INQUIRY SOCIAL COMPLEXITY (ISC) DESIGN INSTRUCTIONAL TO EMPOWERMENT

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INVESTIGAÇÃO DE COMPLEXIDADE SOCIAL (ISC): PROJETO INSTRUCIONAL PARA REFORÇAR AS COMPETÊNCIAS CRÍTICAS E CRIATIVAS (CCT) NA QUÍMICA

INQUIRY SOCIAL COMPLEXITY (ISC): DESIGN INSTRUCTIONAL TO EMPOWERMENT CRITICAL AND CREATIVE THINKING (CCT) SKILLS IN CHEMISTRY

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RESUMO

Para preparar as pessoas para viverem no século 21 com sucesso, é necessário mais do que o conteúdo da matéria. É muito importante que as pessoas saibam como aplicar suas habilidades e conhecimentos através do pensamento crítico, usando o conhecimento em novas situações, compreendendo novas ideias, colaborando, comunicando, resolvendo problemas, tomando decisões e assim por diante. Esta pesquisa é uma inovação da educação disruptiva que visa projetar modelos de aprendizagem que possam capacitar as habilidades de pensamento crítico dos alunos por meio de análise descritiva com base em dados e revisão da literatura. Este estudo utilizou uma amostra de 180 estudantes do ensino médio na cidade de Surakarta, Indonésia. Os resultados da medição das habilidades de pensamento crítico dos alunos na categoria são muito escassos em todos os aspectos, como, por exemplo, 52,80% dos aspectos de análise, 37,28% dos aspectos de inferência, 45,16% dos aspectos de explicação, 35,01% dos aspectos de autorregularão estão em critérios muito baixos e 41,14% dos aspectos de interpretação em critérios muito ruins. Os resultados da medição das habilidades de pensamento criativo dos alunos também mostram categorias muito preocupantes em todos os aspectos que os envolvem a saber: 45,83% no aspecto da fluência, 42,50% no aspecto da flexibilidade, 44,86% no aspecto da originalidade e 47,50% no aspecto da elaboração, todos em muito baixo critério. Os resultados da revisão de literatura também descobriram que o modelo de *design* dos professores de química não maximizou a capacidade de pensar criticamente, de modo que ele precisa de um design de aprendizado que possa capacitar habilidades de pensamento crítico. Através de um estudo bibliográfico baseado em dados, foi formulado um modelo de complexidade social (ISC) para capacitar habilidades de pensamento crítico.

Palavras-chave: *Investigação de Complexidade Social (ISC), Pensamento Crítico, Pensamento Criativo, Química.*

ABSTRACT

To prepare people to live in the 21st century successfully, it is needed more than subject contents. It is very crucial for the people to know in how to apply their skills and knowledge by critical thinking, using knowledge in new situations, comprehending new ideas, collaborating, communicating, problems solving, decision making and so on. This research is an innovation of disruptive education that aims to design learning models that can empower students' critical thinking skills through descriptive analysis based on data and literature review. This study used a sample of 180 high school students in the city of Surakarta, Indonesia. The results of the measurement of students' critical thinking skills in the category are very lacking in all aspects, for instance, 52.80% of analysis aspect, 37.28% of inference aspects, 45.16% of explanation aspect, 35.01% of self-regulation aspect are in very low criteria as well as 41.14% of interpretation aspects in very poor criteria. The results of measurement of students' creative thinking skills also shows very concerning category in all aspects involving: fluency of 45.83% of fluency aspect, 42.50% of flexibility aspect, 44.86% originality aspect, and 47.50% of elaboration aspect are all in very low criteria. Literature review results also found that chemistry teachers' design model has not maximized

the ability to think critically so that it needs a learning design that can empower critical thinking skills. Through a data-based literature study a form of inquiry social complexity (ISC) model was formulated to empower critical thinking skills.

Keywords: *Inquiry Social Complexity (ISC), Critical Thinking, Creative Thinking, Chemistry.*

1. INTRODUCTION:

21st Century learning requires schools to change teacher-centered learning methods into student-centered learning; this is intended to get students who can think critically, deductively, and inductively in learning science in the era of disruption (Affandi and Sajidan, 2017; Trilling and Fadel, 2009). The learning methods carried out conventionally, namely through memorization at this time are not following the paradigm of 21st-century learning (Zivkovil, 2016). 21st Century learning must be able to empower higher-order thinking skills, which consist of critical and creative thinking skills (Trilling and Fadel, 2009; Rubdiyani and Perdana, 2019).

Critical thinking skills are self-regulation in producing something by interpreting, analyzing, evaluating and inferring, as well as using explanations, concepts, methodologies, criteria or considerations that form the basis of conclusions (Facione, 2011). Critical thinking skills are very important to be empowered in the world of education because it allows students to get a more complex understanding of information. Besides, students can also communicate the results of their thoughts through sharing with others as well as describing socially critical thinking (Dwyer, Hogam, and Stewart, 2014; Forawi, 2016). It becomes very essential among practical competences and formative one in the new educational context (Zuriguel *et al.*, 2015). As a complex activity, it requires to build coherent arguments by involving the educators in the organisation of assessments and learning activities (Daly, 2001). It includes the information for analysis, making decision, and reflection (Von Colln-Appling and Guilano, 2017). It is crucial to make provision of quality care with professional responsibility (Paul, 2014). It is also underscore the flexibility as the different in conceptualising the term of critical thinking skills (Kahlke and Eva, 2018). It should be a skill that is possessed inherently that should be designed its strategies to perform this ability (Carvalho *et al.*, 2017). It will have positive effects on their care behaviours and self- reflection (Chen *et al.*, 2018). The development of critical thinking skills becomes challenge both for educator and student for knowledge transmission (Johanns *et al.*, 2017). The educators play the role as the contextual and social factors affecting students' critical thinking skills (Raymond *et al.*, 2018).It will enhance their ability to solve problems that needs to think deductively, provide interpretations, and draw inferences (Cui *et al.*, 2018).

Critical thinking skills have six aspects, including Analysis, Inference, Interpretation, Explanation, Self-regulated, and evaluation (Facione, 2011). Based on the understanding and aspects of critical thinking skills shows that critical thinking skills are defined as thinking skills to understand concepts, apply, synthesize, and evaluate new knowledge or information obtained. This can be understood that not all new information that is used as knowledge that is believed to be the truth is used as a benchmark in thinking and acting. In addition to critical thinking skills, creative thinking skills must also be empowered by each student to be successful in the 21st century (Ataizi and Donmez, 2014; Ledward and Hirata, 2011).

Creative thinking skills are a result of thinking that leads to new insights, new approaches, new perspectives, or new ways to understand, think and produce new ideas or ideas (Facione, 2011, Hartono and Sauber, 2015, Anwar *et al*, 2012). Creative thinking will make students see the world differently and will be happy to experiment to get something new (Anna, Bob, and Mike, 2001). Creative thinking skills are one aspect that must be possessed by every human being to be able to solve problems (Aldig & Arseven, 2017). This shows a person's ability to solve problems correlates with creative thinking skills and achievement towards success (Miller, 2003).

Based on the explanation, it shows that it is important to empower critical and creative thinking skills, which can be implemented in learning. In developed countries, critical and creative thinking skills become one of the competencies of educational goals, even as one of the main goals to be achieved (Subaidah, 2010). Whereas in Indonesia, the empowerment of critical and creative thinking skills is applied through the implementation of the 2013 curriculum, as an effort to improve higher-order thinking skills (Rudibyani and Perdana, 2019). The

implementation of the 2013 curriculum is a reference for learning centered on students, so it is expected to be able to empower not only cognitive abilities but also aspects of attitudes and skills (Nastiti, Rahardjo, Susanti, and Perdana, 2018).

The results of the study (Subagia, 2013) showed problems that could occur in the implementation of the 2013 curriculum, including 1) the habits of teaching teachers, 2) facilities learning support, 3) preparation of learning, 4) implementation of learning and 5) assessment of learning outcomes. The most frequent weakness is that the implementation of learning is not directed at critical and creative thinking skills (Clorawati, Rohiat, and Amir, 2017), this is due to the habits of teachers who teach conventionally. Whereas critical thinking and creative skills can be empowered through science learning (Zubaidah, 2010), one of them is in chemistry subjects. Therefore, the aim of this study was to design learning models that can empower students' critical thinking skills to prepare people to live in the 21st century successfully.

2. MATERIALS AND METHODS:

2.1. Study Design and Ethical Approval

The qualitative study was designed through a cross-sectional concept where the qualitative description of an expereince or event that remain close to participants' accounts (Sandelowski, 2000), and establishes pragmatic apporach to have policy making, inform practice and refine or develop interventions (Neergaard, Olesen, Andersen, & Sondergaard, 2009).

This research was carried out by the recommendations of the Department of Secondary and Special Education Management (BP2MK) of Central Java province which permits the letter of acceptance to conduct and gather the data for research. It is done by the agreement of all samples from180 high school students in the city of Surakarta, Indonesia. The study protocol accepted its ethical approval from the Research Ethics Committee of the Ministry of Education and Culture.

Data collection was carried out using instruments in the form of tests of critical and creative thinking skills, totaling ten items on acid-base chemical materials and salt hydrolysis. The instrument test was first performed an analysis of the instrument quality aided by the Quebec User Evaluation of Satisfaction with Assistive Technology (Quest) program (Demers, Lambrou, Ska, and Demers, 2000). Reliability estimation using the QUEST program is calculated based on items called item separation indexes and based on testees called person separations (Aminah, 2017). The reliability estimation results obtained the value of person reliability of 0.78 and item reliability of 0.75, so it can be concluded that the consistency of the answers from both the testee or from the items has high reliability.

The next criterion is that an item is said to be fit if the value of the MNSQ INFIT is in the range of 0.70 to 1.30 (Aminah, 2017). The output results of the MNSQ INFIT value are presented in Figure 1. Based on Figure 1 shows that the results of the analysis of the test instruments used, overall the items have large support for the total score. This data illustrates that as a whole the items used are accepted, and can be used as a tool for data retrieval.

3. RESULTS AND DISCUSSION:

3.1. Critical Thinking Skills

Critical thinking is reflective of decision making wisdom in solving problems about what to believe and carrying out intellectual processes (Facione, 2011). Based on this definition it can be understood that critical thinking processes require a higher level of cognitive skills in information processing (Choy and Cheah, 2009). Facione (2011) divides critical thinking skills into 6 types that must be mastered to be possessed by someone, so that a person will have good critical thinking skills, skills that must be possessed of six aspects of critical thinking skills, namely Analysis, Inference, Interpretation, Explanation, Self-regulated, and evaluation (Facione, 2011).

The analysis aspect is the skill of identifying the intentions of the conclusions in the relationship between questions and concepts, the description or form of questions expected to express beliefs and decision experiences and reasons, and information and opinions (Facione, 2011). The aspect of Inference that is the ability to identify and select elements needed to form reasonable conclusions or form hypotheses to pay attention to relevant information and reduce the consequences arising from data, questions, principles, evidence, judgment, beliefs, opinions, concepts, descriptions, questions or other forms of representation (Facione, 2011).

Interpretation aspects, namely the ability to understand, express meaning, statement from various experiences, situations, and data, events as well as decisions, conversion of beliefs and

rules, procedures or criteria (Facione, 2011). Explanation aspects, namely the ability to state the results of a person's judgment process to justify the reasons based on evidence, concepts, methodologies, certain criteria in reasonable consideration, and the ability to present reasons in the form of convincing arguments (Facione, 2011).

The aspect of self-regulation is that one's awareness monitors one's cognition, the elements used in the thought process and the results that are developed, specifically applying the skills of analyzing and evaluating one's ability to conclude with questions, confirmations, validations and corrections (Facione, 2011). Evaluation aspect is the skill to assess the credibility of a question or other representation with a value or to describe one's perception, experience, situation, decision, belief and to assess the logic power of an expected inferential relationship or actual inferential relationship including statements, descriptions, questions, or other forms of representation (Facione, 2011).

3.2. Creative Thinking Skills

Creative thinking skills make students see the world differently and will be happy to experiment to get something new (Anna, Bob, and Mike, 2001), and is one of the domains in the concept of higher-level thinking (HOTS). So the creative thinking skills of most experts argue is one important factor in achieving success (Glaveanu, 2018). It can be understood that the creative thinking skills acquired by a person are achieved in personal and professional life. For example the success of innovative institutions that can develop in a complex and dynamic work environment; the success of developed countries that can foster creative industry sectors that can compete healthily and invest in research and development (Glaveanu, 2018).

Indicators of creative thinking skills from four aspects namely Fluency, Flexibility, Originality, and Elaboration (Torrance, Ball, and Safter, 1992). Fluency is the ability to generate a number or many ideas (Torrance, 1980). Flexibility is the ability to produce diverse ideas (Torrance, 1980). Originality is the ability to generate responses to ideas that are not common among . most or rare/unique (Torrance, 1980). Elaboration is the ability to develop and issue ideas (Torrance, 1980).

3.2.1 Field Study

Aspects of critical thinking skills used in conducting field studies, using aspects of Facione (2011) which consists of six aspects of critical thinking skills, namely Analysis, Inference, Interpretation, Explanation, Self-regulated, and evaluation (Facione, 2011). Test results on 180 students in the MA city of Surakarta also showed that critical thinking skills were still relatively low, in the analysis aspect of 60.83% the criterion was very lacking, the inference aspect was 43.19% the criterion was very lacking, the interpretation aspect was 46.25% with very poor criteria, the explanation aspect of 52.08% criteria is very less, the self-regulation aspect of 39.44% criteria is very less and the evaluation aspect of 46.39% the criterion is very less.

Aspects of critical thinking skills used in conducting field studies, using aspects of Torrance consisting of four aspects namely Fluency, Flexibility, Originality, and Elaboration (Torrance, 1980, 1992). Test results on 180 students also showed that the creative thinking ability of students in the MA city of Surakarta was still low, the fluency aspect was 46.81% the criterion was very lacking, the flexibility aspect was 48.81%, the original aspect was 46.39% the criterion was very less, the elaboration aspect of 46.94% criteria is very lacking. Therefore, an appropriate teaching model to train students' creative thinking skills is needed in learning activities.

The results of the measurement of high-level skills of high school students (Istiyono, Mardapi, and Suparno, 2014) that are still in the sufficient category. The solution that should be done to overcome the problem will be less fulfilled indicators of critical thinking abilities and creative thinking abilities of students is to choose an innovative learning model (Rudibyani and Perdana, 2019; Perdana, Budiyono, Sajidan, and Sukarmin, 2019). One of them is inquiry learning model (Perdana, Budiyono, Sajidan, and Sukarmin, 2019; Perdana, Budiyono, Sajidan, Sukarmin, and Atmojo, 2019).

3.2.2 Empowerment of Critical and Creative Thinking Skills

The development of science and technology today has led to higher-order thinking skills. As a result of the development of a global mindset that seeks to produce human beings who are professional and able to solve problems as well as possible. High-level thinking skills are basically divided into critical and creative thinking skills. The inquiry learning model provides

opportunities for students to develop ways of active learning by discovering and investigating their own knowledge (Perdana, Budiyono, Sajidan, and Sukarmin, 2019; Perdana, Budiyono, Sajidan, Sukarmin and Atmojo, 2019). The inquiry model helps practitioners understand important factors and the relationship between activities that are interrelated with learning (Wenning, 2005). The inquiry learning model facilitates students to make them interested in learning. This learning model spurs students to get their own discoveries (Perdana, Budiyono, Sajidan, Sukarmin, and Atmojo, 2019).

Activities in inquiry learning include several activities, including: (1) exploration, in this case, the teacher has the role of asking questions and problems that will be solved by students; (2) introduction to the concept, in this activity students collect information relating to experiences in daily life; (3) application of concepts, in this activity the teacher exposes students to new situations based on exploration activities and application of concepts (Perdana, Budiyono, Sajidan, and Sukarmin, 2019; Perdana, Budiyono, Sajidan, Sukarmin, and Atmojo, 2019).

The inquiry learning model has stepped in observation, manipulation, generalization, verification, application (Wenning, 2005). In this step there is no situation where students can interact and communicate effectively with other individuals to construct the knowledge they will get (Perdana, Budiyono, Sajidan, and Sukarmin, 2019).

Children develop their thinking ability through external factors rather than passive form internal (Vygotsky, 1978), so we need a learning model that can accommodate students to interact with each other based on effective communication indicators to gain wider knowledge. The Inquiry Social Inquiry model (ISC) learning model is obtained from the results of the literature review thinking (Perdana, Budiyono, Sajidan, Sukarmin, and Atmojo, 2019). Here are pictures of thoughts obtained from the study:

Figure 2 shows that the elements of social complexity are weak at all levels of inquiry, students who have high levels of cognitive are weak, so it is necessary to add an element of social complexity from the study of some literature, because social elements are very important to do in learning to empower the abilities of students from the low level to the high level in cognitive and skills (Trif, 2015; Russo, Verna, and Wolbert, 2015). The ability of a child is influenced by the ability to solve problems and exchange information with others who know more about it will be clearer (Wooand Reeves, 2007). In this case, the teacher can be used as a source to guide and give students the opportunity to find out how far students understand in studying the lesson. The Design Inquiry Social Complexity (ISC) is presented in Figure 3.

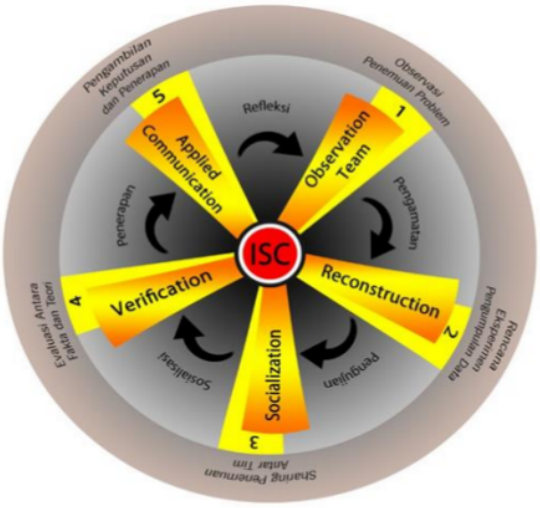

Figure 3. *Design Model Inquiry Social Inquiry (ISC)*

ISC Model display according to Figure 2 in a circle, each syntax clearly visible, equipped with the main learning activities in each syntax with a colorful, adding to the attractiveness of the model design. Arrows clockwise, describing the syntax sequence marked with a number at each step. According to experts who validate the model, the design of the model is considered attractive, and in the picture, there are also elements that are also new. According to the syntax revision, the learning activities were improved in the syntax of team observation, reconstruction, and applied communication. Activities in learning using the inquiry social complexity model:

1) Observation Team: students work together in teams to observe phenomena that have been provided by the teacher in the form of video/demonstration of events to bring up problems that will be researched and studied in learning. At this stage the students detect and produce a unique idea from a question or situation they face.
2) Reconstruction: students in each team create ideas and collect data both qualitatively and quantitatively. Data collection is done through the preparation of practicum tools and materials

made by students in groups. At this stage, students are able to identify the truth between questions and concepts and can state decisions with the right information.

3) Socialization: students in small groups express ideas between groups on the data collected, 1 participant in the group stays in the group then other members play a role in finding the results of other groups through sharing which is presented by other groups which will then be explained again by him to his group friends about what participants get from sharing other groups, each student has an important role to participate effectively in the group. At this stage, students are able to explain the truth between the data with the applicable theories and can defend their opinions to be accepted by others.

4) Verification: Students in the team conduct tests and analyze the truth of the facts they find by linking them with the theoretical basis they already know from the previous stage. At this stage, students are able to assess the credibility of the question or presentation by describing a person's perceptions, experiences, situations, decisions, beliefs and assessing the logic power of actual inferential relationships or other forms of representation. In addition students are able to describe something in more detail to be understood by others.

5) Applied Communication: students in groups express their opinions using oral or written through the media presentations from the results of group discussions in turn to then be agreed on the truth with the teacher's direction which is true in learning and can be applied in everyday life. At this stage, students are able to make or accomplish things in a different way but are of truth or usefulness.

4. CONCLUSIONS:

The results showed that critical and creative thinking skills were in a low category, which is below 50%. The solution that should be done to empower students' critical thinking skills and creative thinking skills is to choose an innovative learning model. One innovative learning model is the inquiry model, but there are weaknesses in that model. In this model there is no situation where students can interact and communicate effectively with other individuals, so we need a learning model that can accommodate students to interact with each other. The learning model that can be used is the Inquiry Social Complexity (ISC), learning model.

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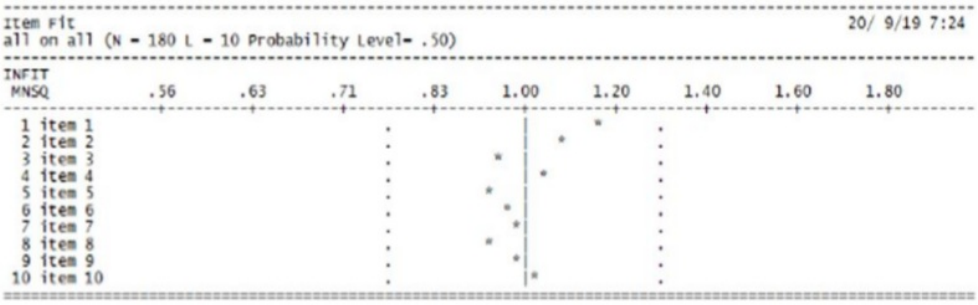

Figure 1. *Output of Quest analysis results on MNSQ INFIT values*

Model of Inquiry	Discovery Learning	Interactive Demonstration	Inquiry Lesson	Inquiry Laboratory	Real-Word Application	Hypothetical Inquiry
Student Skills	Rudimentary Skills	Basic Skills	Intermediate Skills	Integrated Skills	Culminating Skills	Advanced Skills
SINTAC	Observation Manipulation Generalization Verification Application					
cognitive	Low	Intellectual Sophistication				High
Teaching Activity	Teacher	Locus of Control				Student
Social Complexity	Deep	Intermediate				Shadow

Figure 2. *Literature review of the level of inquiry, level of cognitive, teaching activity and level of social complexity (Perdana, Budiyono, Sajidan, Sukarmin, and Atmojo, 2019).*

INQUIRY SOCIAL COMPLEXITY (ISC) DESIGN INSTRUCTIONAL TO EMPOWERMENT

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