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CONSTRUCTIVISM LEARNING AND FORMATIVE ASSESSMENT IN SCIENCE EDUCATION

***Dewani Goloi and Kamisah Osman**

Universiti Kebangsaan Malaysia

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ABSTRACT

The very common feature of constructivism learning and formative assessment in science education is their emphasis on learning process rather than the final product. Students will have many opportunities to engage in the learning process by integrating their intellectual, emotional, and spiritual intelligences with everyday life situations. Both constructivism learning and formative assessment involve interaction of learning adaptation processes and learning experiences that continuously supplement information to formulate or synthesize new knowledge. Constructivism learning enables students to acquire knowledge by actively engaging in building that knowledge based on experiences, existing knowledge and reflection. The knowledge is regarded as dynamic phenomenon because the interpretation of something can change based on the self-interpretation given to the environmental phenomenon. Similarly, formative assessment reinforces student learning and provides continuous improvement in student's achievement in the classroom. The similarities between constructivism learning and formative assessments in science subjects can be categorised into eight categories; the incorporation of learning with the pupils' culture; emphasis on inquiry and reflection approaches; exploration; authentic learning based on experience; strengthening critical thinking; awareness of the importance of learning science; informal learning, and; teachers recognize students' potential.

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INTRODUCTION

The focus on learning process in constructivist practice (Hayatdavoudi and Ansari 2011) is in line with the formative assessment expressed by Fogarty (1998) and Hedge (2010) that students will have many opportunities to engage in the learning process. Both approaches encourage students to integrate intellectual intelligence, emotional intelligence, existing spiritual intelligence with everyday life situations (daily experience). Any attempt to understand formative assessment must be based on the impression of learning from a constructivist perspective or experience (Staunton and Dann 2016). Constructivist assessment instruments are also found in parallel with formative assessment instruments involving activities such as problem solving, portfolio, project, composition, performances based on authentic assessment, drama, interviews, group discussions, and investigations. Formative assessment is to reinforce student learning and improve dramatic student achievement if it is practiced continuously in the classroom.

Emphasis on the Journey of Knowledge Acquisition

In constructivism learning, as well as in formative assessment, the journey of acquiring knowledge is as important as the knowledge itself. Baron (2016) shows that students learn better when they can build their own knowledge through constructivism activities. Constructivism is more likely to be assessed for learning and as learning such as used in formative assessments. While behaviourism and cognitivism focus on the measurement of objectives objectively, constructivists tend to assess subjective student work (Bereiter and Scardamalia 1992). Among the key features of constructivism learning are, this learning enables students to acquire knowledge by actively engaging in building that knowledge and in this regard are perceptions, experiences, existing that knowledge and reflection. Constructivism learning also involves interaction of learning adaptation processes and learning experiences

****Corresponding author:*** **Dewani Goloi**
Universiti Kebangsaan Malaysia

continuously to supplement information to formulate or synthesize new knowledge. Knowledge should be regarded as dynamic not a static phenomenon because the interpretation of something can change based on the self-interpretation given to the environmental phenomenon.

Similarly, formative assessment is used to monitor student's learning to provide ongoing feedback that can be used by instructors or teachers to improve their teaching and used by students to improve their learning.

Constructivism and Formative Assessment in Science Education

According to Taber (2010) constructivism is a broad-based perspective in the study of science education and has been used as the official guide of pedagogy among science teachers in England. Constructivist learning practices are in line with the nature of the formative evaluation expressed by Stiggins (2005) stating that formative evaluations enable learning to be guided according to the student's ability level. Qarareh (2016) study found that using constructivist learning models succeeded in improving student achievement and scientific thinking in teaching science. Qarareh (2016) suggests that additional attention should be given to using constructivist learning models in science courses, and conduct further studies on the effects of constructivism learning models on various learning outcomes. This is in line with the findings of Creghan and Creghan (2013) that one of the key to improving student achievement score is to 'modify' formative evaluations based on investigative and constructivism processes throughout the 5E Teaching Model phase: engage, explore, explain, elaborate, and evaluate.

Knapp's (2013) study found that West Virginia science teachers were often reported using constructivist teaching practices and demonstrating a moderate level of teaching effectiveness. Lew (2010) also examines the perspective of constructivist practice among teachers. Lew (2010) found that experienced teachers (ETS) outperformed new teachers (NTSs) in general in the use of constructivist teaching practices studied. As a result of the literary references, we categorized the relevance of formative assessments with constructivism learning in science subjects into eight categories, namely the incorporation of learning with pupil culture, emphasis on inquiry and reflection approaches, exploration, authentic learning based on experience, strengthening critical thinking, awareness of the importance of learning science, informal learning and teachers recognize students.

Merging learning with culture and student values: Giron (2012) notes that constructivism maintains a more meaningful direction when it is relevant, social and interactive. Since formative assessment involves constructive teaching and learning, the incorporation of student culture with formative assessments can produce a very effective learning outcome. Yap (2014) notes that the awareness of teachers to integrate science, ethics and morale is evolving to develop sophisticated science epistemology, including the appreciation of social contexts in terms of ethical thinking. This effort enables students to integrate ideas about their scientific issues and their own values, beliefs and ethics. Mansour (2011) explores the view of Egyptian science teachers on religion and science in the context of Islam. Mansour (2011) concludes that the personal beliefs of teachers on Islamic-religion can describe their beliefs about the nature of science and its uses. Taskin (2014) outlines the perceptions of four Muslim students on Islam and its impact on their approach to teaching and learning science. Taskin (2014) stated that there was misinterpretation and abuse of constructivism as well as the notion of scientific theory as a way to deny the theory of evolution. Misunderstandings and abuse of constructivism occur because there is a belief that the interaction between science and religion in daily life is considered part of the cultural atmosphere in Islamic countries, as well as the notion that reality can only be found in the Qur'an.

Inquiry and reflection approach: According to Staunton and Dann (2016) the most important thing for a teacher is to find out whether a student has understood the full learning. This can be detected by asking deep questions to get into the minds of the students. This in-depth question needs to be done continuously and not in the form of recalled questions (Staunton and Dann 2016). This ongoing question will encourage dialogue sessions that eventually generate high-level thinking. Kingir *et al*. (2013) found that, in a classroom environment that supports autonomy and pupil control, pupils tend to develop higher interests in the assignment, employ more self-regulatory strategies, and perform higher academic performance. In order to create the learning environment, teachers can design open inquiry activities that can provide students with the opportunity to take responsibility, make reflections based on their own views and solve challenging tasks (Kingir *et al*., 2013).

Collaborative activities: Rahman (2012) shows that the use of constructivist teaching approaches (POEs) encourage teachers to change their teaching perceptions based on traditional approaches (didactic). Rahman (2012) notes that the practice of science teachers in using POEs and collaborative activities enables them to share, further developing their capacity to develop personal insights into their own practice of teaching. Fung andLui (2017) stated that pupils showed better scientific learning progression with their involvement in cooperative learning and debate sessions that apply the Vygotsky proximal proximal zone development framework. Learning in a group is also found to be effective if the teacher acts as a student driver during the construction of conceptual knowledge. Turcotte and Hamel (2016) found that collaborative online scaffolding using online scaffolds can help students understand and practice scientific authentication inquiries.

Exploration: Winning (2012) found that students appreciate learning through exploration and collaboration with peers in the pursuit of learning science. Cetin-Dindar (2016) also noted that, science educators should give more emphasis on the linkages and exploration of science in schools with real life to increase student motivation to learn science. Technology also provides students with opportunities to explore learning tasks that are beyond their habits (Machado 2012). Additionally, new technology movements such as laptops, mobile phones and tablets, provide students with learning opportunities anytime, anywhere (Machado 2012). The technologyin game-based learning provide students with opportunities real-life contexts in online formats (Routledge 2009). Technological skills themselves are seen as a necessity for progress in the current and future societies. By combining constructivist approaches to learning and technology, students acquire more than one useful skill.

Strengthening critical thinking: Based on the theory of constructivism and reasoning strategy, Chaipichit *et al*. (2015) has developed a science learning model to reinforce critical thinking among school children. This strategy is in line with formative assessment for Chaipichit *et al*. (2015) examines issues related to the management of science learning, problems encountered, and further develop a learning management model to address the problem. It was found that teachers who implemented the constructivist learning model agreed that the model used could reinforce the students' critical thinking at the highest level.

Authentic learning based on experience: According to Reeves and Okey (1996), formative assessments in constructivism focus on the processes experienced by students in the process of knowledge creation. Each student is considered different in terms of advantages, weaknesses, existing knowledge and experience. Assessment focuses on how a student is able to learn new material by associating it with existing knowledge to establish lasting relationships in the minds of the students. Through this relationship, pupils are assessed based on their ability to apply learning to the real-life context. Herrington and Oliver (2000) provide nine features of an authentic learning environment:

- Provides a valid context reflecting the way that knowledge will be used in real life.
- Providing authentic activity.
- Provides access to expert presentations and process modeling.
- Provides various roles and perspectives.
- Support for co-operation of knowledge.
- Reflects to allow abstractions to be formed.
- Providing articulation to enable implicit knowledge to be made clear.
- Guiding and scaffolding by teachers in critical moments.
- Provides for authentic assessment of learning in the task.

Glackin's study (2016) suggests that teachers who successfully teach outside the classroom generally have social constructivism and appreciate authentic scientific opportunities. On the other hand, less successful teachers in classroom teaching have the beliefs of traditional learning and consider outside classroom learning as an innovation and the potential for fun (Glakin 2016). Prins *et al*. (2016) states that one of the challenges of science education is to integrate the activity, content, and apparatus tools meaningfully. To address the challenges of science education is the transformation of authentic science practice into the context of learning, in line with the theory of socio-cultural activities. By practicing authentic scientific activities, students can relate learning content to the use of apparatus on a logical basis and relevant (Prins *et al*., 2016). Abramovich and Loria (2015) examines the impact of Education for Conservation Authentication (EFS) on new teachers in the real-life environment of science and technology (among families, communities and working environments). The findings of the Abramovich and Loria study (2015) show that the Education for Sustainability (EFS) course clearly improves teacher awareness of the environment and responsive teachers (responding) with greater responsibility.

Ketelhut *et al*. (2013) states that current science assessments usually produce a series of fact-based questions separately, not fully representing the complexity of science-building in the real world. This should be changed to a more authentic model of practice of science. Therefore, Ketelhut *et al*. (2013) suggests that good scientific assessments should consist of several key factors: integration of science content with scientific inquiries, questions in the form of constructs, grading efficiency and validity and statistical reliability. Gilbert *et al*. (2014) using the learning program through real / internship experience among university students. The intervention also provides the effect of active learning at a high level. Rivera Maulucci *et al*. (2014) explored the experience of six secondary school students in an authentic science inquiry program. The findings of Rivera Maulucci *et al*. (2014) suggests that an authentic science inquiry project is able to provide students with academic excellence, provide students the opportunity to acquire skills, have the potential to challenge students' knowledge of science, enhance student / student engagement with science, and improve student achievement in science.

Awareness of Science interests: Karahan and Roehrig (2015) suggests that student awareness towards the environment and support for activist needs has improved on a different scale (personal, community, global) across the learning process of constructivism. The constructivist science module can indeed encourage students to become more aware of modern biotechnology, although encouraging more critical attitude towards modern biotechnology should be more attentive (Klop *et al*., 2010). Brophy and Alleman (1998) stated that the three curriculum goals (understanding, appreciation, and life applying) are contained in the core of constructivist teaching and should serve as guides in the assessment methodology. Aydin (2013) recognizes the role of constructivist students in the acquisition of chemical education in the Québec region of Canada. In the learning of constructivists, students (1) control the learning process (2) students act in selecting, developing and actively learning process (3) students performing responsibilities in constructive learning environment (4) students constructing their minds for knowledge acquisition and 5) students communicate and discuss issues with other students and teachers. Bayne (2012) uses learning methods in constructivist environments (CLES) to identify the learning experience of grade 9 (14 years) in New York. Bayne (2012) found that CLES provides students with the opportunity to understand ontology and help to create / access appropriate resources which in turn leads to success in science classes. According to Scholtz (2007), meaningful assessments (such as formative assessment) should reflect the profession, career or practical practice assessed, while at the same time providing opportunities for students to demonstrate their knowledge and skills. Shepard (2000) explains this meaningful assessment as a performance-based assessment, where teachers combine the assessment of pupil knowledge, peer feedback and self-assessment by pupils as a social process will result in the intellectual development of intellectual students, knowledge building and identity building.

Informal Learning: Wallace and Brooks (2015) study reports that the lack of time to teach science in a traditional class in the US has led some science teachers to conduct science teaching in an informal environment using constructivism approaches. The constructivism approach is found to enhance peer co-operation and enhance the close relationship between teachers and children. The interaction enhances teachers' understanding of diverse student learning needs (Wallace and Brooks 2015). Allen's study (2008) finds that the constructivist-provisiona list approach has undesirable effects (note: provisionalism is the current thought that may affect future knowledge). The intended effect is (1) promoting positivist set-up when conducting science-based work in schools. This positivist set up triggers a confirmation of bias attitude; and (2) creating an epistemological confusion (knowledge field) that tends towards positivism that will continue to higher education and subsequent levels.

Teachers Recognize Students' Potentials: Scholtz (2007) notes that constructivist assessment requires educators to spend a lot of time recognizing each student potentials individually to determine the learning process, strengths, weaknesses, existing knowledge, and so on. In doing so, the conflict that arises with this observation, sometimes a subjective form of assessment when parents or administrators disagree with the assessment (Scholtz 2007). The constructivist (formative) assessment expressed by Sholtz (2007) supports Lucy's argument (2007) that in formative assessment, teachers need to help individual students to reach their own band or standard without comparing with other students. Similarly, constructivist assessment takes into account the differences between pupils. On the other hand, there are many worldviews through the eyes of the students. This view is derived through personal experience and social interaction (Kamiiand Lewis 1990). Likewise, the way that teachers interpret the world or build knowledge is very different from students.

In implementing a constructivist approach, teachers play a role in evaluating the learning process of thinking and to evaluate current learning comprehension. This assessment is used not as a tool to compare pupils or criticisms, but as a tool to understand how individual students think and take on the course of knowledge creation. Brooks and Brooks (1993) provide 12 list of principles that teachers need to use in constructivist classes to maximize these results:

- Promote and accept student autonomy and initiatives.
- Using raw data and primary sources together with manipulative, interactive, and physical materials.
- Use cognitive terms such as "classify", "analyze," "predict," and "create" when designing tasks.
- Enables pupils to guide teaching, divert teaching strategies, and alter learning content.
- Ask about students' understanding of the concept before sharing their own understanding of the concept.
- Encourage students to engage in dialogue with teachers and each other.
- Encourage student inquiries by asking questions that require deep thinking, open-ended questions and encouraging students to ask each other.
- Requires a pupil to describe the answer given.
- Involve students in an experience that may have contradicts their early hypothesis and then discusses the discussion.
- Spend time waiting after asking questions.
- Give time to students to build relationships and create metaphors.
- Nurturing the students' natural curiosity through the frequent use of learning cycle models.

Conclusion

Constructivism and formative assessment focus on the processes experienced by students in the process of knowledge creation on their own pace and abilities. The final product of education is not the most important aspect of constructivism learning nor formative assessment; teachers should focus on the process and experiences that a student needs to go through in order to achieve the ultimate educational goal. In doing so, each student must be considered different in terms of advantages, weaknesses, existing knowledge and experiences. Formative assessment on how a student is able to learn new material constructively by associating it with existing knowledge will establish lasting relationships in their minds. Through this relationship, students are facilitated and assessed based on their ability to apply learning to the real-world context. Thus, the future educators should be taught the theory and practice of constructivism and how to integrate this pedagogical skill with formative assessment in the classroom.

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