Development of Students' Informal Reasoning across School Level

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Abstract

Informal reasoning is the basic reasoning frequently used by people to solve complex daily life problems. Unlike scientific reasoning, informal reasoning includes cognitive and affective processes in which the types of reasoning can be intuitive, emotive and rational. This cross sectional study aims at analysing development pattern of students' informal reasoning at elementary school, junior high school, and senior high school. Moreover, the study also identifies differences between boys and girls reasoning. The participants were 20 elementary school students, 30 junior high school students, and 30 high school students who attended schools managed by the same foundation. The data were collected using five items test on issues found in everyday life. Students' responses were grouped into intuitive, emotive, or rational reasoning. The study finds that students' informal reasoning tends to develop in accordance with the school grade. Related to gender, the study finds that girls tend to use rational reasoning while boys tend to use intuitive reasoning.

Keywords*: gender, informal reasoning, school level*

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Introduction

Reasoning is a process of constructing and evaluating arguments (Shaw, 1996). Similar definition was also used by Means and Voss (1996) who define informal reasoning as … "a goal-dependent process that involves generating or evaluating (or both) evidence pertaining to a claim or conclusion" (p. 140). A strong claim should consist of closely related conclusion and premises (Shaw, 1996) or claim, data warrant, backing, qualifier, and rebuttal (Toulmin, 1958). These suggest that reasoning is the ability to make logically make sense and strong construction of arguments on certain issues.

In our daily lives, we make reasoning prior to making any decision. People frequently use reasoning though they may not realize it. Informal reasoning is very important in a situation where information is limited or the problems are complex, debatable and open to different acceptable solutions. In such, an individual need to build an argument or a claim justified by evidence (Means & Voss, 1996). Therefore, it is understandable that reasoning is considered as one of important competencies to be acquired during schooling (Kementerian Pendidikan dan Kebudayaan Republik Indonesia, 2016; Mullis, Martin, Foy, & Hooper, 2016; OECD, 2016).

Literature on reasoning suggests that there are two types of reasoning, i.e. formal reasoning or scientific reasoning (Abrahamsen & Bechtel, 2015; Brigandt, 2010; Lawson, 2010; Tsui & Treagust, 2010) and informal reasoning (Dawson & Venville, 2009; Wu & Tsai, 2011a). While scientific reasoning follows systematic and well-structured method for confirmation and explanation, informal reasoning is not structured, uses inductive inference and is frequently used in situations where there are reasons that both support and against the conclusion (Shaw, 1996).

Despite its nature as a less rigorous way to reason, informal reasoning is very useful in everyday life, especially in complex issues with no clear right or wrong answer. Sadler and Zeidler (2005) believe that informal reasoning is construct subsumes the cognitive and affective processes. This suggests that informal reasoning to certain extend involves some subjectivity of the individuals. Although it commonly belief that informal reasoning is more prone to subjectivity and bias, Thompson and Evans (2012) suggest that belief bias may occur in both formal and informal reasoning.

Sadler and Zeidler (2005) suggest that informal reasoning can be in the form of three categories, i.e. intuitive reasoning, emotive reasoning and rational reasoning. Intuitive reasoning is a type of reasoning largely influence by subjects' feeling and immediate reactions. It reflects a personal reaction to a specific case or situation. Emotive reasoning is a type of reasoning influenced by subjects' emotions (sympathy and empathy) and consideration of wellbeing. This type of reasoning is rooted in rational and emotion of the subject. Rational reasoning is a type of reasoning based on reason and logic. It is free from the emotion of the subject. These patterns of informal reasoning do not operate independently. An individual may develop multiple reasoning combinations of intuitive and emotive, emotive and rationalistic, and rationalistic and intuitive (Sadler & Zeidler, 2005; Topcu, Tuzun, & Sadler, 2011).

A number of studies have been conducted on students' informal reasoning (Dawson & Venville, 2009; Means & Voss, 1996; Topcu et al., 2011; Wu & Tsai, 2011a) but yet very few study focus on the development of students' informal reasoning. A study on high school informal reasoning reported that students' reasoning were largely intuitive and emotive, and did not involve a rational informal reasoning component (Dawson & Venville, 2009). A study conducted in Turkey (Topcu et al., 2011) reported that even preservice science teachers used intuitive, emotive and rational reasoning. Although these three categories do not refer to development, however, one would expect that older person use more rational reasoning than intuitive and emotive reasoning. Evidence from these studies shows that age does not necessarily relate to a person's preference in using certain category of reasoning.

Studies on informal reasoning reported that there are factors that influence one's reasoning. Conceptual understanding of the subject is one of the key factors that influence students' informal reasoning (Means & Voss, 1996; Sadler, 2004; Wu, 2013). Moreover, Means and Voss (1996) also reported that intellectual ability plays crucial role in students' performance in formulating reasoning. Similar to Kuhn, Katz and Dean's (2004) opinion, a study conducted in Indonesia (Widodo, Waldrip, & Herawati, 2016) indicated that grade level correlate to the ability to reason. However, they suspect that such improvement may due to maturity, more experience and better knowledge understanding of the topic (Means & Voss, 1996; Sadler, 2004). Other factors that influence informal reasoning are personal experiences, social considerations, moral-ethical considerations, and technological concerns (Topcu et al., 2011).

Research on strategies to improve students' informal reasoning usually focus on using socio-scientific issues (Karpudewan & Roth, 2016; Topcu, Sadler, & Yilmaz-Tuzun, 2010; Wu & Tsai, 2007). Socio-scientific issues are frequently used because they provide contextual problems that allow students

to develop arguments and different possible solutions. The development of internet allow researchers to make use of it (Wu & Tsai, 2011b) but the context is somehow remain about socio-scientific issues.

Regarding gender preferences and informal reasoning competencies, no specific research studies was found in the literature. Results of the TIMSS 2015 in science subject reported that girls tend to outperform boys in reasoning (Mullis et al., 2016). Similar esults was also found in our previous study (Widodo et al., 2016). One of the factors that may contribute to this result is maturity. As reported in the study on brain maturity (De Bellis et al., 2011), girls' brain tend to mature earlier than those of the boys. This may contribute girls' ability to reason better than boys.

Review of the literature suggests that research on the development of students' informal reasoning is rare, particularly related to the following questions.

1. How does students' informal reasoning develop throughout their schooling from elementary school, junior high school and senior high school?
2. Is there any difference of informal reasoning between boys and girls?

Method

A cross sectional data collection method was employed to gather data from elementary school students, junior high school students and senior high school students. Since students' reasoning can be influenced by the school policies and the school environment, this study was conducted at three schools managed by the same foundation that are located in at the same place. The foundation has long experience in managing education. It runs kindergartens, primary schools, junior secondary schools and senior high schools on a very similar policy. Therefore, students are assumed to have similar school environmental context.

Participants of the study were 20 primary school students (10 female and 10 male), 30 junior high school students, (15 female and 14 male) and 30 senior high school students (20 female and 10 male). Participants were chosen using cluster random sampling technique and all students in the selected class are requested to participate in the study.

Qualitative approach was employed in collecting and interpreting data that are collected using 14 open ended questions followed by interviews. The questions are designed to create conflicting situation that requires students to think deeply before answering the questions. Cases presented in the questions are issues drawn from daily life, i.e. HIV/AIDS, thalassemia, precious stone (*batu akik*), food preservatives, and rabies. Here is an example of questions in the instrument.

"An ex-prostitute is infected by HIV/AIDS, a fatal disease that attacks human immune system. Now she is very sick and has to live alone because no one wants to interact with her. People are afraid of getting infected by the virus.
a. Do you agree with the people who avoid any interaction with her?
b. If the prostitute were your relative, would you avoid her?
c. Do you agree with people who believe that she is cursed by God because of her sinful behavior?"

Responses to the questions were categorized based on Sadler and Zeidler's (2005) and Dawson and Venville (2009) category, i.e. intuitive reasoning, emotive reasoning and rational reasoning. Since an individual may develop a mixed of reasoning for the same topic, the types of a student' reasoning to the 14 questions was calculated to determine the preference of the student's reasoning. Here is an example of responses given by a primary school student for a case on HIV/AIDS.

"a. Do you agree with the people who avoid any interaction with her?
*Yes, she has committed a terrible sin and therefore she deserved the disease that is transmitted through sexual activity (**intuitive reasoning**)*
b. If the prostitute were your relative, would you avoid her?
*No, I do not agree. I feel very sorry for her and as her relative, we should not isolate her (**Emotive reasoning**)*
c. Do you agree with people who believe that she is cursed by the God because of her sinful behaviour?
*Yes, every sinful behavior will result in punishment from the God (**intuitive reasoning**)"*

A student reasoning preferences is decided based on his/her highest score in the three categories of reasoning. When a student has the same score in two or more categories, she/he is categorized into multiple reasoning combinations of intuitive and emotive, emotive and rationalistic, or rationalistic and intuitive.

Results and Discussion
Profile of Students' Informal Reasoning at Different School Levels

As presented in Figure 1, the majority of the elementary school students (70%) use intuitive reasoning. This result suggests that many primary school students use their feelings as the bases of their decision. According to Sadler and Zeidler (2005) intuitive reasoning is a result of immediate positive or negative reaction to the situation, and these feelings contributed to their negotiation and eventual resolution of the issue.
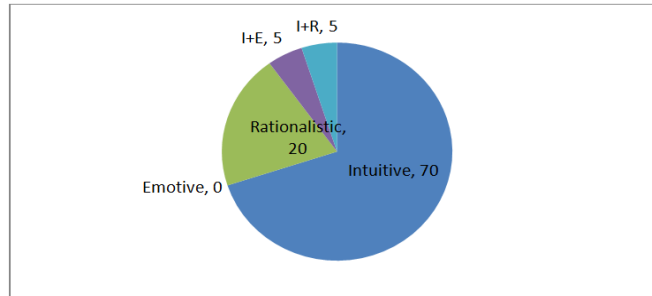

Figure 1. The profile of elementary school students' informal reasoning

A more detailed analysis of students' responses to the issues/topic shows that students consistently used more intuitive reasoning in all cases. On average 75% of the students used their intuitive reasoning in responding the questions. The lowest score is on Thalassemia issue (65%) while the highest score is on Rabies (85%). This result implies that students' informal reasoning is not affected by the issue but it is rooted deeper in their thinking and feeling.

Interviews to the students revealed that students' reasoning were influenced by their religious teaching. They said that bad things done by a person, such as adding borax to food or being stingy, would result in bad consequences to them. So, miserable live a person has is karma or punishment for what they have done before. This idea is in line with Piaget's (1997) theory on moral judgement that younger children develop immanent justice of heteronomous morality. At this stage of moral development, children believe that every naughty behavior or misbehave will result in a punishment.

At junior high school level, students' informal reasoning shows very different profile compare to elementary school students (Figure 2). Rationalistic reasoning is the dominant informal reasoning used by the junior high school students. Unlike the other two categories, rationalistic reasoning is not influenced by the emotion of the subjects (Sadler & Zeidler, 2005). Rationalistic is powered by thinking and logic of the person.
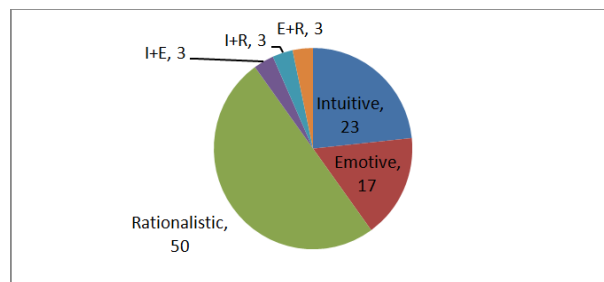

Figure 2. The profile of junior high school students' informal reasoning

The average score of the junior secondary school students' rationalistic reasoning is 54.8. A more detailed analysis to each issue shows that there is a wide variation. While rationalistic reasoning on borax reach up to 75% of the students, only about 20% of the students used rationalistic reasoning on Thalassemia. This suggests that students' reasoning is influenced by the issue/topic.

In responding questions related to a wife who cheats her husband and has a child from her boyfriend, most students used their emotive reasoning. As suggested by Sadler and Zeidler (2005),

emotive reasoning is strongly influence by moral and ethical, as well as empathy and sympathy. As in Indonesian context, a wife who cheats her husband is considered as to have a terribly bad behavior and students' reasoning is influence by such emotion. A typical respond by the students is "*The doctor should not let her husband know because it will hurt his feeling very much*". So, empathy to the husband is so strong that the students use their feeling instead of their rationalistic consideration.

At senior high school level, rationalistic reasoning is the most common reasoning though the percentage is lower than those of junior high school (Fig. 3). This finding suggests that reasoning does not develop in linear and constant pattern. At senior high school, students' reasoning seems to be distributed. Emotive reasoning that is not found at primary school and only identified for about 17% at junior secondary school, increases significantly at senior high school. This suggests that high school students have stronger emotion involvement to the issues.
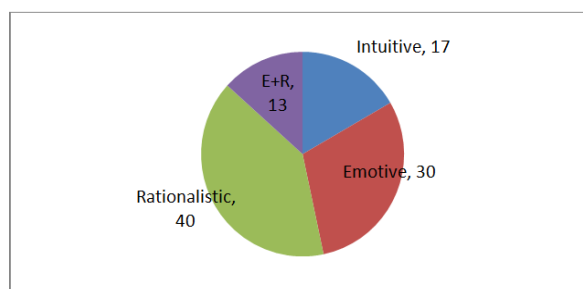

Figure 3. The profile of senior high school students' informal reasoning

At senior high school level, wide variation of students' reasoning is also observed. While the number of students with emotive reasoning on precious stone is only 20%, the situation is very different on Thalassemia as 83% of the students use emotive reasoning. There are two issues where senior high school students show strong emotive reasoning, i.e. HIV/AIDS and Thalassemia. As suggested by Sadler and Zeidler (2005), emotive reasoning is a combination of rational dan emotion. This means that when presented with a dilemmatic case, students use their conceptual understanding and their moral judgement.

Since at high school level, students have learned about HIV/AIDS and Thalassemia, they used their knowledge about the issue to provide a better solution in favor of the victim. Here is an example of a student's answer on the question whether we should avoid contact to people with HIV/AIDS:

"I do not agree with people who avoid any contact or isolate a person with HIV/AIDS. I know that HIV/AIDS will not infect people through physical contact. Only when you have sex with her, you will get infected. People in the community isolate her simply because they hate what she previously did as a prostitute. So, I think people give social punishment to her for what she has done as a prostitute."

This opinion indicates that the student understands what HIV/AIDS and how it infects people. In addition, the student also understands why people isolate the victim. The isolation is a form social punishment for what she has done. At the end, however, she decided to make a different decision from those of the community because she considered the feeling and wellbeing of the victim.

The general pattern of the development of students' reasoning from elementary school to senior high school shows that intuitive reasoning tends to decrease while emotive reasoning tends to increase (Figure 4). Rationalistic reasoning, however, does not show clear pattern of development.

This result supported the previous studies (Means & Voss, 1996; Widodo et al., 2016) where students' ability to reason correlate with grade level. This study also notes that development of students' reasoning is a dynamic process rather than linear or constant. This means that the process may move backward and forward as the students gain more knowledge. Hence, conceptual understanding of the issue does play a key role in students' reasoning (Means & Voss, 1996; Sadler, 2004; Wu, 2013).
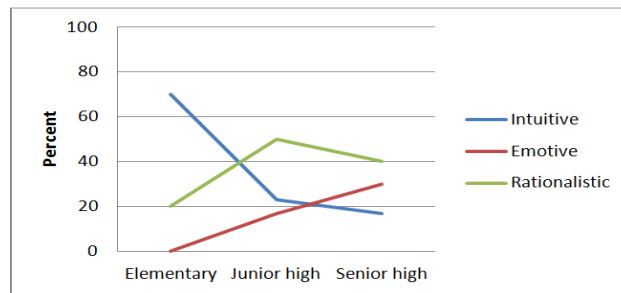
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Figure 4. Development of students' informal reasoning at each school level

Gender and student' informal reasoning

Unlike the common beliefs that girls tend to use their feelings, this study shows that girls are more rationalistic than boys (Figure 5). This suggests that girls rely more on reason and logic rather than their feelings and emotions.
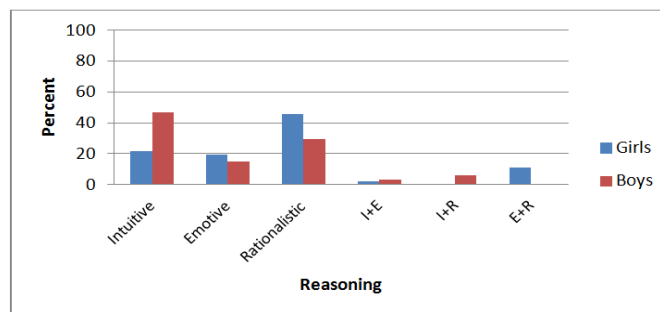

Figure 5. Distribution of students' reasoning by gender

The following is an illustration how girls and boys give different responses to a question whether they agree with the opinion that the child who was born by a cheating mother was a "cursed child" (*anak sial*).

"Girl: "*No, the child is not a "cursed child". It is the genes of the mother and her boyfriend that contributed to the Thalassemia. So, the child is innocent*" (**rational reasoning**)

Boy: "*No, the child is ok. A child is a gift from God and we should not reproach such a gift*" (**intuitive reasoning**)"

While the girl used her understanding of genetics the boy used his personal feeling as the bases of his reasoning. This finding supports the notion that students' conceptual understanding of the issues influences their reasoning (Means & Voss, 1996; Sadler, 2004; Wu, 2013).

Analysis on the difference between girls' and boys' reasoning across the school levels finds that there is a clear variation of students' informal reasoning (Figure 6). At the elementary school, intuitive reasoning is common both for girls and boys. Thus, there is not so much different between girls and boys (Figure 6a). At the secondary school levels, however, there is an obvious difference between girls and boys. Girls tend to use rationalistic reasoning while the boys use intuitive reasoning (Figure 6b). At senior high school, girls are rationalistic while boys emotive (Figure 6c).
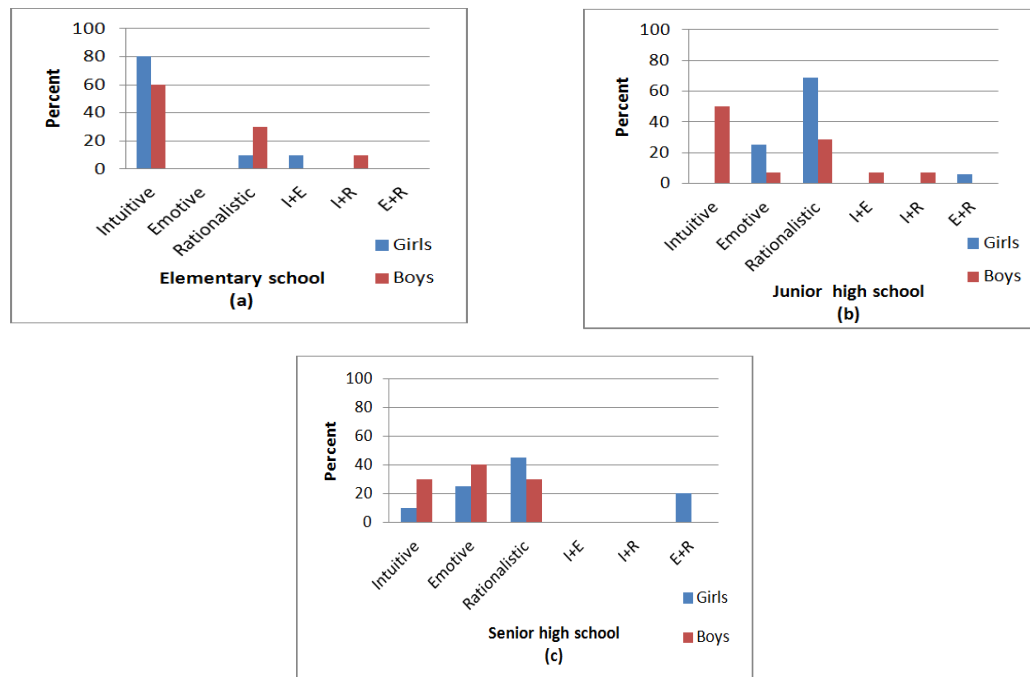
Figure 6. The difference between girls' and boys' reasoning at elementary school

These data suggest that there is a change of girls' and boys' reasoning across the school level but there is no clear pattern of development. It is noted that girls and boys show different types of reasoning within and across the school levels but it is too difficult to identify any pattern.

Discussion

The first issue addressed in this study is the development of students' informal reasoning. As presented earlier, the results of this study show that there are variations of informal reasoning used by students at different school levels. While intuitive reasoning is the most common informal reasoning found in elementary school students, rationalistic is more common in junior high school and senior high school students. This suggests that there is a change in the pattern of students' informal reasoning from intuitive reasoning towards rationalistic reasoning. Since rationalistic reasoning is based on logic (Sadler & Zeidler, 2005), this finding suggests that students at higher school level use logic more than students at the lower school levels. As suggested by Kuhn, Katz and Dean (2004), at the early years, children are not at the position to fully develop awareness in coordinate between claim and evidence. The process of gaining metaconitive control over their reasoning begins only from middle childhood to adoleccence. Students' mental maturity can be one of the important factors that contribute to students' ability to use their logical competencies. Students at junior high schools and senior high schools are presumably have reached more advance cognitive development that allow them to think and conduct formal and abstract operations.

Another factor that also contributes to students' rationalistic reasoning is conceptual understanding of the topic. Numerous studies on students' reasoning suggest that conceptual understanding of the issue help students to develop higher level of reasoning (Means & Voss, 1996; Sadler, 2004; Wu, 2013). Although this study did not assess students' understanding of the topic, it is very likely that students at higher school levels have developed a better conceptual understanding of the content as they learned more advanced content.

Literature of reasoning used the terms "pattern of reasoning" (Karplus, 1980; Kuhn et al., 2004; Sadler & Zeidler, 2005) but none give explicit explanation on how one's reasoning change from one category of reasoning to the other. This study really demonstrates such difficulties since the development of students' informal reasoning is a fluid and dynamic process. There is no such linear development that allows us to predict a sequential pattern of students' informal reasoning. A student may use different reasoning for the same issue depending on their logic and their emotional involvement.

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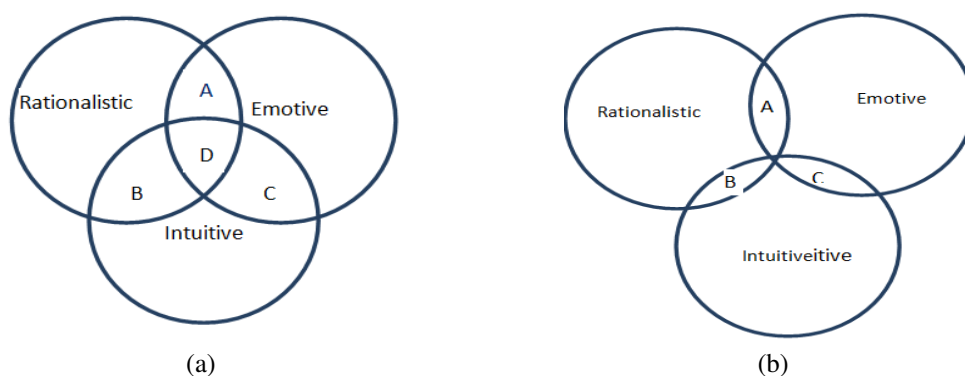
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$$(a) \qquad\qquad\qquad\qquad (b)$$

Figure 7. Overlapping reasoning proposed by Sadler and Zeidler (2005) compares to the current study

This study supports the idea of Sadler and Zeidler (2005) that a person may develop a combination of two reasoning (intuitive and emotive, intuitive and rationalistic, emotive and rationalistic). However, this study does not find a person who develops a multiple reasoning of intuitive, emotive and rationalistic. This study finds the same result as the study conducted by Topcu, Tulun and Sadler (2011) that there is no area of overlap amongst the three category informal reasoning (Figure 7).

As illustrated in Figure 7b, this study identifies students who are at the overlapping position (A, B, or C) but none is at D position. The fact that there is no student at D position suggests that development of informal reasoning might follow a certain "pattern", but the current study is unable to draw such pattern. This result indicates that the development of informal reasoning is not progressing in linear direction. Although Sadler and Zeidler (2005) suggest that emotive reasoning is a mixed of logic and emotion, it does not mean that it is located somewhere in between intuitive and rationalistic.

With regards to gender issue, this study supports the previous studies on reasoning in which to a certain extent there is a different reasoning between girls and boys. We do not suggest that girls and boys reason differently, rather than girls and boys at the same age group show different reasoning preferences. This studysupports our previous study that in the classroom, girls tend to have higher level of reasoning compare to the boys (Widodo et al., 2016). This result may be explained in terms of different mental maturity between girls and boys (De Bellis et al., 2011), but we suspect that there are other factors involved.

Conclusion

Across the school level, there are changes of students' informal reasoning. Intuitive reasoning is the most common at elementary school and the number steadily decrease at junior high school and senior high school. The development of emotive reasoning seems to negatively correlate to intuitive reasoning. At the elementary school, it is very limited but it steadily increases at junior high school and senior high school. Rationalistic is reasoning that does not show a clear pattern. It increases significantly from elementary school to junior high school, but is decreases at senior high school. Since science intensively makes use of rationalistic reasoning, this study shows that more efforts are needed to develop students' rationalistic reasoning. Development of students' rationalistic reasoning skills should not be taken for granted, rather a deliberate and well-structured program is needed. It does not mean that schools should create a specific program on developing students' reasoning but schools should encourage teachers to organize lessons that give opportunities for students to practice their reasoning.

With regards to gender, this study finds that girls and boys show different reasoning. While girls tend to be rationalistic, boys are more intuitive. Girls' and boys' reasoning do not have clear pattern across the school levels. Moreover, this study also finds that girls and boys at the same age tend to reason differently. These findings on gender suggest that teachers may need to adopt slightly different strategies in developing reasoning for girls and for boys. Since boys and girls at the same age group tend to develop different reasoning skills, group works consisting of boys and girls may bring more benefit rather than separating boys from girls.

More research is needed to address the issue of the development of students' reasoning, such as factors that influence reasoning and strategies to facilitate students' informal reasoning. Longitudinal studies that follow the development of an individual child reasoning can be an alternative approach to gain a better understanding of the development pattern of reasoning.

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