Constructivism 25 Years on: Its Contribution, Missed Opportunities?

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Abstract. *Science Educators have endorsed and advocated adopting a constructivist approach in science teaching for these past 25 years. This is indicated by the massive research published during this period about children's ideas and describing teaching schemes developed within a constructivist framework.. Yet, as the PISA results [14] highlight, students' performance across the world vary widely and too many students still lack the basic scientific literacy needed to understand and apply basic scientific principles to contexts.*

The aim of this paper is to review the development of constructivist learning theory highlighting its main contributions. The main approaches: cognitive conflict; scaffolding; and metacognition will be each discussed in detail. However, like any other theory, constructivism has its shortcomings, particularly in treating the learning context in a holistic way within a sociological perspective. Reasons for which constructivism has not brought about the significant improvement in the understanding of science as predicted by science educators will be put forward. Possible directions that constructivism can take up in dealing with the new demands of the social impact that major current scientific research such as cloning is making, will be proposed.

Keywords.
Constructivism, review, children's Ideas, teaching approaches.

1. Introduction

Students' performance and level of understanding has been a cause for concern for as long as there has been research in science education. Science teaching has experienced a shift from the traditional 'transmission' approach [14] to focus on process skills and discovery learning (see Nuffield Science) to constructivism. The shift has been in two directions: from teacher-centred to child-centred; and from a passive view of learning to one which considers the learner as actively involved with the learning content.

In the transmission view, the learning process is considered as the simple transfer of knowledge from the teacher (the knowledgeable) to the pupil (the less knowledgeable). The teacher is the active participant whereas the student is the passive receiver of knowledge, hence the teacher-centred approach. Science educators soon recognised the insufficient adequacy of the transmission view [14]. It was recognized that effective learning could not take place without the active participation of learners. One thus finds the famous statement 'children learn by doing' approach as advocated in the Nuffield approach [2]. This was a shift from one extreme to another whereby students within the 'discovery approach' were left to their own devices to understand not only the scientific concepts but also what they were supposed to learn. Hence, one finds the criticism put forward by Rosalind Driver [3] who compared this approach to a simple guessing game where students were more concerned with finding out what they were supposed to learn rather than focusing on understanding the concepts involved in the situation presented to them. Constructivism succeeded the Nuffield Science, following research findings that students already hold ideas (and often wrong ideas) about scientific concepts. This implied that students naturally like to make sense of things and consequently learning involves recognizing these ideas and building on them. Thus the constructivist approach endorses a child-centred approach as well as considers the learning

process as the active construction of knowledge by the learner.

2. Contribution of Constructivism

Constructivism has provided a number of significant contributions to the teaching of science, these being listed to mainly include: developing teaching approaches based on theories of learning; recognising students' ideas; changing the role of scientific knowledge from objective and infallible to being socially constructed; recognising the role of language as a part of the learning process; changing the role of practical work.

Despite the evident little improvement in the learning and understanding of science, constructivism has none the less, provided a contribution to the understanding of the learning process. Not only has it consolidated the shift from teacher-centred to child-centred approach, but it has also provided insight into how learners construct knowledge. Although the main criticism put forward to constructivism is that it does not tend to be much of a theory [], on the other hand it has great potential in its possibility for application in the classroom. Many teaching schemes and approaches in fact have been developed under the umbrella of constructivism. This is also reflected in the number of theories developed by key people such as Piaget, Ausubel and Vygotsky. A common theoretical basis for each teaching approach developed is that they all view the learner as a cognitive process where the learner is actively angaged, on a personal level internally and/or within a social context with the learning material in the process of constructing knowledge. So one finds applications such as the use of cognitive conflict [1], scaffolding[12] as well as metacognition[10,19].

Congitive conflict can be considered as a means of provoking the construction of knowledge. When there is difference between an experimental outcome, learning material or other students' ideas with those that the learner holds, the learner experiences a state of dissonance. Consequently accommodation (using Piaget's language) takes place during learning. We thus find examples [8] where students were asked to predict actual experiments' outcomes. These activities are usually designed in such a way that they bring out students' alernative frameworks which differ from correct scientific concepts creating cognitive conflict. One also finds examples of group-work which is used to get students to spell out their ideas about specific scientific concepts with the aim of generating different models and ideas. This also creates cognitive conflict. In any case, these are situations where students are given ownership of their own learning as they would want to know whether their ideas are correct and if not for what reason. The successful use of cognitive conflict depends on the types of conflict created. It cannot be too difficult as otherwise it would be beyond the students' capabilities. On the other hand, it shouldn't be too easy as it would not be challenging enough to motivate the students. It should be targeted within Vygotsky's zone of proximal development [17].

Work by Vygotsky [17] based on his theory of zone of proximal development and the use of scaffolding is another example of how teaching schemes have been developed within a constructivist approach. In scaffolding the teacher provides support so that students are able to do activities that they would not otherwise be able to tackle. As students gain experience, the teacher removes the amount of help and support provided gradually until they can perform the task on their own. The role of the teacher is to create learning situations and support structures so that mediation of learning takes place. Such an approach can be considered to be within the constructivist approach as the responsibility for learning shifts from the teacher to the student.

Metacognition can be described as the ability to 'think about one's own thinking'. Such cognitive process is at a higher level of thinking than cognitive conflict and scaffolding. Whereas the latter two deal directly with the learning context, metacognition goes further as it requires the learner to reflect on his/her process of thinking in dealing with the learning content. Approaches devised include examples where students are asked to describe their learning path at the end of a teaching session [8], or at the end of a teaching scheme. Metacognition is difficult to achieve but it provides the learner with control over his/her developed learning processes.

Another major contribution of constructivism is that it acknowledges the existence of students' ideas and gives value to them. If one goes through literature published during the 80's one finds many studies on children's alternative

frameworks [6,7] in practically any area of science. Whole publications, for example Driver et al [6,7] and Pfundt & Duit [15] are classic examples of such collections. These studies have brought insight of the ideas that students hold, before and often also after formal science teaching, to science education. Consequently, they have shifted the focus from the teacher and content to the students and given value to their existing "knowledge". This was a major shift since up to that point science educators tended to focus mainly on content and its logical structure from an epistemological point of view rather that from the students' learning point of view. It also served to acknowledge students' attempt to understand natural scientific phenomena that they encounter in their everyday life. The commonly used label of alternative frameworks [5] fully endorses the value given to students' ideas.

Going to a completely different type of contribution, constructivism has changed the way that science educators view scientific knowledge. Within a constructivist perspective, science educators hold the view that learners, and likewise scientists, construct models and theories about natural and scientific phenomena. Thus scientists are also involved in the social construction of knowledge. Scientific knowledge has thus lost its positivisic image of being totally objective and infallable. Scientific knowledge is now recognised as being constructed by the community of scientists. This change of view has brought closer the accepted scientific views to the students' alternative frameworks. However, the latter still have much lower status compared to that of the scientific knowledge within the community of scientists.

Another contribution of constructivism is the recognition of the importance that language has as a tool to promote the construction of knowledge. Language is not only the means through which scientific ideas are communicated, it is also the medium through which ideas are constructed [18]. Language can be used for more than transmitting knowledge to learners. It is also the vehicle through which learners become aware of their own thoughts, thus facilitating understanding. This brought about a change in the types of activities organised within science classrooms. Constructivist teaching promotes student participation in discussions, group-work, in interacting with texts etc. This is a move from the passive student or the physically active learner, to the cognitively active learner.

In the same way as the role of language has changed in science education, so has that of practical work. Traditional practical work tends to consist in the illustration of relationships and concepts described in class. Experimental reports usually followed (and often still do) the same traditional format of aim, method, results etc. Constructivism has placed practical work at the heart of the learning process. Worksheets developed within a constructivist perspective are designed in such a way as to provoke student thinking and reflection on what happened in the experiment and more importantly to explain why. The why requires students to try and make sense of their observations using their existing frameworks. When these fail to provide plausible explanations, then, hopefully construction of good scientific understanding, takes place. Such an approach falls within, but is not exclusive, of the conceptual change [11] teaching strategy.

3. Criticisms to constructivism

If one had to make up a list of the most overused and abused words within educational settings, constructivism would feature high on the list. In the literature one finds all sorts of constructivism suc as: cognitive constructivism, sociocultural constructivism, piagetian constructivism, sociological constructivism, pragmatic constructivism, radical constructivism to structural constructivism within sociologiy of education. Too many labels for one construct leads to confusion. One theory cannot have so many aspects. This leads to a situation where different educators mean different things of else that the theory is too wide. A too open a theory tends to become vague and is prone to be interpreted in many different ways. In any case such situation weakens the position of constructivism from being recognised as a serious and well developed theory of learning.

The main criticism that I bring to constructivism comes from another point of view. This is that it does not deal with the learning process holistically but limits itself just to the congitive aspect of learning. As stated in the begining of this paper, constructivism refers to learning as the active construction of knowledge, whether this is considered to take

place internally at a personal level or in a group within a social context. It, however, fails to include a sociological perspective to learning. If one were to review the many constructivist methodologies developed, the main focus tends to be students' alternative ideas within a psychological prespective. The focus is just on making students construct scientific knowledge where the only difference between the learners tends to be mainly the different alternative framworks. There is no recognition of other types of conceptions that students hold and bring with them to the learning situation. Let us just consider one extreme situation. What if a student in a classroom comes from a poor background, does not even have basic living conditions at home, has always been told that he is slow, incapable of learning, would get up to no good in life. How can a student with such background possess the desired readiness that leads to learning. Unfortunately, science educators have failed to include this perspective within their schemes. This nearly total disregard of the sociological perspective may be the root as to why constructivism has fallen short of providing the so much desired improvement in student learning. Sociological readiness to learning is the basis on which pyschological readiness stands. It is only when both are in place that valid and effective construction of knowledge takes place. This is thus an aspect that eductors need to keep in mind when developing new methodologies within a constructivist framework.

4. A word in defense of constructivism

However, the inability to improve significantly student understanding may not only necessarily be the inadequacy and limitation of constructivism, but rather that constructivism has not been given the chance to be fully implemented within the educational system. What does this mean? The constructivist approach, whether involving cognitive conflict, scaffolding or any other approach, has one thing in common. It is time consuming. It thus requires much more time to help students learn content material in a constructivist methodology than the typical transmission approach. This has created great practical limitations to the implementation of constructivism since syllabi have not really changed much in amount of content over the past years. Constructivism is not really as yet, the main approach adopted when teaching in science. One can say that developments in science education research have not really found their way to actual classroom practice. Hence, maybe, it would be unfair to blame constructivism for failing to bring about the much desired improvement in students understanding. It is not sufficient to expect significant and long-term effect from short 3-6 weeks of constructivist teaching. It is thus a problem that constructivism has never really been fully implemented than its failure as a valid theory of learning.

A similar argument can be put forward with respect to assessment procedures. Assessment procedures have more or less remained unchanged within education systems worldwide. Many still prefer a summative approach. If students have an examination at the end of the school year, this tends to promote the accumulation of knowledge. In many cases students are faced with a thick pile of notes which they need to know well. This is a type of assessment that promotes the accumulation of knowledge. It is thus often the case that many students cram their learning, resorting particularly to rote learning. Students thus, may not find constructivist teaching that fruitful within a summative structure of assessment. Rote learning tends to give good results in the short term, as often examinations tend to ask student to regurgitate content covered in class. On the other hand, constructivism has a more long-term effect which could not be in line with the students' goals at the time. Assessment thus sends a strong message to students that learning demands the accumulation of knowledge without the need to really 'understand' it, making constructivism and the learning of knowledge appear futile and a waste of time to learners.

5. What are the challenges that science education is currently facing?

If one looks at recent publications, there appears to be shift in the interest of science educators. Constructivism has moved away from centre stage. There is now more interest in social aspects of science and citizenship. These are not just the result of researchers' personal interests. They are the consequence of the impact that scientists' work such as that in the field of genetics related to cloning and the use of stem cells for research is having on the role that science is currently taking up in society. There is

suddenly a great crisis where citizens are being bombarded with information about scientists' work and are expected to have opinions and to express them, and to give consent or to disapprove not only as politicians but also as citizens. One case in point is Italy, where normal citizens were asked to express their opinion about this issue in a referendum. Such circumstances mean that science education does no longer only have the responsibility of preparing young people with a basic level of scientific knowledge. It now needs to equip young people with the ability to realize what the social implications of certain scientific activities are, to consider them from an ethical point of view, and to know how to weigh the pros and cons of such activity in order to be able to participate as active citizens in the debate.

One may wonder in what way constructivism can contribute to this new challenge. Science educators are now faced with the additional problem of understanding how attitudes, values and ethical consideration are taught and in what way do students develop a critical attitude that will help them to weigh up social implications. Constructivism can be that framework within which researchers can work to start understanding this new process of learning attitudes and values, reflection and civic action. In addition, if one were to take a wider view of constructivism and include the sociological perspective, then society and social implications will be integrated within constructivist theory.

So how can this new dimension of constructivism be implemented within the classroom. If one is to include the sociological aspect within the constructivist theory of learning, then it must also be present when it is applied to classroom practice. Part of the science education thAT students are to experience need to include the discussion of science and its social implications. One, however, would need to go beyond simple role playing. Social players involved can be taken inside the classroom, asked to view their concerns and then students are helped with weighing the implications and deciding what opinion they would like to have and for what reasons. This would help students construct attitudes and values. In this case, rote learning would not provide better assessment. Attitudes and values cannot be assessed through a written examination. Constructivism would then be the better approach for them to adopt.

6. Conclusion

As always it is much easier to talk about possibilities than implementing them. It is my hope that what I put forward as a possible alternative today can be one possible direction for research in science teaching that would promote further growth of constructivism rather than its eventual extinction.

References

[1] Adey, P., S., Shayer, M., & Yates, C., Thinking Science: The Curriculum Materials of the CASE Project, London: Thomas Nelson and Sons, 1989.

[2] Alexander D., Nuffield Secondary Science: an evaluation, London: Macmillan Education, 1974.

[3] Driver R, The Name of the Game, School Science Review, 1981:56, 800-805.

[4] Driver R., Leach J., Scott P., Millar R. Young People's Images of Science, Milton Keynes: Open University Press, 1996.

[5] Driver R., & Easley J., Pupils and Paradigms: A Review of Literature related to Concept Development in Adolescent Science Students, Studies in Science Education, 1978:5, 61-84.

[6] Driver, R., Guense, E. & Tiberghein A., Children's Ideas in Science, Milten Keynes : Open University Press, 1985.

[7] Driver, R., Squires A., Rushwork, P., & Wood-Robinson, V., Making Sense of Seconday Science : Research into Children's Ideas, London : Routeledge, 1994.

[8] Gatt S., Altenrative Frameworks about Newton's Laws of Mation: Examination Performance, cognitive development and cognitive styles of Maltese Fourth Form Junior Lyceum Students, Unpublished Ph.D. Dissertation, University of Malta, 2002.

[9] Gatt S., & Vella Y. (eds.), Constructivist Teaching in Primary School Social Studies,

Mathematics, Science, ICT, Design and Technology, Malta: Agenda, 2003.

[10]Gunstone R., The Importance of Specific Science Content in the Enhancement of Metacognition in Fensham P., Gunstone, R., & White R., (eds.), The Content of Science: A Constructivist Approach to its Teaching and Le**arning,** London: The Falmer Press, 1994.

[11]Hewson P.W., A Conceptual Change Approach to Learning Science, European Journal of Science Education, 1981:Vol. 3, No.4 p383- 396.

[12]Hobsbaum, A., Peters, S., & Sylva, K., Scaffolding in Reading Recovery, Oxford Review of Education, 1996:22, 1 p17-35.

[13] Matthews M., Science Teaching: The role of History and Philosophy of Science, New York : Routledge, 1994.

[14] OECD, Learning for Tomorrow's World - First results from PISA 2003, OECD report, 2004.

[15]Pfundt H., & Duit R., Bibliography, Students' Alternative Frameworks and Science Education, (4th Edn.), Kiel: Institute for Science Education, 1994.

[16]Sutton C., Words, Science and Learning, Milton Keynes: Open University Press,1992.

[17]Vygotsky L.S., Mind in Society : The Development of Higher Psychological Processes, Cambridge Massachusetts: Harvard University Press, 1978.

[18]Vygotsky L.S., Thought and Language, Cambridge Massachusetts: MIT Press, 1986.

[19]Wittrock M., Generative Science Teaching, in Fensham, P., Gunstone, R., & White R., (eds.), The Content of Science: A Constructivist Approach to its Teaching and Learning, London: The Falmer Press, 1996.