Developing mathematical reasoning to reduce the wide-spread of hoax distributions

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Abstract. Social media platforms has influenced the way we run our life, we have been frequently buffeted by its changes as nowadays the big portion of population obviously rely on it to stay tune of the very latest updates. As the consequence, we give the misleading contents to fill the air, the hoaxes. Content can be relayed among users with no significant third party filtering, fact checking, or editorial judgement, and an individual user with no track record or reputation can in some cases reach as many readers as national or international media. This study assesses possible positive correlation between developing mathematical reasoning and reducing the spreading of hoaxes through study literature. We start the study with defining and describing the characteristic of both mathematical reasoning and hoaxes. Furthermore, we examine a series of implication that shows a path that goes from mathematical reasoning towards reducing the hoaxes, at the end of the study we propose a brief method and content to be applied to Indonesian high school student by using logic in Mathematics topic.

1. Introduction
Indonesia is a country with the population more than 260 million people. Distributing information might have been the major problem for any country with huge amount of citizens like Indonesia. It is not surprising that communication and critical thinking skills are highly demanded [1]. This study is a systematic literature review to find the truth of implication between improving mathematical reasoning and reducing the spread of the hoaxes.

Mathematical reasoning and its teaching and learning have been the focus of many studies [2-9]. Mathematical reasoning is a broad term encompassing several different types such as induction, deduction, abduction [10] and adaptive reasoning [11]. It involves a focus on the mathematical aspects of an object or event, conjecturing about this object or event, and then drawing inferences based on relationships between those aspects [2, 12]. Reasoning may be communicated to others in a variety of ways through “different representations, including visual, verbal and dynamic” [13]. Alternatively, it may be used in self-talk in an attempt to clarify and justify one’s own thinking [2, 5], this attempt leads to the conclusion that people with good mathematical reasoning or intelligence will have critical thinking skill as well. People with significant logical/mathematical intelligence are good at logical reasoning, problem-solving and scientific investigation [14].

Digital social networks have substantially facilitated the process of information sharing and knowledge construction [15]. The term “fake news” has become increasingly prevalent in public discourse over the last year and this is not a good news since it is a truism that a functioning democracy
relies on a well-informed public [16, 17]. Conversely, if people are pervasively misinformed, chances are that societal decisions will be suboptimal. Likewise, if an individual is misinformed, that person’s decisions may not be in their best interest and can have adverse consequences [17]. There is evidence that the presence of misinformation causes people to stop believing in facts altogether [18]. Falsehoods are generally more viral than truths on social media. Hence, it takes much longer to resolve rumors that turn out to be hoaxes than those that later prove to be true [19]. The insidious fallouts from misinformation are particularly pronounced when the misinformation is packaged as a conspiracy theory. The mere exposure to conspiratorial discourse, even if the conspiratorial claims are dismissed, makes people less likely to accept official information [20]. Misinformation is therefore not just about being misinformed. It is also about the overall intellectual well-being of a society [17]. To be effective, scientific research into misinformation must be considered within a larger political, technological, and societal context. The post-truth world emerged as a result of societal mega-trends such as a decline in social capital, growing economic inequality, increased polarization, declining trust in science, and an increasingly fractionated media landscape [17].

Logic is the basis of all mathematical reasoning, and of all automated reasoning. It has practical applications to the design of computing machines, to the specification of systems, to artificial intelligence, and to other areas of computer science, as well as to many other fields of study [21]. We believe with learning logic will give the foundation and the big picture in analyzing the words, the sentences, the paragraph, and of course, the news. Logic gives tools to check the validation of an argument, proposition (a statement that can be proven true or false but not both), definition (which given in a very precise and clear form), theorem, and along with the arsenal of different equipment and methods in proofing. The sets of lessons and activities in logic likely to give students a solid understanding that a lot of things including a lot of news might not always right. This paper discusses one specific useful proofing method, proofing an implication.

If two propositions can be linked with “If ... then ...”, then we have an implication. The implicative statement “if p then q” is written p \rightarrow q and reads “p implies q”, p is called the antecedent and q is called the consequent [22]. When the truth is validated, the implication asserts that q is true when p is true. Table 1 below gives simple illustration for the implication “if I get the bonus this morning then I will buy everyone here lunch today”.

| Get the bonus | Buy everyone lunch | Truth of implication | Respond |
|---------------|--------------------|----------------------|---------|
| T             | T                  | T                    | Happy   |
| T             | F                  | F                    | Disappointed |
| F             | T                  | T                    | Happy   |
| F             | F                  | T                    | Still OK |

The table simply shows that the only disappointing condition is when I get the bonus and I did not buy everyone food for lunch. The last row of table 1 shows that if the antecedent and consequent are both false will resulting true implication as well. It is true since I did not break the promise.

2. Method
This paper examines a series of implication that goes from the first antecedent to the last consequent and concluding a short implication when all implication in between are true and validated. For example, if you go to good school then you must study hard, if you study hard most likely you will pass the exam, if you pass the exam you could go to university. If all the implications in between the first antecedent and the last consequent are true, then we could confidently conclude that if you go to good school then you could go to university.
3. Results and discussion

3.1. If we develop mathematical reasoning skill then we will reduce the wide-spread of hoax distributions

Above is the short implication that we examined and concluded from series of implication in table 2 below. The truth of all implications are described and validated with the previous research and scientific writing. The table contains set of implication that would be used to construct a series of implication. For Example, at first row of table 2, the antecedent $P_1$ states mathematical reasoning and the consequent $Q_1$ states critical thinking. This $P_1\rightarrow Q_1$ implication means if we have mathematical reasoning ability then we shall have critical thinking ability. The validation column, next to it, is the more detailed description and validation of the implication that derived from previous scientific writing.

Table 2. The series of implication and the validation.

| Implication (Pn $\rightarrow$ Qn) | Validation |
|----------------------------------|------------|
| $P_1$: mathematical reasoning    | Alternatively mathematical reasoning may be used in self-talk in an attempt to clarify and justify one's own thinking [2, 5]. |
| $Q_1$: critical thinking         | People with mathematical intelligence are good at logical reasoning, problem-solving and scientific investigation [14]. |
| $P_2$: mathematical reasoning    | Reasoning may be communicated to others in a variety of ways through “different representations, including visual, verbal and dynamic” [13]. |
| $Q_2$: logical reasoning, problem solving, scientific investigation | Logic is the basis of all mathematical reasoning, and of all automated reasoning [21]. |
| $P_3$: mathematical reasoning    | People with high logical/mathematical intelligence have the ability to use numbers effectively and are sensitive to logical patterns and relationships [23]. |
| $Q_3$: different representations | They like experimenting, questioning and figuring out logical puzzles. They have a unique way of searching for relationships and connections, categorizing, sequencing, and outlining [14]. |
| $P_4$: logic                     | Logic has practical application [21]. |
| $Q_4$: practical application     | Logical thinking is seen as the key to the processes of mental reservation and complex problem solving [24]. |
| $P_5$: logical thinking          | Logical thinking is one of the ways used in acquiring advanced mental activities. Thus, this ability is an application level activity which depends on the knowledge and comprehension level of the objective’s cognitive area stages [25]. |
| $Q_5$: mental reservation and complex problem solving | Logical thinking ability refers to an individual’s ability to solve a problem by using mental operations or his ability to reach principles or rules by making certain generalizations or abstractions [26]. |
Table 2. cont.

| P13 : logical thinking                      | Sinnott showed that one's capacity for logical thinking, predicts the ability to solve day-to-day problems, especially in the arena of interpersonal relations [27]. |
| Q13 : ability to solve day-to-day problems in the arena of interpersonal relations |

| P14 : critical thinking                      | It is essential not only for academic studies but also for solving social, political, and ethical problems as well [28]. |
| Q14 : solving social, political, and ethical problems as well |

| P15 : critical thinking                      | Different skills are involved in critical thinking, which concerns questioning the source of knowledge, testing the validity of the acquired information, analyzing its reliability,... [29, 30]. |
| Q15 : questioning the source of knowledge, validity of information, analyzing the reliability |

| P16 : conspiracy theory packaging            | The insidious fallouts from misinformation are particularly pronounced when the misinformation is packaged as a conspiracy theory.... makes people less likely to accept official information [31]. |
| Q16 : people less likely to accept official information |

| P17 : well informed public                   | ...a functioning democracy relies on a Well-informed public [16, 17]. |
| Q17 : functioning democracy                 |

| P18 : intellectual well being of society    | Misinformation is therefore not just about being misinformed. It is also about the overall intellectual well-being of a society [17]. |
| Q18 : avoiding misinformation               |

The shaded implications above are picked to prove that there is a valid implication concluding that developing mathematical reasoning will reduce the wide-spread of hoax distribution. Observe the series of implication P2→Q2, P10→Q10, P15→Q15, P17→Q17, and P18→Q18. If we have mathematical reasoning then we would have a logical thinking skill then we would be critical, we would question the source of knowledge, validity of information, and also analyzing the reliability of things. If so the public in general will be well informed resulting the democracy becomes more functioning. Hence the overall intellectual of well being of a society will be improved, misinformation could be reduced, distributions of hoaxes will be reduced.

3.2. A brief method and content to be applied
The above result use only 5 out of 18 implications, based on the whole facts and implications we propose a formal logic workshop to be delivered to high school students as the starting, this activity will help students to make coherent argument [32]. The workshop shall be conducted explicitly with specific instructions and practice until the students are able to integrate, combine, and combine information in a meaningful way [33]. Dialogue, questioning, and presenting opposite belief methods will be used to stimulate evaluative thinking by exposing learners to different opinions in the process of clarifying or validating [34]. Steps in filtering the news will be illustrated prosedurally and analytically to help students understand some logical fallacies.

3.3. Brief examples
Below are some typical examples of headline to be examined by the students during the workshop.
- “Was a half-monkey, half human hybrid found in Surabaya?”
- “Indonesian man claims to be world’s oldest human at 176.”
- “Bandung Government prohibits all online transportations to operate”.
Student will be guided to find the contradiction of an argument, to analyze the quantifier of series of statement and to validate the source or the writer of the source.
4. Conclusions
The contribution of this paper is uncovering the relation of developing mathematical reasoning and reducing the wide-spread of hoaxes distributions. A brief method and content shall be delivered to support the truth of implication with all the findings and facts. On further research, the detailed workshop should be presented to complete the reduction of hoaxes. Scoring the news should also be researched to helps student make more accurate decision regarding hoax forwarding.

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