

Constructive Realism and Science Education

واقع‌گرایی سازنده و آموزش علوم

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Constructive realism (CR) is an attempt to overcome the difficulties associated with naive realism and radical constructivism. There are different versions for CR. In this paper, I defend a particular version of CR. Complexity of reality, on the one hand, and the impact of human mind, language, and culture, on the other, leads to the inevitable contribution of constructs in knowledge development. According to the CR, even if mental, linguistic and cultural side of constructs could not be avoided in principle, a certain proportion of reality-contact can be considered and defended for the constructs. In this sense, human mind and culture has a constitutive role to play in knowledge acquiring instead of being an innocent means in the process of acquiring knowledge. On the other hand, the role played by the reality in this process cannot be ignored because, according to the CR, knowledge consists after all of knowing 'something' in the real world. On the whole, taking into account both the constitutive role of mind and culture, on the one hand, and the inevitable role of the reality, on the other, shows the difference between the CR and pure realism, pure constructivism, and those versions of CR that do not take the constitutive role of mind into account.

There are requirements for the CR in science education. First of all, there must be a constant caution for making sure that our scientific theories have caught the proportion of reality-contact. This point shows the difference between the CR and pure constructivism. This caution should be present in our science teaching as well. Secondly, we should encourage our students to develop imaginative alternative constructs when they are learning sciences. This shows the difference between the CR with naive realists who ignore the importance of students' imaginations in suggesting alternative constructs. Notwithstanding, while we encourage the students to develop their imaginative constructs, there should be considered a limitation for their over-justification about their constructs. In this way, we as teachers should urge them to take counter-evidence most seriously into account. This is a point in which constructive realists are distinguished from pragmatists too. Pragmatists do not give up their theories in confrontation with counter-evidence but rather look for almost limitless changes in their constructs in order for making the counter-evidence compatible with their theories, whereas constructive realists will be ready to take counter-evidence more serious and correct their constructs accordingly.

Keywords: Constructive Realism, Science Education, Counter-evidence, Proportional Reality-Contact

واقع‌گرایی سازنده (CR) تلاشی در راستای رفع مشکلات مربوط به واقع‌گرایی محض و سازنده‌گرایی بنیادین می‌باشد. قرائت‌های مختلفی از واقع‌گرایی سازنده وجود دارد. در این مقاله نویسنده دلایلی را در حمایت از یکی از نسخه‌های خاص واقع‌گرایی سازنده (CR) ارائه می‌دهد. پیچیدگی واقعیت از سویی و اثرات ناشی از ذهن، زبان، و فرهنگ انسانی از سوی دیگر به مداخله‌ی انکارناپذیر سازه‌های مختلف در رشد دانش منجر می‌گردند. بر اساس CR، حتی اگر اساساً نتوان از ابعاد ذهنی، زبانی، و فرهنگی سازه‌ها اجتناب کرد، باید به میزان خاصی از تماس با واقعیت برای سازه‌ها توجه داشت. از این لحاظ انسان و فرهنگ نقش سازنده و مهمی در کسب دانش ایفا می‌کنند و صرفاً ابزاری برای این فرآیند محسوب نمی‌شوند. از سویی دیگر نقش واقعیت در این فرآیند را نمی‌توان نادیده گرفت. زیرا، بر اساس CR، دانش به معنای دانستن «چیزی» در دنیای واقعی است. به طور کل، در نظر گرفتن نقش ذهن و فرهنگ از یک سو و نقش اجتناب‌ناپذیر واقعیت از سویی دیگر تفاوت میان CR واقع‌گرایی خالص، سازنده‌گرایی خالص، و دیگر قرائت‌های واقع‌گرائی سازنده که نقش سازنده‌ی ذهن را مورد توجه قرار نمی‌دهند را به خوبی نشان می‌دهد.

برای CR در آموزش علوم الزامات خاصی وجود دارد. در وهله‌ی اول، باید همواره توجه داشت که نظریات علمی بخشی از تماس با واقعیت را در برمی‌گیرند. این نکته نشان‌دهنده‌ی تفاوت میان CR و ساخت‌گرایی محض می‌باشد. این مورد را در تدریس علوم نیز باید مورد توجه قرار داد. دوم، در طول فراگیری علوم فراگیران باید به استفاده از سازه‌های تخیلی جایگزین تشویق شوند. این نشان دهنده‌ی تفاوت میان CR و واقع‌گرایان محض است که اهمیت تخیلات فراگیران را در رشد سازه‌های تخیلی مد نظر قرار نمی‌دهند. با این وجود، در حالی که ما فراگیران را به رشد سازه‌های تخیلی خویش تشویق می‌نماییم باید حدودی نیز برای این امر قائل شد. بدین صورت، ما در مقام معلم باید فراگیران را تشویق کنیم تا شواهد نقض را به طور جدی‌تری مورد توجه قرار دهند. این در واقع همان تفاوت میان واقع‌گرایان سازنده گرا و عمل‌گرایان می‌باشد. عمل‌گرایان در مقابله با شواهد نقض کننده دست از نظریات خود نمی‌کشند بلکه به هدف همگام ساختن شواهد نقض با نظریاتشان در پی ایجاد تغییرات نامحدودی در سازه‌ها هستند. این در حالی می‌باشد که واقع‌گرایان سازنده شواهد نقض را بیشتر مورد توجه قرار می‌دهند و سازه‌های خود را طبق آن تصحیح می‌نمایند.

کلیدواژه: واقع‌گرایی سازنده، آموزش علوم، شواهد نقض، تماس نسبی با واقعیت



Introduction

The term “constructive realism” is generally used in epistemology. In epistemology, the issue of knowledge can be considered in terms of either “the knower” or “the known”. According to realism, when we regard knowledge or wisdom from “the known” point of view, some characteristics can be enumerated of which these two are more important: Discovery and correspondence to reality.

The characteristic of discovery implies that knowledge stands for “something”. Based on this view, we can speak of knowledge only when “something” becomes known. Regarding this characteristic we can say: in knowledge, not only an independent reality is being recognized for the known but also the possibility of exploring or receiving this reality is presupposed.

The characteristic of correspondence to reality stems from the first characteristic namely discovery. According to realism, correspondence to reality acts as a criterion for truthfulness of claims. On this basis, knowledge is obtained when it is in accordance with reality.

On the other hand, when we consider the characteristics of knowledge regarding “the knower”, other aspects of knowledge emerge that are related to the "constructive" part of "constructive realism". Two basic elements of this part are: 1) knowledge is innovative 2) knowledge is related to human needs. The first implies that the knower creates knowledge. In other words, scientists try to capture the known by means of their creativities. Also, the relation between knowledge and human needs shows the role of the knower and his interference in the process of knowledge because this leads the knower to treat knowledge selectively so that he or she can solve his problems *as a human being*.

According to some epistemological viewpoints, there is a strict confrontation between realistic and constructive characteristics of knowledge. However, constructive realism tries to overcome this confrontation. According to constructive realism, the two sides of the supposed confrontation can be termed as naïve realism and naïve constructivism. Constructive realism, as I understand it, avoids the both sides of confrontation in the following way. In avoiding the naïve realism, it is held that the realities of things are complicated and, at least partly, hidden from human beings. Thus, the reality cannot be

grasped once and for all. For reaching this complicated and hidden reality, the knower has to create different conceptual schemes till one of them can be shown to have correspondence to reality. The discovery and invention of knowledge are closely intermingled here. On the other hand, in avoiding the naïve constructivism, it is necessary to hold that our constructs are 'of' something. Otherwise, illusion and knowledge will be on a par. Even though our needs and language are constitutive in our constructs, this does not necessarily turns our constructs into pure creations of our own without any relation to the reality of things.

In a nutshell, when knowledge is considered from the perspective of the known, discovery obtains but when it comes to the knowledge from the knower's point of view, knowledge turns to be inventive and manufactured. Constructive realism, in this version, is an attempt to make these two viewpoints compatible. The constructive realism by distancing itself from naïve realism and naïve constructivism exposes its complicatedness and depth. In what follows, I will argue for this version of constructive realism against naïve realism and constructivism respectively and then I will give the implications of constructive realism in science education.

Constructive Realism and Naïve realism

Naïve realism is simplistic for two reasons. First, it considers reality very simple without complication and claims that it can easily concur reality. In other words, the hard-to-explore layers of reality are not considered in naïve realism. Second, disregarding constant activity of mind and its endeavor to trap the reality, naïve realism takes cognition in relation to reality to be simple and passive. In this way, the mind is regarded as a reflective mirror that simply reflects the reality and its cognition is nothing but passivity.

The result of this extreme simplicity is a twin: being gullible and dogmatic about facts that one achieves. In terms of gullibility, once his cognition of reality has been backed by his theoretical and practical evidence, naïve realist soon assumes that he has known reality once and for all. Dogma towards his cognition and rejecting any other account of the reality is the other twin that a naïve realist has on his hands.

Constructive realism distances itself from the simplistic view of naïve realism and the results coming from it. According to constructive realism, neither is reality one-layered, nor the knowing of this reality



passive. As far as the reality is concerned, the constructive realist holds that reality is labyrinth and complicated as well as gigantic. It is gigantic because the human being is like a fly in a bottle striving to know the reality that overwhelms it. On the other hand, as far as the mind is concerned, it is and should be active as it has to develop very many constructs and try them one after the other to make sure that one of them is capable to capture this gigantic reality although we can never be sure about knowing the reality.

By distancing itself from simplicity, constructive realism distances itself from both dogma and gullibility. Putting gullibility aside, we have to always be ready to accept that what we have known as reality may be illusory or false. One of the results of reality being complicated and labyrinth is that it is not necessarily and easily sensitive to our mistakes and this can lead us to think of our illusions as knowledge. The error-tolerance of nature that Nicholas Rescher (1987) refers to this point. This tolerance that nature or reality shows towards our errors can lead us to shape a picture from the reality as we find some evidence for it, while our picture might be wrong altogether.

The error-tolerance of nature can have different reasons. One reason is related to scales. For example, in the case of flat earth theory, because the surface we deal with in house building is extremely small in comparison to the surface of the earth, our error is negligible and we can successfully make houses. Although this theory was wrong, it led to complete practical success. We can show the formula of this mistake as $(0=100)$ in which '0' stands for our construct of the earth as being flat and '100' for the reality of the earth being curve. Our practical success in house building leads us to hold our wrong theory as true. However, success is not by itself enough for truthfulness of our constructs.

Another reason for error-tolerance of nature is what might be termed as upside-down-ness of our constructs. For example, in the geo-centric theory, our construct was wrong because of its being upside down, and thus correct results came out of it and the prediction of solar and lunar eclipses were precise. We can show the formula of this error as $(001=100)$ in which the upside-down-ness of our constructs in comparison to reality resulted in our success, as if they correspond to reality. It is possible that other forms of error that the nature tolerates

exist. These kinds of theories include wrong constructs that human beings have attributed them to reality for a long time. Paying attention to the error-tolerance of nature prevents us from reaching conclusions about finality of our constructs and that we have to always be conscious about the possibility of their erroneousness.

Constructive realism prevents us from dogma, the other bitter result of simple mindedness. Parallel to the tolerance Rescher has spoken of and in order to expand it, I suggest another kind of tolerance to which I refer as 'difference tolerance'. By this I mean that different and various constructs can be tolerated by the nature as far as they remain in the threshold of flexibility of reality. In other words, even if we represent some parts or aspects of reality in our constructs without paying attention to all aspects, we will gain from truth and its credits as much as we have dealt with reality. Based on this idea, different constructs despite the differences and varieties they might have, can have a proportionate truth. Paying attention to this type of tolerance prevents us from dogmatic thoughts to the effect that only one construct is true. In such cases, different types of constructs instead of rejection should accept each other and look for a more complete truth by means of providing a suitable combination (even though not accumulation) out of rival constructs.

An example of difference-tolerance of reality can be seen in the case of cognitive and behavioral theories in psychology. A behaviorist tries to find all psychological aspects of humans in their behavior, whereas a cognitive psychologist looks for them in people's cognitions. Proponents of each theory find ample evidence for what they claim because each has focused on a proportion of reality and is true to that extent. Dogmas prevail only when behaviorists claim that humans are *nothing but* their behavior or cognitive psychologists say they are *nothing but* their cognitions. This kind of error that takes a part or representation of reality as the whole reality can be shown in a formula as $(60=100; 40=100)$ where 60 and 40 stand for two sets of constructs and their proportional truths. It is noticeable that while each of the two theories has a proportional truth, their combination can bring about a higher correspondence to reality.



Constructive Realism and Naïve Constructivism

So far I have dealt with the difference between constructive realism and naïve realism. Now it is time to consider differences between constructive realism and naïve constructivism. In the latter, mind and its constructs are focused on at the price of denying the ability to achieve reality itself. In other words, what is called human experience is thought to be captivated in human mind and language patterns, and since human beings cannot get out of their mind and language patterns, the constructivist concludes that representing reality is not possible or it does not make sense at all.

Rorty (1999, XXVI), for instance, says:

We describe giraffes as we do, as giraffes, because of our needs and interests. We speak a language which includes the word ‘giraffe’ because it suits our purposes to do so. The same goes for words like ‘organ’, ‘cell,’ ‘atom’ and so on—the names of the parts of things out of which giraffes are made so to speak. All the descriptions we give of things are suited to our purposes. . . . The line between a giraffe and the surrounding air is clear enough if you are a human being interested in hunting for meat. If you are a language-using ant or amoeba, or a space voyager describing us from above, that line is not so clear, and it is not so clear that you would need or have a word for ‘giraffe’ in your language.

This is why constructivists do not care about “truth” in epistemological debates and appeal instead to viability of human constructs and their role in coping.

One can see efforts to replace ‘viability’ with ‘truth’ in Von Glasersfeld’s writings. As a radical constructivist, Von Glasersfeld defines knowledge as follows: “Conceptual structures that epistemic agents, given the range of present experience within their tradition of thought and language, consider *viable*.” (Von Glasersfeld 1989, p. 124) He tries to replace the concept ‘truth’ with ‘viable’: if it turns out that a prediction was true, a constructivist can only say that the knowledge that the prediction was based on it, has shown that in circumstances related to the issue, has been viable. He also states that Piaget has stressed on viability and has replaced truth with it in his own constructivism. The following is Von Glasersfeld’s (1993, p. 26) interpretation of Piaget:

All that we really know is that we have had, or are having, a perceptual, or as Piaget would say, a sensory-motor experience To conclude that, because we have a perceptual experience which we call “chair”, there must be a chair in the “real” world is to commit the realist fallacy. We have no way of knowing what is or could be beyond our experiential interface. If we can reliably repeat the chair experience, we can only conclude that, under the particular circumstances, it is a viable construct.

Other constructivists are univocal with Von Glasersfeld on that patterns of mind and language form our knowledge. On this issue, Confrey states:

Put into simple terms, constructivism can be described as essentially a theory about the limits of human knowledge, a belief that all knowledge is necessarily a product of our own cognitive acts. We can have no direct or unmediated knowledge of any objective reality. We construct our understanding through our experiences, and the character of our experience is influenced profoundly by our cognitive lens. (Confrey, 1990, p. 108)

In fact, clinging to the idea that reality is not knowable to us as it is, constructivists and all the other opponents of realism have stressed on the role of patterns of mind and language in knowledge. Kitcher (1994) has called the standpoint of the opponents of reality ‘The Inaccessibility of Reality Argument’. He states: ‘The IRA is a terrorist weapon which anti-realists employ with enormous confidence’ (Kitcher 1994, p. 122). The full confidence that has been spoken of here is because that the role of patterns of mind and language in human knowledge and cognition is undeniable. And these patterns of mind and language bridge the human to reality.

Notwithstanding we have to see whether constructivists have reached right conclusions. There is no doubt that this wide disregard that constructivists have for reality, as well as truth, is rooted in naïve realism’s mistake that reality is easily knowable. Because many of the cognitions that were assumed to be true turned out to be false, constructivists turned their backs to reality and truth altogether and embraced mind and language’s constructs and spoke of their maximum practicality in solving problems. The claim that human knowledge is directly attached to reality is not acceptable but constructivists, in



reaction, have gone too far in denying knowledge of reality even in its indirect form.

Even though, we have to accept that our mind and language have a role in our knowledge but it is not enough to conclude that our mind and language are the only elements decisive in our knowledge, and reality has no share in our mental inventions. Some constructivists like Desautels and Larochelle (1990) insist on this absolute role of mind. They hold that knowledge has been invented to give meaning to our observations which are full of theories. According to them, there is no such thing as big book of nature that one can consult and then claim the correspondence of theories to reality.

The constructivist's claim that knowledge is merely invention is not tenable. By clinging to inevitable conceptual constructs in the field of human knowledge, the constructivist claims that knowledge is merely invention. However, this argument is not convincing. An example can be helpful here. If someone has visual impairment and can see only 30% of what others see, definitely he can't see as well as others do but he can see with 30% of visual competence. Even though he can't capture the whole picture of what he observes, we should not say that he merely creates some pictures and constructs in his own mind with no relevance to the complete pictures that normal people see or, for that matter, with no relevance to the reality itself. He can see what others can but with less precision and with some flaws. On the other hand, so far as the reality is concerned, he can see everything even though only with 30% accuracy. The point that he can see everything with a certain and fixed impairment indicates that a certain degree of objectivity is involved in his observation. There are significant questions to be asked here: Why does he not see things with different percentages of precision, each time with a particular percentage? Why does he see at all instead of having illusions? What is the difference between seeing and illusion? The fact that he sees instead of having illusions and that he sees with a fixed impairment indicate that an objectivity is involved in his seeing in which both his visual apparatus and the reality have their particular proportions in providing objectivity.

Constructive Realism

Having considered difficulties of both naïve realism and naïve constructivism, we are prepared to conclude that constructive realism is a sophisticated view. Our concluding remarks are as follow:

First, contrary to naïve realism, having a particular visual apparatus and conceptual capacity, human beings cannot claim that they have direct access to the reality. In other words, they cannot take God's eye view.

Second, the impairment involved in human mental apparatus is applied systematically to everything in the process of human knowledge. On the one hand, contrary to naïve realism, this indicates that we do not have an exact and full objective knowledge. On the other hand, contrary to naïve constructivism, this point indicates that a partial objectivity is or can be involved in human knowledge because of the systematic and fixed procedure involved in human perception and knowledge. Even a systematic illusion has some indication about objectivity and, thus, the difference between a systematic and unsystematic illusion should be sought in the relevance to reality and objectivity. Thus, one cannot say that human beings are trapped in their constructs without any degree of objectivity.

Third, when the possibility of cognition even though with impairment is accepted, a different path from what constructivists hold should be taken. According to constructive realism, as we can have a partial objectivity in our knowledge, we can and should speak of partial correspondence to reality in that knowledge. Thus, we cannot put truth aside altogether or reduce it to viability.

Fourth, Constructivists should also take note that their option of 'viability' relies ultimately on reality. Without presupposing reality one cannot speak of viability either. Viability does not necessarily imply correspondence to reality because under some conditions, such as error-tolerance of nature, our errors are allowed to be viable. But the point is that our errors are viable so far as they rest in the domain of error-tolerance of nature, that is, in the end, viability depends on reality. If our constructs don't take reality into consideration one way or another and stay out of the threshold of error-tolerance and difference-tolerance of reality, then they will not be viable either.



Implications

Constructive realism has important implications for science education. I am going to address two implications here; one in relation to the reality component of constructive realism and the other in relation to the constructive component.

First, there must be a constant caution for making sure that our scientific theories have caught the proportion of reality-contact expected from a scientific theory. This point shows the difference between constructive realism and pure constructivism. Accordingly, pupils should be encouraged to be careful and sensitive about what is going on around them. This sensitivity to reality can be brought into science teaching by emphasizing on 1) observation; 2) evidence; and 3) results. These are three strands that make it possible for pupils to have contacts with reality. They should make good observations, look for evidence in relation to their hypotheses, and be sensitive about the results of applying the hypotheses.

Let me explain the first case, namely observation, a bit further. As far as observation is concerned, pupils should be encouraged to be good observers. Observation is one strand of relation to reality. Observation is not limited to consequent observation derived from holding a hypothesis or theory; rather it includes antecedent observation as well. By antecedent observation I mean a more or less free observation; a kind of being sensitive about what is going on around us. Even though the so-called "theory-ladenness of facts" indicates that a free observation is not possible, one should not be excessive in negating the possibility of a more or less free observation. History of science shows that not only scientists sometimes engaged in simple gathering of facts but also that these facts played a significant role in the subsequent theories. Robert Hooke, for instance, for the first time reported observations that he made under his newly invented microscope in 1665. He reported observations of the cellular structure of fly's eyes, pointing end of a nail, and microscopic organisms in water. What is clear is that Hooke did not make these observations based on a theory but merely for curiosity. Hooke also gathered some information about weather changes to understand the difference of seasons. Unlike what Hooke intended, his gathered information is used now for considering

the global warming (Nola & Irzik, 2005, p. 209). Thus, Sensitivity to observation should be emphasized in our science teaching.

Second, as for the constructive component, we should encourage our students to develop imaginative alternative constructs when they are learning sciences. This shows the difference between constructive realism and naïve realism in which the importance of students' imaginations in suggesting alternative constructs is ignored. Notwithstanding, while we encourage the students to develop their imaginative constructs, there should be considered a limitation for their over-justification about their constructs. In this way, we as teachers should urge them to take counter-evidence most seriously into account. This is a point in which constructive realists are distinguished from pragmatists such as Rorty who has taken a radical constructivist position. Pragmatists do not give up their theories in confrontation with counter-evidence but rather look for almost limitless changes in their constructs in order for making the counter-evidence compatible with their theories, whereas constructive realists will be ready to take counter-evidence more serious and correct their constructs accordingly. While pragmatists will be satisfied by providing coherence along with workability for their theories, advocates of the constructive realism will be cautious because they do see coherence and workability as necessary but not sufficient conditions for total acceptance of theories. It is true that in the real fact the difference between constructive realists and pragmatists in this regard is hard to see but the alertness in the former to face counter-evidence makes sense.

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