Constructive Numeracy Teaching as a Gateway to Independent Learning

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Abstract

There is a new wave going on in the Dutch Adult Education, similar to the ideas of Open Learning Centers in Further Education in Great Britain. The intention of this movement is to structure adult education in a way that it fits everyone. That means: more flexible programs, focusing on more individual education, more teacher independent and with grading by certificates at different levels. People must be able to study in their own way, time and pace. The basic idea of the new system is 'Independent Learning'.

Some starting points of Constructivism can be a base for independent learning. In that way we may wonder how Constructivism and Realistic Mathematics Education can be a gateway to independent learning in adult education. If we are able to develop a numeracy program for Adult (Basic) Education, based on the learning principles of Constructivism and RME, then the students can be trained in learning to work more independently at the same time.

1. Developments in Adult Education in the Netherlands

Hot topic in the Dutch adult education nowadays is 'independent learning'.
The whole education system has been changing into a way of teaching and learning in which adult students can do courses in a more individual and effective way: choosing own study programs and studying in their own time and pace. Organizing programs which offer such possibilities to students, asks lots of energy from teachers as well from students.

Students are supposed to be able to study in an effective and independent way and the teachers' role will be changed into a more guiding and tutoring task.
Both, the adult student and the teacher, are not yet used to this.

Many experiments in this area have been tried out up to now, especially on training study skills. There has been developed lots of programs on training study skills and effective instruction, focusing on learning and teaching in small groups. But research in the past has showed that only training of study skills as a skill in its own does not result into

qualitative long term study skills (Simons, P.R.J., 1993). Training students' study skills exists of changing attitudes and changing a way of thinking and working and this asks time.
Either only training the students' study skills is not sufficient, it is also necessary to change the teacher's way of instruction. This means that the teacher has to be trained in effective teaching and guiding skills and by this the students will be trained in changing their study attitudes as well. However in this presentation we will focus on the students' study skills in relation to math skills. This will be done by bridging social norms and socio-math norms, both as part of the constructivism theory, with Realistic Mathematics Education (RME).

2. Constructivism and Realistic Mathematics Education

Constructivism is a learning theory in which the way of acquiring knowledge has been discussing in general. Basic assumption in constructivism is that everyone creates his own knowledge. It is a process of continuous self-organization in which every person reorganizes his own knowledge and skills at any time.

The learner links knowledge he already has acquired with new knowledge that is offered to him or that he encounters. Everyone goes through this process in his own way and pace and everybody will only remember that knowledge that has become relevant to him. But there is an ongoing theoretical discussion about differences and similarities between individual and socio-cultural constructivism. (Cobb, 1994a, 1994b, Gravemeijer, 1996)
In short we can say about this that in the individual stream learning is assumed to be a process that everybody goes through in an individual way and pace and in the socio-cultural theory however the essence of learning is communication with other people. People construct joint knowledge in society as a whole or in small groups like classroom communities and this is the base of individual knowledge as well. However the question is which way the most authentic way of learning might be, either the individual or the social way. (Cobb, 1994b). Many discussions about this issue are going on nowadays, also linked with the Russion action theory and the Piaget theory. (Bereiter, 1994, Cobb, 1994b, Gravemeijer, 1996)

Within the socio-cultural stream 'socio-math norms' has been discussing nowadays (Gravemeijer, 1996). With this agreement is meant among students in the classroom community for about the quality of solution procedures as for math problems and about the essence of what exactly might be the insight into the solved math problem and this could probably be the base of cooperative learning.

Basic assumption in RME is that math is an essential part of society. Math education is derived from real life situations and math knowledge and skills must be directly applicable in real life situations (Treffers 1987, 1991, Gravemeijer 1994). In daily life people always communicate with each other. They learn from and teach to each other, mostly in an informal (constructive) way. Therefore communication, interaction and reflection is a very important part of RME. Math tasks, based on real life contexts, must be described in such a way that students will need each other to solve them. These discussions may lead to creative solving procedures. Students need to work cooperatively and constructively.

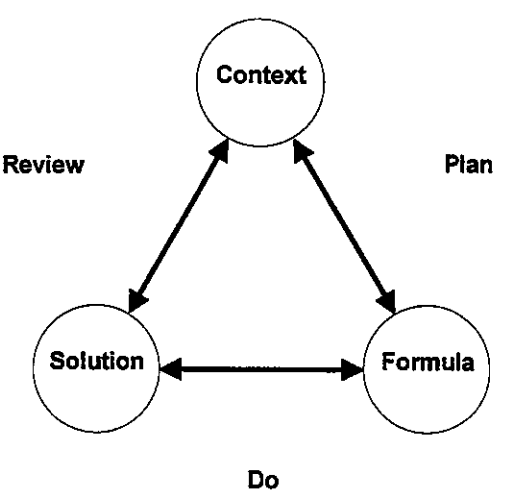
The teacher's tasks exists of stimulating and guiding these procedures and keeping watch on the quality of the solutions. (Bereiter, 1994, Driver, c.s. 1994)
In this way socio-cultural constructivism, socio-math norms and RME go hand in hand.

3. An Integrative Representation Model

The basic procedures in Realistic Mathematics Education can be described in six steps:

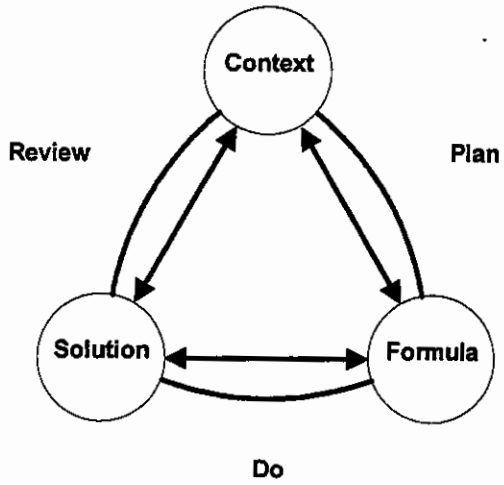
1. There is functional, real life math problem to be solved
2. Students have to analyse the problem and to plan a procedure to solve the problem jointly
3. They come to agreement about the formulas they will use
4. They do the computations
5. There will be a solution
6. The students reflect on this solution and the followed procedure and will take conclusions from this for the future.

These six steps can be shown in the next picture:



Picture 1: Basic scheme RME

The same steps can be used as a pattern for socio-math norms but then the quality of the three procedural steps plan, do and review will be stressed. Most problems can be solved in different ways and it depends on the insight of the students which way will be followed and which will ascertain the quality of the solution procedure. In this way a second triangle can be drawn in which the quality of actions can be showed. The quality of performance of the computations regarding the problem can be mentioned as cognitive skills.
The discussions about what skills could be used and which to choose are part of meta-cognitive skills.



Picture 2: RME and Socio-Math Norms

In a third triangle the socio-cultural norms are showed. These skills are required to be able to do cooperative problem solving. These meta-cognitive skills also regard the planning, doing and reviewing of activities in general and will be the base of studying independently.

For this the following, among other things, could be mentioned:

Skills for being able to plan activities, f.e.:

- reading and understanding the problem or
  helping each other to understand the problem
- looking for lacking information
- linking with pre-knowledge
- asking questions to other students if something might be unclear
- analyzing information
- systematizing information
- thinking about a creative solution procedure
- agreement about the solving procedure that will be followed
- agreement about the formulas which will be used

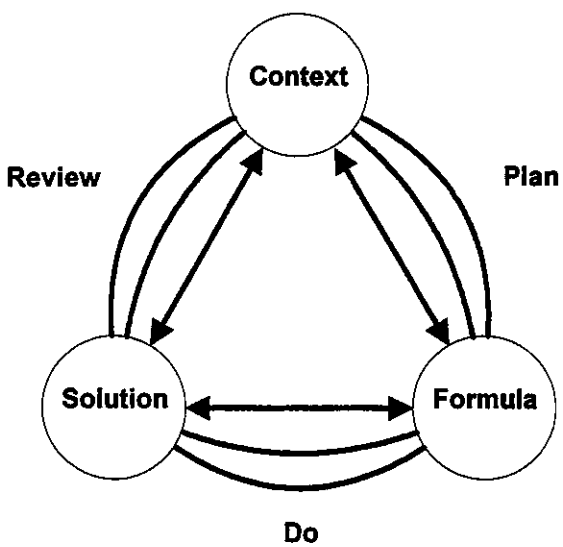
Skills for being able to do the computations, f.e.:

- Students must be able to do basic computations like addition, subtraction, division and multiplication, mostly in combination with doing measure, percents and/or fractions and in a flexible way.
- Quality of the computation may depend on experience with suchlike problems, insight and on the extent of practising such computations.
- Students need to know what kind of help they need if they get problems during the

solving procedure and how and whom to ask for help
- Being able to change into an alternative way when it appears to be necessary
- Watching the process of doing

Skills for being able to review the followed procedure, f.e.:

- checking the answer
- checking and discussing the way of problem solving and perhaps alternative ways
- accepting corrections from others
- describing encountered problems
- agreement about the quality of the used procedures and computations.
- agreement about the quality of the result
- reviewing the total learning process



Picture 3: RME, Socio-Math Norms and Socio-Cultural Norms

4. Independent Learning in Adult Basic Education

The third circle could be restricted to math education but could also be broadened into study skills in general and these are exactly the skills adults need to be able to study cooperatively and independently.
Students in adult basic education are mainly people who are used to managing their own family in real life, used to working situations and they mostly take part in different kinds of social activities. However in school situations they often present themselves as completely dependent on teachers' decisions and activities and these might depend on each given teacher. From former school years they often remember that working together was forbidden. Students got to do most of the activities in school on their own.They also had to do their tasks without an own critical view on targets, discussions about procedures

and review on their own results. The teacher graded papers and tasks and there was no comment required from the students. The teacher was the expert.
Both, teachers and students in adult basic education will have to get used to the new situation. For teachers this will mean instead of teaching big classes more working with and asking questions to small groups of students, guiding and tutoring. In addition to this they must have well organized instruction materials and learning environments. (van den Brink, 1991). This all is not unknown to teachers but changing their own role from a teacher into a tutor could be very radical and in ABE this may be double difficult because ABE-students with little or no school-experiences don't have good study skills.
In daily life teaching to and learning from each other mainly exist of showing, imitating and giving the right answer instead of giving hints. Students in ABE need to learn how to study in general, how to work together and how to study independently and cooperatively. (Resnick, 1987)
A second problem might be that many ABE students don't master the Dutch language. Therefore they mostly show each other the computations including the answers and there is little discussion about problem solving strategies. Training these kinds of activities asks lots of energy from the teacher. The teacher needs to focus continuously on three aims: the students' study skills and their math skills and this in combination with his own teaching and guiding skills.

In adult education many programs have been developing nowadays with the aim to improve study skills in general. These programs mainly focus on meta-cognitive skills similar to the ones mentioned in the third triangle and they are often offered separately from any content or with some contents from different areas as an example. Training these necessary study kills in ABE should be started in a more natural way in combination with real contents like math in RME. (Resnick, 1987) When creating learning situations in the way of RME and Constructivism as described above, students will learn to study more independently in a natural, more authentic way. This means that math education for ABE students should start with real life contexts, should allow them to solve problems in their own manner and train that knowledge and those skills which can directly be transfered into real life situations.
If this all would be instructed in the way as described above, study skills could be trained at the same time without creating artificial learning situations and discussing these study skills as a bare activity. Actually this way of learning is part of our socio-cultural communication.

5. Summary

Constructivism is a learning theory, not an instruction theory. It does not give directives for writing curricula or instruction materials. It only advises a good learning environment. RME is an instruction theory. When starting with RME in ABE together with learning principles for socio-math norms and socio-cultural norms as part of constructivism, skills needed for independent and cooperative learning can be trained at the same time and in a more natural and spontaneous way.
The whole topic has been summerized in the review on the next page.

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	RME	Socio Constructivism	
		Socio-Math Norms	Socio-Cultural Norms / Independent Learning
1	context		
2	plan	Discuss different possible ways to solve the problem and choose the most effective one.	- read the instruction - ascertain the object of the task - read the problem - analyse the problem - systematize information - mathematize information - get extra information about the subject if necessary - what procedures will be used - how to work together
3	formula		
4	do	Try to find the most effective way of doing the computations and perhaps try a few ways to look for the best one.	- divide sub-tasks - controle the ongoing process - recognize and note encountered problems - ask for help and give help - take activities from other students into account
5	solution		
6	review	Discuss the computations and decide jointly what could be the best one. Reflection on what each of the students has learned by solving this problem together. This last step may result into new individual knowledge and skills.	- review ways of comparing different solutions and solution strategies - discuss the encountered problems - review the way of working together - review the totall learning process in general.

References

Bereiter, Carl (1994): 'Constructivism, Socioculturalism and Science Education'.
In: *'Educational Researcher'*, Vol. 23, number 7, October 1994 (21-23)

Brink, Jan van den. (1991). Didactic Constructivism.
in: Glasersfeld, E. von (ed). (1992) *Radical Constructivism in Mathematics Education, p.195-229.*
Dordrecht, Kluwer Academic Publishers.

Cobb, P. (1994a): Constructivism in Mathematics and Science Education.
In: *'Educational Researcher'*, Vol. 23, number 7, October 1994 (4)

Cobb, Paul (1994b). Where is the mind? Constructivist and Sociocultural Perspectives on Mathematical Development.
In: *'Educational Researcher'*, Vol. 23, number 7, October 1994 (4) (13-20)

Driver, Rosalinde, Hilary Asoko, John Leach, Eduardo Mortimer, Philip Scott (1994): 'Constructing Scientific Knowledge in the Classroom'
In: *'Educational Researcher'*, Vol. 23, number 7, October 1994 (5-12)

Gravemeijer, K.P.E. (1994). *Developing Realistic Mathematics Education.* (Dissertation)
Utrecht, University Utrecht, Freudenthal Institute

Gravemeijer, K. (1996). Het belang van social norms en socio-math norms voor realistisch reken-wiskundeonderwijs. [The importance of social norms and socio-math norms for Realistic Mathematics Education]
Tijdschrift voor nascholing en onderzoek van het reken-wiskundeonderwijs, Panama-Post. 14 (2), 17-24. Utrecht: Hogeschool van Utrecht, Freudenthal Institute.

Resnick, L.B. (1987). Learning in school and out.
In: *Educational Researcher,* 16, 13-20

Simons, P.R.J. (1993). Constructive learning: the role of the learner. In: T. Duffy, J. Lowyck & D.H. Jonassen (eds.), *Designing environments for constructiv learning.*
Berlin, Springer

Treffers, A. (1987). *Three Dimensions, a Model of Goal and Theory Description in Mathematics Instruction.*
Dordrecht, Kluwer

Treffers, A. (1991). Realistic mathematics education in The Netherlands 1980-1990.
In: Streefland, L.: *Realistic Mathematics Education in Primary School.* On the occasion of the opening of the Freudenthal Institute.
Utrecht, Freudenthal Institute