

Indonesian science teachers' competencies

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INTRODUCTION

Teachers play a key role in the system of education in Indonesia. They are the peoples who most intensively interact directly with students for almost the entire of students' time during at school. Indonesian cultural, which places the teacher as a model of whole person for their students, adds the importance of the role of teachers in Indonesia. Teachers not only must be successfully to teach students with the subject matter of their licensure, but also must be a good example for their students in many aspects of life.

In this era of SBC (school based curriculum, KTSP), the Indonesian teacher's role is very crucial. They are now having more widely duty and authority, from designing the curriculum of the subject matter to determine the students' graduation standards in their schools level. Therefore, teachers in Indonesia must exhibit a distinctive set of competencies to ensure the achievement of national education goals.

Indonesian ordinances concerning on teachers (The Law of Republic of Indonesia No 14, year 2005 and Indonesia-MONE's Regulation No 16, year 2007) state that Indonesian teachers should demonstrate the four kinds of competence, i.e.: professional, pedagogical, social, and personal competence. Professional competence refers to a deeper and broader understanding of subject matter in the field of their licensure. Pedagogical competence refers to a deeper insight of general pedagogical knowledge including how student learn, how schools work, and how teaching and learning processes should be well planed, implemented, and evaluated. Social competence refers to the ability to develop well social relationship with students and others members of school communities, as well as with all educational stakeholders outside the school. Personal competence refers to the well integrity and personality that the teacher should behave.

MONE's Regulation no 16, year 2007 defines the more detail list of teacher's competencies for every field of licensure, including the competence of science teacher. However, in my opinion, the list of science teacher's competence needs to be further elaborated in order to describe the more distinctive competence of science teacher.

This paper intends to describe the keys performance for a professional science teacher, especially in the context of Indonesia. The main references are the content standards of science education stated in MONE's Regulation No 22 year 2006, the standard of national education concerning on the process (MONE's Regulation No 41, year 2007), and the Indonesian

ordinance concerning on teachers. The relevant literatures in the field of general education and science education are also considered.

THE GOAL OF SCIENCE EDUCATION IN INDONESIA

The main responsibility of the science teachers is to bring their students to the goals of science education. Therefore, the best way to formulate the science teachers' competencies is by looking at the goals of science education. The goals of science education in Indonesia, as stated in MONE's Regulation No 22 year 2006, include the general and specific goals. The general goal refers to the common or similar goal of all the disciplines of science education (Physics, Chemistry, and Biology), and the specific goal refers to the goal of science education in the particular discipline.

The general goals of science education

- Develop positive attitude towards science by realizing the regularity and the beauty of nature and glorify the greatness of God Almighty.
- Cultivate scientific attitudes including honest, objective, thorough, curious or skeptical, open to new ideas or others' opinion, and willing to work collaboratively with others.
- Develop scientific abilities through the activities of formulating a problem, proposing a hypothesis, testing the hypothesis by collecting data (through observation or experiment), processing and interpreting data, and formulating conclusions, and communicating their work both in oral and written.

The specific goals of physics, chemistry, and biology education

Physics Education	Chemistry Education	Biology Education
Having deep understanding of concepts and principles of physics as well as self confidence and ability to develop knowledge as the provisions to pursue higher education and develop science and technology	Deep understanding of concepts, principles, laws, and theories and their relationships of chemistry, as well as their application in daily life and technology	Deep understanding of concepts and principles of biology and their relationship with other branches of science, develop knowledge, skill, and self-confidence
Improving the ability in scientific reasoning, including analytic, deductive, and inductive thinking by applying the concepts and principles of physics to describe the natural phenomena and solve problems quantitatively or qualitatively	Improving the awareness of the dangers and benefits of chemical substances for human life and environmental sustainability	Improving the awareness and engagement in environmental preservation Using the concepts and principles of biology to develop analytic, inductive, and deductive thinking skills Applying the concepts and principles of biology to create simple technologies useful for human need

SCIENCE TEACHERS' COMPETENCIES

The goals of science education described above portray the future generation that generated through science education. They are the religious, scientifically informed, critical,

honest, and collaborative persons; they able to use science to improve their god-fearing to the God, they aware to applying science and technology wisely by considering the society welfare and environmental sustainability, and they have scientific abilities useful for solving many kinds of social issues related to science.

Science teachers, of course, must demonstrate such characteristics. It is not enough for the teachers to teach simply students with words or instructions, or with their knowledge as well. Instead, they also should be an inspiring teacher as well as the proper paragon for their students. Perhaps, that is the essence of science teachers' competency.

1. Personal Competency

MONE's Regulation no 16, year 2007 defines five sub competencies (the document call it as the core competency) in the domain of personal competency as follows. (1) Always acting in accordance with the norms of religious, law, social tradition, and national culture held in Indonesia; (2) Always perform as the honest and well-behave person such that they become the proper paragon for their student and communities as well; (3) Always perform as the stable, mature, wise, and sapient person; (4) Demonstrate a high work-ethic, high responsibility for their task, pride for being a teacher, and robust self-confidence, and (5) Tightly hold the ethics code of teachers.

It is clear that the above list of competencies merely describe the general personality of teachers; there is no difference, for instance, between science teacher and social science teacher. Perhaps, it is also the general characteristics of good citizen of Indonesia. Therefore, in spite of their significance, in my opinion, it is important to describe additional key performances that closer to the characteristics of science teachers. In the following paragraph, I propose a little bit of example of my opinion.

a. Demonstrate a high attitude toward science

One of the goals of science education is to promoting students' attitude toward science and realizing the regularity and the beauty of the nature in order to glorify the greatness of God Almighty. Therefore, science teacher should demonstrate a high-positive attitude toward science. Science teachers should also demonstrate the habit of using science as a way to admire the beauty of God's creation and carefully treated any living object in scientific investigation. There are many topics in science that appropriate for this purpose. Teachers must create and use as much as possible opportunities to show them to their student. Teachers who exhibit enthusiasm and interest and who speak to the power and the beauty of scientific understanding instill in their students some of those same attitudes toward science.

b. Demonstrate the characteristics of educated-scientific person

One of the goals of science education is to cultivate students' scientific attitudes including honest, objective, thorough, curious or skeptical, open to new ideas or others' opinion, and willing to work collaboratively with others. This goal is very close to the aspect of

personality. Therefore, it is very important for science teachers to be having such attitude or personality so that they will serve the good paragon for their students. Science teachers should consistently show these attitudes to their student in many situations, in every science lesson they conduct.

c. Exhibit the behavior of the professional teacher

The fourth sub competency in the domain of personal competency states that the Indonesian teachers should demonstrate a high work ethic, high responsibility for their task, and pride for being a teacher. If the teachers consistently show this competency in their daily work, students will get a lot of good examples of professional workers. Science teachers have more opportunities to do it, as they must make many efforts for preparing and conducting better science teaching. They must provide student with adequate recourse learning, they must develop and prepare set up of experiment or demonstration, bring real phenomena to the classroom, guide and facilitate every student with their diversity to learning science, etc. Such efforts demand the science teacher to spend a lot of their time and energy.

Another important aspect of professional workers is the motivation to improve their knowledge, skill, and ability. Science teachers should do so. They must create and use any opportunity to develop their knowledge, skill, and ability. They should be able to learn from their own teaching practices as well as from others teachers. They should improve their knowledge by following the development of science and technology, particularly in the field of their expertise. However, science teachers should focus on their PCK development, as the PCK is the most important knowledge for science teaching.

2. Social Competency

MONE's Regulation no 16, year 2007 defines four sub competencies in the domain of social competency as follows. (1) Being inclusive, objective, and indiscriminative in making social relationship with students, colleagues, and others communities member in and around the school, (2) able to develop effective, polite, and empathetic communication with students, colleagues, and others communities member in and around the school, (3) able to adapt to various kinds of social environment in all areas of Indonesia wherever they are assigned, and (4) actively develop communication with their professional association as well as with other professions.

In this section, I propose a little bit more about the significance of social relationship for science teachers. I will focus on the kinds of social relationships should be developed by science teachers, and how science teachers should take advantage from that relationship for improving the quality of science education in school.

The success of science teachers in developing social relationships with colleagues, school administrator, and the community outside the school is a necessary condition for their professional development. Teachers' disclosure in accepting criticism, especially from colleagues and supervisors, is also a social aspect that is essential for their on going professional

development. The involvement of science teachers in Lesson Study and professional association, for instance, is a little bit of a good example.

Science teachers should be able to work collaboratively with their colleagues in school. Such good relationship is necessary condition for the success of developing better science programs or curriculum as well as the continuous quality improvement of science education in the school.

Healthy relationship with technicians and the school administrator is very important for science teachers in order to provide their student with equipment and other resources for learning science. Creating an adequate environment for science teaching is a shared responsibility. Teachers responsible to design and use the resources, school administrator responsible for procurement the resources, and technician responsible for maintaining and ensuring that the resources are ready to be used.

Science teachers also should be able to conduct good communication with the community outside the school. The classroom is a limited environment. The school science program must extend beyond the walls of the school to the resources of the community. There are many specialists and resources (e.g. experimental park, museum, science center, university, etc) available in the community. Science teachers should know the available resources around the school and able to get them. Sometimes, science teachers need secondary data for their lesson, especially for more complex topic where the students impossible to gather primary data. In this situation, science teachers should be able to get data from relevance institution.

Science teachers should actively involve in science teachers' associations. Through this forum, they exchange experiences to improve the quality of their science lessons. They take lesson learned from the successes as well as the difficulties of other teachers. Conversely, they also must give contribution to others by explaining their good practices. Through this forum, science teachers can also improve their communication skills, both oral and written.

3. Pedagogical Competency

MONE's Regulation no 16, year 2007 differentiates the competency into ten sub competencies. They cover many aspects of general pedagogic including the knowledge of students' characteristic, the knowledge of principles and theories of learning, the ability to develop curriculum, the ability to plan and conduct an educating teaching, the ability to use the information and communication technology, and the ability to conduct assessment and use the assessment results for several purposes. As in the personal and social competences, this sub competencies list is also too general and lack of the nuances of science education. There is also some overlapping with others domain.

a. Demonstrate a deep understanding of general principles of education

Although the general pedagogic knowledge itself does not work in science education, science teachers should deep understanding of the general principles in education. Science teachers should understand the essence of educational activity, teaching, and learning.

Science teachers should be able to differentiate the educational activities from miss-educational activities. Educational activities refer to the further growth of the learner. They will develop the human capacity of knowing, understanding, judging, and behaving intelligently. Educational activities concern to the life of mind. The mind will be weakening if not carefully nurtured. The center of educational activities is therefore to develop the "cognitive perspective"-- the structure of mind, or conceptual framework, through which the experiences are understood, organized, and made sense. The miss-educational activities, on the other hand, do not lead to the further growth. They block growth instead. If a lesson, for instance, turns student close their mind to further thought or dull the sensibility, then the lesson is not educational.

Science teachers should understand the essence of learning. Learning is an educational activity. Learning is a coming to understand, a struggle to grasp the full meaning of ideas, and a coming to a deeper insight. In learning science, student should internalize the relevant concept, the forms of judgment, and the ways of enquiring. But, any concept does not stand by itself. It belongs to a conceptual framework of the learner, and its meaning can be grasped only within the framework. Recent prominent learning theory, constructivism, beliefs that peoples create their own new understandings on the basis of an interaction between what they have already known and believed and the ideas and knowledge will come into contact.

Finally, science teachers should understand the essence of teaching. Teaching is also an educational activity. An action can be considered as teaching if it brings the learning. It must lead the learners to develop their capacities, skills, understandings, and modes of appreciation in order to see the world in more valuable way. It takes into account the learner where, and it regards the nature of what to be learnt (subject matter). Teaching that disregards the student's readiness or the nature of subject matter should be considered as a bad teaching, or even not teaching at all. Teaching is the effort to bridge the gap between the state of mind of the learner and the subject matter. If students always fail to learn anything, the teacher has really not been teaching. Constructivism belief that people learn by creating own understanding. Effective teaching is therefore one that successfully to facilitate creation by engaging, then monitoring and guiding thinking.

b. Able to develop science program to realize the goals of science education

The spirit of SBC curriculum is to provide the teachers with opportunity to develop their own education program for their school. In this aspect, science teachers take responsibility for setting yearlong as well as short-term science program for their students. In doing so, science teacher should deeply understand the goals of science education stated in the content standard and use them as the starting point in developing science program. Although there is an established document of competency standards as well as their corresponding competency bases, it is not enough for science teacher to look at this document only. They must employ the list of the goals and the list of the competencies as the two sides of one coin.

Science teacher should be able to design the route map of learning experiences that students should undergo in order to achieve the goals and competencies. In developing such science program, science teachers should deeply understand the significance as well as the scope and dept of every topic of science they will teach, appropriately arrange these contents based on their logical sequence, and surely provide their students with the opportunities to develop their both attitude toward science and scientific abilities. In arranging the content, science teacher should also consider the opportunity to teach student with inductive thinking in the early stages of their study and gradually move to deductive thinking. In the case of physics for instance, the concepts of kinetics and dynamics are feasible to be learned inductively. That is way the physics curriculum usually put those topics in the early years. The main goal of these efforts is to provide students the opportunity to build the well-structured knowledge of science as well as to develop and cultivate their attitude and scientific abilities.

Once the program has been defined, it is still subject to change and revision in the light of experience.

c. Able to plan and conduct inquiry-based teaching

The goals of science education include both content and process of science. Content of science refers to concepts, principles, theories, etc of science. Process of science, on the other hand, refers to the ways in which the content of science was constructed by scientist. Scientists develop their knowledge and understanding as they seek answers to questions about the natural world. We call the ways in which scientist works as the scientific inquiry.

Scientific inquiry refers to the diverse ways in which scientists study the natural world and propose explanations based on the evidence derived from their work. It is characterized by empirical criteria, logical argument, and skeptical review.

Therefore, inquiry in science education refers to the activities of students in which they develop knowledge and understanding of scientific ideas, as well as an understanding of how scientists study the natural world. When engaging in inquiry, students describe objects and events, ask questions, construct explanations through observation or experiment, test those explanations against current scientific knowledge, and communicate their ideas to others. They identify their assumptions, use critical and logical thinking, and consider alternative explanations. In this way, students actively develop their understanding of science content while develop their scientific ability.

Thus, by learning through inquiry, students will acquire both science knowledge and scientific ability. Therefore, science teachers should be having strong beliefs about the power of inquiry in science education and consistently engrave to teach their student with inquiry, as frequently as possible. In doing so, science teachers should be able to plan and conduct many kinds of inquiry-based science teachings.

d. Able to develop effective communication with and among students

The effective communication in science classroom is very important, as the nature of science language is often a metaphor and technical. The meanings of words depend on context and the conceptual framework of the listener or speaker. In science, everyday words are often adopted and given a special technical meaning. For example, 'work' then becomes the *product of force and distance traveled in the direction of the force* as well as *that by which someone earns a living*. An example of metaphoric nature of science language is “an electric charge of 100C moves in the electric field”. The term “an electric charge of 100C” is a metaphor of “an object that electrically charged in the amount of 100C”. Therefore, science teachers should pay more attention in describing the science concept using words or verbal representation. It is very important for the teacher to use multiple representations in describing any science concept. The use of information technology is also helpful.

For becoming an effective communicator in science classroom, science teacher should be aware with students' daily language and responsive to student's making meaning. Sometimes, teachers should understand the unspoken words, the gestures, and the facial expression of their students.

Science teachers should also able to develop community of science learners in the classroom. A healthy learning community will provide students to learning science through full participation and making meaningful contribution in science classroom. For doing so, science teachers must support and respect a diverse ideas, activities, expression, and thought. Teachers teach respect by focusing on their own and students' positive interaction and confronting disrespect and prejudice whenever it occurs in the classroom. Teachers work with students to develop an environment in which all students fell safe in expressing their ideas. Engage students in such community will promote students' communication ability too.

e. Conduct assessment and use the result for several purposes

Assessment is an integral part of educational program. Science teachers should be aware that assessment is a primary feedback mechanism in the science education system (feedback for students, teachers, school administrators, and others policy makers).

For teachers' perspective, assessment is a process of gathering data needed to make many decisions about teaching and learning. In science education, data concerning on the students' prior knowledge (usually naïve in nature), students' belief, interest, and motivation, and student's learning style are very important input for developing lesson plan. Assessing students' current understanding, students' difficulty, student's think, and students' involvement during the science lesson are also important for teachers to make necessary decisions about teaching and learning process, including the classroom environment. Data about students' achievement gathered through formative assessment (usually conducted at the end of a lesson or after several lessons), is a useful feedback for teachers to improve their future teaching and learning process. Data of students' achievement (knowledge, skill/ability, and attitude toward science) gathered through summative assessment give useful feedback

for science program. Shortly speaking, science teachers should approach their teaching in the spirit of inquiry: assessing, reflecting on, and learning from their own practices.

Assessment is also a manifestation of teachers' obligation to report student achievement to the stakeholders, including students and their parents. In this aspect, teachers must be able to collect and process all of assessment data and develop reports including grade and the profile of student achievement.

There are many kinds of strategies and modes of assessment: paper and pencil test, performance test, observation, portfolio, interview, investigative report, written essay, etc. Each mode serves particular purposes and has particular strengths and weaknesses. Therefore, science teachers should be able to use multiple assessment tools and strategies to achieve important goals of instruction.

In conducting on going assessment (i.e. the assessment conducted during a science class) for instance, science teachers should be a skilled observer of their students. They must be able to get any signals of students' learning and immediately take an appropriate action based on their observation.

Skilled teachers can also conduct student self-assessment. Student's self-assessment helps students to be aware about science concepts they have mastered or not yet mastered well and about what they must further do. Teachers encourage their students to develop a self-assessment to analyze their own learning.

Another important aspect of assessment is the defining the important aspect of learning should be assessed. In this aspect, American National Science Education Standard recommends the future better practicing assessment as in the following table. It is better for Indonesian science teachers to accommodate this recommendation.

LESS EMPHASIS ON	MORE EMPHASIS ON
Assessing what is easily measured	Assessing what is most highly valued
Assessing discrete knowledge	Assessing rich, well-structured knowledge
Assessing scientific knowledge	Assessing scientific understanding and reasoning
Assessing to learn what students do not know	Assessing to learn what students do understand
Assessing only achievement	Assessing achievement and opportunity to learn
End of term assessments by teachers	Students engaged in on going assessment of their work and that of others

Adopted from NSES pp. 100

f. Develop science program to facilitate students whose high motivation and interest

In many schools, there are some students whose high interest and ability in science. Science teacher should be able to get such talented students as early as possible. They need to know the detail information about their potencies including social and cultural background, ability, attitude, interest, and learning style.

Science teacher should be able to facilitate such students to develop their talent, ability, and interest. Teachers can challenge the students to conduct a comprehensive scientific investigation, engage them in many kinds of science competitions, or engage them in solving related-science social issues.

4. Professional Competency

MONE's Regulation no 16, year 2007 differentiates the competency into five sub competencies. They include: (1) deep understanding of subject matter, (2) deep understanding of standards and bases competencies, (3) developing subject content, (4) developing their own professionalism, and (5) using information technology for self-improvement.

As I have mentioned in the previous sections, it will be better if we develop a distinctive descriptions of professional competencies for science teachers. In the following paragraph, I will describe a little bit more of the issues.

a. Hold a proper belief about the nature of science

The teachers' beliefs and values about science determine their ways to teach science. In addition, the understanding of the processes used to establish a new knowledge and determine the validity of claims is also influence teacher in teaching. Therefore, science teachers should hold a proper belief about the nature of science as well as the ways through which science was be constructed and developed. Unfortunately, there are myths about the nature of science. Science teachers should hold the proper one, instead the myths one.

Myths	Corrections
Scientific laws and other such ideas are absolute	Scientific laws have limitations and can be subject to revision
Science and its methods provide absolute proof	Accumulated evidence can provide support for a law or theory but never prove them to be true
Scientific models represent reality	Scientific models are created to describe aspects of the natural world and are useful in giving predictions and explanations
Scientists are particularly objective	Scientists are no different in their objectivity from other professionals. They do try to be careful in analysis of evidence
A general and universal scientific method exists	No research method is applied universally. Scientists approach and solve problems with imagination, creativity, prior knowledge and perseverance
Evidence accumulated carefully will result in sure knowledge	It is impossible to make all possible observations and to secure facts for all time
Science and its methods can answer all questions	Science cannot answer moral, ethical, social, aesthetic questions
Experiments are the principal route to scientific knowledge	Scientific knowledge is gained in many ways including observation, analysis, speculation, library investigation and

Adapted from Grace and Ratcliffe (2003)

b. Possess skilled scientific abilities

It is more appropriate to use term “scientific abilities”, instead of "science-process skills", to describe some of the most important procedures, processes, and methods that scientists use when constructing knowledge and solving experimental problems. The reason is that these are not automatic skills, but are instead processes that students and teachers need to use reflectively and critically.

One goal of science education is to develop scientific abilities through the activities of formulating a problem, proposing a hypothesis, testing the hypothesis by collecting data (through observation or experiment), processing and interpreting data, and formulating conclusions, and communicating their work in both oral and written. It is clear that science teachers should possess such scientific abilities in order for successfully achieve the goal.

In the case of physics, Etkina et al. (2006) develop the list of scientific abilities including: (1) the ability to represent physical processes in multiple ways; (2) the ability to devise and test a qualitative explanation or quantitative relationship; (3) the ability to modify a qualitative explanation or quantitative relationship; (4) the ability to design an experimental investigation; (5) the ability to collect and analyze data; (6) the ability to evaluate experimental predictions and outcomes, conceptual claims, problem solutions, and models, and (7) the ability to communicate. It is necessary for physics teachers to skilled themselves with such abilities.

c. Demonstrate a deep understanding of content subject-matter

The successful science teachers should have deep understanding on three pillars of knowledge, i.e. content knowledge, pedagogical knowledge, and pedagogical-content knowledge. Content knowledge refers to the knowledge of subject matter they will teach. Pedagogical knowledge refers to the general knowledge of how people learn and how schools work. Pedagogical-content knowledge (PCK) refers to the special knowledge for teaching a particular topic to particular student in a particular condition.

Both pedagogical and content knowledge itself does not work in teaching science. That does work is PCK. PCK is not only the knowledge that distinguishes the science teachers from that of counterpart scientist, but also the knowledge that colors the ways the teacher teach. PCK is something of “knowledge in action”. Therefore, PCK is the most important knowledge that teacher should develop continuously. However, in order to able to develop a comprehensive PCK, teacher should have broader insight and deep understanding of knowledge content knowledge. Science teachers should have a well -organized conceptual knowledge not only within a particular branch of discipline (example in physics: mechanics, electrodynamics, etc), but also across branches of physics (e.g. mechanics and thermodynamics, etc).

Deep content knowledge is a necessary condition for the development of PCK and for understanding the nuances of every competence standards stated in national standard of education. If a teacher themselves does not understand the nuances of the concept, the deep relationships between this particular concept and other concepts, and the ways through which this concept was constructed by the science community, then translating these nuances into student understanding is impossible. Without deep understanding of content, it is also impossible for teacher to understand the nuances of competence standards and translate them into the better lesson plan.

Deep content knowledge is a necessary condition for the teachers to be successfully helping their student to build well-structured knowledge of science.

d. Aware with safety working environment, especially in laboratory

Safety is fundamental concern in all experimental-sciences. Science teachers must know and able to apply the safety regulation in storage of material and the care of the material used by students. Teachers also need to teach students how to safely do experiment or investigation, both in laboratory and in outside the classroom. It is important for teacher to declare the safety regulation and guidelines for using material and conducting experiment.

e. Having insight about the history of science, especially in the field of their licensure

Today science has undergone a very long history. We can learn more from the history of science. We can find out how scientific ideas have been develop and influenced by culture, beliefs, and social situation in that various time. We also learn how a theory was developed, tested, and refined. We can also learn what persistent the scientists work, what the intense they debate, and what the beautiful the collaboration between them. In short, we can draw many values from the history of science, such as honesty, openness, precision, and curiosity. Our beliefs about the nature of science depend on our insight about the history of science. Therefore, it is very important for science teachers for having insight about the history of science.

RECOMMENDATION

Teacher is central to education, but they must not be placed in the position of being solely responsible for science education quality. Teachers need support from others stakeholders of science education (supervisor, headmaster, science education experts, parent, and their colleagues). For example, teachers need adequate resources, materials, as well as space and time for maintaining their spirit to provide their students with better learning environment. In this example, teacher responsible for designing and using the resources and materials, but school administrators, students, and parents must meet their responsibility to ensure that the resource are available to be used. Headmaster should also provide teacher with adequate time and space for developing better lesson plan.

Teachers need many opportunities to improve their knowledge and skill continuously. It needs the works of professional development system.

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