53.

Lehrer, R., & Schauble, L. (2015). Learning progressions: The whole world is not a stage. *Science Education, 99*(3), 432-437.

Lucas, B., Claxton, G., & Spencer, E. (2012). Progression in student creativity in school: First steps towards new forms of formative assessments *OECD Education Working papers, No 86*, OECD Publishing.

McDonald, C. V. (2014). Preservice primary teachers' written arguments in a socioscientific argumentation task. *Electronic Journal of Science Education,18* (7), 1-20.

Mullis, I., Martin, M., Ruddock, G O'Sullivan, C., & Preuschoff, C. (2011). *TIMSS 2011 Assessment Frameworks* TIMSS & PIRLS International Study Center, Boston College.

Nielsen, J. A. (2013). Dialectical features of students' argumentation: A critical review of argumentation studies in science education. *Research in Science Education, 43*, 371-393.

Osborne, J. (2010). Arguing to learn in science: The role of collaborative, critical discourse. *Science, 328(5977)*, 463-466.

Prain, V., & Waldrip, B. (2006). An exploratory study of teachers' and students' use of multi-modal representations of concepts in primary science. *International Journal of Science Education, 28*(15), 1843-1866.

Republik Indonesia. (2005). *Undang-Undang Republik Indonesia no. 14 tahun 2005 tentang Guru dan Dosen* [Law on teachers and lecturers]. Jakarta: Republik Indonesia

Sampson, V. & Gleim, L. (2009). Argument-driven inquiry to promote the understanding of important concepts and practices in biology. *American Biology Teacher, 71*(8), 465-472.

Sutopo, Liliasari, & Waldrip, B. (2013). Impact of multiple-representations approach on students' reasoning, generic science skills, and conceptual understanding on Mechanics. *International Journal of Science and Mathematics Education.* 12, 741-765.

Toulmin, S (1958). *The uses of argument.* Cambridge: Cambridge University Press.

Tytler, R., & Prain, V. (2010) A framework for re-thinking learning in science from recent cognitive science perspectives. *International Journal of Science Education. 32* (15), *2055-2078.*

Tytler,R., Prain,V., Hubber, P., & Waldrip, B (Eds.) (2013) *The role of representation in learning science: A pedagogy for engagement with learning.* Dordrecht: Sense Publishers.

Waldrip, B.G. & Prain, V. (2012). Reasoning through representing in school science. *Teaching Science, 58*(4), 14-18.

Waldrip, B.G., Prain, V. & Sellings, P. (2013). Explaining Newton's laws of motion: Using student reasoning through representations to develop conceptual understanding. *Instructional Science, 41*(1), 165-189.

Widodo, A., & Riandi. (2013). Dual-mode teacher professional development: challenges and revisioning future TPD in Indonesia *Teacher Development: An International Journal of Teachers' Professional Development, 17*(3), 380-392.

Zembal-Saul, C. (2008). Learning to teach elementary school science as argument. *Science Education, 93*(4), 687-719.