Remember fast, act skillfully

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8 General discussion

Summary of findings
This thesis investigates methods designed to increase retention of CPR and AED skills and to speed up retrieval of this knowledge. It is important to train as many people as possible in delivering CPR and using an AED, and as effectively and efficiently as possible. The studies carried out are based on the assumption that future learning environments will be subject to fewer restrictions of time, place, and method, and that less sophisticated teaching materials will be needed. Poster-based, video-based, and web-based training are promising alternatives for improving retrieval, but additional studies are needed to assess whether these alternatives have been developed well enough to be equal or superior to instructor-led training in terms of skill retention.

Relating the findings to the conceptual framework of this thesis
The process of learning new skills is reproduced in figure 2 of Chapter 2 (p. 19). Errors that can occur during acquisition are: people receive incorrect information or they store the information incorrectly; during retrieval: recall takes too much time or irrelevant information is retrieved; during transfer: people hesitate or deliver inadequate help.
In Chapter 2 three didactical elements were discussed: adult education, educational evolution, and retention and retrieval. In addition to these elements, there are two educational theories which are of relevance to the context of this thesis. These are cognitive theory and constructivism theory. Cognitive theory is based on the concept that people learn from concrete observation (i.e. watching a demonstration) with the intention of remembering, and is based on individual experience.[1-4] Other learners have no influence on the learning result of the individual learner, which is built through personal experience and individual mental processes. The amount of knowledge and the speed of learning are influenced by the capacity of the working memory of each individual learner.[5,6] Cognitive theory identifies three phases: the cognitive phase, the associative phase, and the autonomous phase.[7,8] Skill knowledge for resuscitation develops across these three phases.
Constructivism theory is based on the idea that people learn from their experience in a social environment.[9-13] It is then up to the learner to decide whether the information gleaned from such an experience is worth storing in memory for subsequent retrieval (accommodation) or is of no

use and need not be stored. Once an experience has been stored for a specific situation, the knowledge generated can also be applied to another situation (assimilation). In this theory, learning takes place as a result of an experience, which could be deliberate or by coincidence. Teaching or training means that experiences are planned to help the learner learn new information with the help of other learners and of the instructor.
The main differences between these theories are set out in Table 1, from which it would appear that alternative training methods are more or less based on the principles of constructivism.
However, the principles of cognitive learning theory also have a role to play in resuscitation training, in that this approach focuses on the automation of skill knowledge after a conscious learning phase, which enables the learner to act very efficiently and effectively in a life-threatening situation. The test results of the post-test and retention test of the study described in Chapter 3, suggests that a ceiling effect has occurred in the learners who followed the instructor-based training. This might be due the cognitive load as presumed in the cognitive learning theory.

The studies in this thesis are based on actual insight into educational research, and are intended to improve education with the objective of increasing retention and faster retrieval of CPR and AED skills. The links between the results of the studies and the three elements of education as described in Chapter 2 (adult education; educational evolution; retention and retrieval of learning results) will be discussed in the following subsections (see also Table 2).

Adult education

As described in Chapter 2, adult education focuses directly on application in the daily life of the learner, who is motivated by a professional or personal need for development. Police officers (in Chapter 4), nurses (in Chapter 5), and lifeguards (in Chapter 6) followed CPR and AED training for their professional needs. They belong to the group of lay-people with a duty to respond, mostly in cases where they have been dispatched to a location to deal with a life-threatening situation. Despite their professional situation, they can be categorized as lay people when it comes to CPR and AED skills. In Chapters 3 and 7, participants who followed the CPR and AED training did so on the basis of personal motivation and all participated voluntarily. They were entirely responsible for their own learning; there was no sanction or other consequence for participants who failed to attain an acceptable level of competence.

	Cognitive theory[1] Constructivism theory[1]	Instructor-led training	Poster training	DVD-training	Web based training
Instruction-responsibility	Instructor	✓			
	Coach/mentor				
Facilitator competencies	Didactical	✓			
	Domain expert		✓	✓	✓
Learning	Individual	✓		✓	✓
	Collaborative learning[2]	±	±		
Learning objectives	By the Resuscitation Council	✓	✓	✓	✓
	By the learners		±	±	±
Subject matter of teaching	Based on the ideas of cognitive load[3]	✓			
	Based on learners personal needs[4]		✓	✓	✓
Instruction strategy	Systematic, elaboration	✓		✓	✓
	Working in small groups	✓	±		
Assessment	Continuous assessment and formal assessment. Feedback is important	✓			
	Self and peer assessment as part of the total learning process		✓	✓	✓

[1] The items relating to cognitive theory are on a white background. The items relating to constructivism theory on a grey background.
[2] Collaborative learning in constructivism theory differs from working together in class, in that collaborative learning does not involve an instructor. Learners construct their own knowledge by asking each other questions.
[3] Cognitive load means that there is a limit to the amount of knowledge that can be stored.
[4] The personal needs influenced the amount of knowledge that is collected and stored.

✓ = Study clearly reflects this item

± = Study reflects this item to some extent

Table 1.

Main differences between cognitive theory and constructivism theory applied to the training methods used in this thesis.

The studies in this thesis are based on actual insight into educational research, and are intended to improve education with the objective of increasing retention and faster retrieval of CPR and AED skills. The links between the results of the studies and the three elements of education as described in Chapter 2 (adult education; educational evolution; retention and retrieval of learning results) will be discussed in the following subsections (see also Table 2).

Adult education

As described in Chapter 2, adult education focuses directly on application in the daily life of the learner, who is motivated by a professional or personal need for development. Police officers (in Chapter 4), nurses (in Chapter 5), and lifeguards (in Chapter 6) followed CPR and AED training for their professional needs. They belong to the group of lay-people with a duty to respond, mostly in cases where they have been dispatched to a location to deal with a life-threatening situation. Despite their professional situation, they can be categorized as lay people when it comes to CPR and AED skills. In Chapters 3 and 7, participants who followed the CPR and AED training did so on the basis of personal motivation and all participated voluntarily. They were entirely responsible for their own learning; there was no sanction or other consequence for participants who failed to attain an acceptable level of competence.

The studies in Chapters 5 and 6 compared one type of self training with instructor-led training. Chapter 3 compared three different types of self training with instructor-led training. Of these four training methods, two used either no manikin or only a simplified training manikin, and DVD instruction without scenario. Two other training methods used scenarios to help students transfer their learning experience to a real-life situation. One method did make use of a simplified and inexpensive training manikin. We found that training with a scenario resulted in a better learning effect than without a scenario, and that training given by an instructor was the most effective. We also found that a test is a powerful learning tool. (Table 2)

Our conclusion confirms a recent study that found that testing as part of resuscitation training improved learning outcome compared with spending an equal amount of time practising the skills.[14] This effect may last for 6 months.[15]

An essential aspect of adult learning is the application of skill knowledge to daily life. It is important that skill knowledge is transferred to the memory in such a way that people can immediately recognize a life-threatening situation such as a cardiac arrest, and immediately remember what to do. Recognizing a cardiac arrest cannot be achieved by simply repeating

the same skill again and again (near transfer), because the real-life context differs from the learning situation. The learner needs 'far transfer', as the transfer setting is dissimilar from the learning setting.[16-18] It has been established that almost 50% of cardiac arrests are not detected by bystanders.[19] In Chapter 4, we found that successful training correlates well with successful performance in the field, but that it does not guarantee successful performance. In 79% of the police teams, successful completion of the course was associated with good performance during a resuscitation attempt, but of the nine teams categorized as "incompetent" in training, three performed well during a real-life resuscitation attempt.
Another relevant observation with regard to real-life application (in Chapter 3) is that older providers took longer to respond in the simulated situation, and some of them did not use the AED at all.
An undesirable delay in life-saving help was also found when teams of police officers did not use the AED adequately (Chapter 4). It might be useful to place greater emphasis on following the CPR/AED algorithm smoothly and quickly in all training methods, and to carry out additional research into the reasons why people hesitate to use or ignore the presence of an AED.
The self-training designs in this thesis are all based on the principles of adult learning. If there is no intrinsic motive for studying the poster, the DVD or the web-based programme, it is less likely that an acceptable level of CPR/AED skills will be reached.[24-27] Additional studies are needed to find solutions for a good balance between self training and instructor assessment or additional skill training. The results of this thesis do not therefore apply to people who are not willing to accept their own responsibility in learning CPR and AED skills, for instance because they are not motivated or they are afraid to administer BLS.

Educational evolution

Until now, instructor-led training has been the standard method of teaching CPR and AED skills.[28] Most resuscitation training is delivered according to the transfer model: an instructor delivers the training in a classroom, using manual and graphic presentation during a lecture and a manikin for demonstration and practice (Chapter 2). In Chapters 5 and 6, we found that the instructor is not crucial in achieving a good result. This notable conclusion was also found recently in a study of computer-based versus instructor-led training in ultrasound for emergency medicine.[29] There are several arguments which call the role of the BLS instructor into question. One is that no quality control by experts takes place in the classroom.

Study	DVD training (Chapter 3)	Real-life events (Chapter 4)	Initial training with poster for nurses (Chapter 5)	Refresher training with poster for lifeguards (Chapter 6)	Web-based training (Chapter 7)
Delay before starting	+	+			
Test-effect possible	+			+	
Scenario gives better learning effect than no scenario	+				
Instructor-led training appears superior	+		-	-	
Instructor not crucial to good result	-		+	+	+

+ = analyses confirm this conclusion

- = analyses do not confirm this conclusion

AED: Automated External Defibrillator

RIB: Rigid Inflatable Boat

Table 2.

Overview of the conclusions of the studies in this thesis.

Many instructors have a tendency to deviate from the standard guidelines for teaching resuscitation, often giving additional background information that is not included in the standard course, and not giving students enough opportunity for hands-on practice.[30,31] However, the conclusions of the above-mentioned studies should be handled with care, as the additional analysis shown in Table 3 provides a different view of the results, and demonstrates that instructor-led training is still superior to alternative training methods.

Our studies strongly suggest that alternative training methods, corresponding with the ideas of the independent learning model and the interactive learning model, have the potential to match the results of the instructor-led training method. The evolution towards the independent learning model and interactive learning model will mean that the instructor will have to become acquainted with a different role, shifting from the role of teacher to the role of facilitator. (Figure 1)

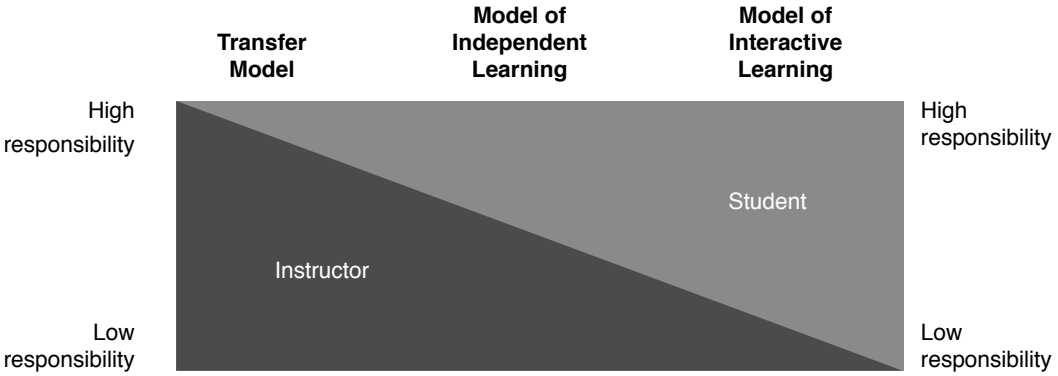

Figure 1.
Learning responsibility.

The effects of the independent learning model and the interactive learning model are partly related to social interaction between learners. The concept of the powerful influence of social interaction was introduced by the influential educational psychologist Vygotsky, and several other educational scientists, such as Bandura and Lewin.[1,32,33] This has been demonstrated repeatedly in school education,[34-36] also in veterinary, medical and nursing education.[37-39] Learners can help each other by asking questions and explaining concepts in a collaborative learning process.[40,41] This could be the reason why ward nurses and lifeguards learned effectively using only a training poster, a training set with a manikin, and an AED training device (Chapter 5 and 6). Many of the students practised in pairs, and as they discussed between themselves the content of the poster, they worked together according to the interactive learning model.
All learners practised the skills themselves, except those who followed the video-only method (Chapter 3) and those who followed the web-based

training (Chapter 7). Almost all learners who followed the web-based training were subsequently capable of administering CPR and using an AED. This is most likely because they were able to construct their own knowledge in their own way and expand on it with the help of the web-based programme.[42-45] The results of Chapter 3 indicate that learners should not only copy the skills from an instructor, video, poster, etc. (transfer model), but should practise these skills, preferably in scenario-based training with a variety of recognizable simulations in order to be able to apply them in real-life contexts (independent learning model).[46,47] This corresponds with the previous described ideas of the constructivism theory about learners constructing their own knowledge.

Retention and retrieval of learning results

One of the objectives of this thesis was to examine whether alternative training methods could improve retention and retrieval. Our studies showed that poster-based, video-based and web-based training are promising alternatives which improve retrieval, but that additional studies are needed to assess whether the alternatives have been well enough developed to be equal or superior to instructor-led training in terms of skill retention. Any such studies should include the elements of educational science.
It is also important to take the period for retention testing in consideration. Traditionally, the period to a retention test is set at 6 months in studies about CPR or AED use. But if the time interval between initial training and retention test is too long, knowledge to accomplish the skill will be strongly reduced. Recognizable differences in knowledge to accomplish the skill are found between one and three months.[48-51]

Neuroscience

The studies in this thesis focus on cognitive and social-personality psychology. Educational science is based on cognitive psychology, social-personality psychology, and neuroscience. (Figure 2)
Neuroscientific aspects have not been included in this thesis, yet, these aspects are very promising in terms of gaining a better understanding of study retention and retrieval. The concept of “mirror-neurons” equips us with a particularly interesting angle on how to train laypersons in lifesaving skills. Mirror neurons are neurons which fire when someone acts, but also when someone observes the same action performed by another person. In other words, the neuron “mirrors” the behaviour of another person, as though the observer was performing the action himself. In humans, brain activity consistent with mirror neurons has been found in the premotor cortex and the inferior parietal cortex.[52,53]

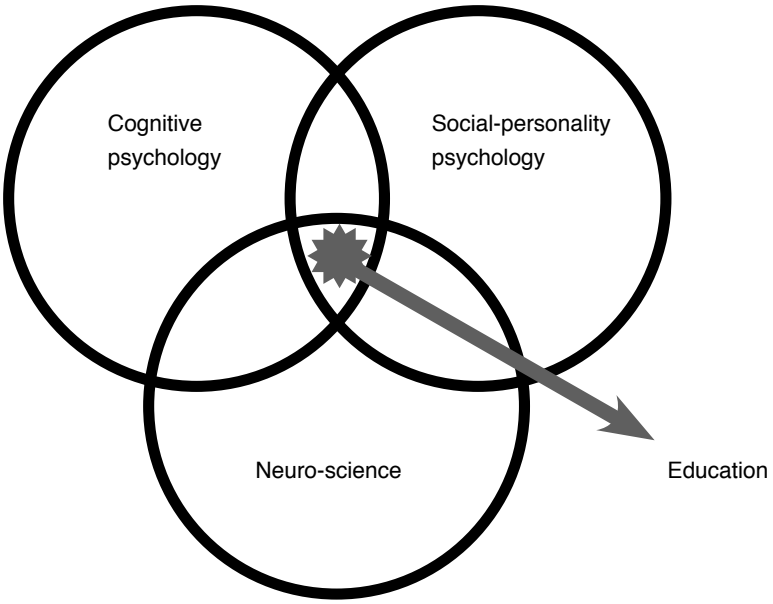

Figure 2.
Educational science is based on cognitive psychology, social-personality psychology, and neuroscience.

These neurons may be important in understanding the actions of other people and in learning new skills by imitation.
When an individual watches others performing an action, the mirror neurons build neuron networks that are exactly the same as the networks that would be built if the individual were performing the action himself. This might be compared to what is known in cognitive psychology as mental rehearsal: the learner's ability repeatedly to visualize a task in his mind, before actually attempting to perform it.
The existence of mirror neurons may serve as a hypothetical, neuroscientific explanation of why video-scenario training (Chapter 3), poster-based training (Chapter 5 and 6), and web-based training (Chapter 7) deliver good results, and why training in small groups enables students to learn from watching the performance of other students.
While the discovery of "mirror-neurons"[54,55] provides a speculative explanation of how simple training methods such as video-scenario training (Chapter 3), poster-based training (Chapters 5 and 6), and web-based training (Chapter 7) have proved to be effective, it is clear that their role in CPR and AED training needs further study.

Limitations

Three studies in this thesis compared two or more different training methods: the DVD training method in Chapter 3, the initial poster training method in Chapter 5, and the refresher poster training method in Chapter 6. The two poster studies were assessed using conventional superiority analyses such as Kruskal-Wallis and Mann-Whitney tests. No clinically relevant differences between training methods were found.

The scale of the AMC Comp test (see Appendix) was validated during a not-published study by researchers of the Academic Medical Centre Amsterdam, we focused only on the reliability. As we found high inter reliability scores during our study of Chapter 4 we used this evaluation sheet till the publication of the validated Cardiff list.[56]

It is likely that superiority could not be detected due to insufficient sample size and power (type 2 or β error), but the lack of superiority does not mean presence of non-inferiority.

To examine this possibility, an additional non-inferiority design analysis was carried out. (Table 3) In both poster studies, a score list with a 7-point VAS scale per item was used. The 'Statistics' section of Chapter 5 (p. 57), and the 'Assessment' section of Chapter 6 (p. 67/68) contain descriptions of how competence per item was analysed. For this non-inferiority analysis, a relative risk margin of less than 0.2 was assumed for non-inferiority, as this was the accepted margin in the study described in Chapter 3. Thus, the lower bound of the two-sided 95% confidence interval for the relative risk of passing the test using a poster-based training method compared to the instructor-led method had to exceed 0.8.[57]

As can be seen in Table 3, none of the alternative methods had a lower bound of 0.8 or above. Non-inferiority could therefore not be established. However, all 95% confidence intervals included '1', which means that the observations of the study are still compatible with all three possibilities: inferiority, equality, or superiority. In retrospect, we conclude that the sample size of these studies was insufficient to make a conclusive judgment of the three possibilities.

	Initial training with poster	Refresher training; retention test after 6 months	Refresher training; retention test after 12 months
	(Chapter 5)	(Chapter 6)	(Chapter 6)
Relative risk of passing compared to instructor-led training	0.33	1.02	1.24
95% CI	0.06 – 1.96	0.44 – 1.41	0.62 – 2.50
Non-inferiority testing	H_0 of inferiority not rejected	H_0 of inferiority not rejected	H_0 of inferiority not rejected

Table 3.
Non-inferiority analysis.

Towards evidence-based CPR and AED training

The instructional design for quality training should be evidence-based to the greatest possible extent. Remarkably little educational research has been published on the quality of CPR and AED training. Clinical papers vastly exceed educational papers in number. It is unclear whether this is due to a lack of interest or a lack of appreciation in education. Not all educational research is high quality.[53] Many educational studies lack adequate statistical elements such as effect sizes, confidence intervals, and reliability and validity coefficients.[58]

In health care research, randomized controlled trials with effect measurement blinded to the intervention are considered to provide the highest level of evidence.[59] However, in CPR and AED education-related research, randomized controlled studies are difficult to perform, as many factors which might influence learning and retention are unquantifiable or uncontrollable and there is no single standardized method of measuring performance.[60] The performance of practical skills is particularly difficult to measure. In addition, the heterogeneity of courses and of their participants makes comparison between different studies difficult and statistical analysis defective. Randomization of individuals is difficult, as instructors train groups of students.[61] The student, as a study object, cannot be blinded for the intervention as he has to follow BLS /AED training according to the study design, and this is bound to influence his attitude and possibly interfere with the outcome of the assessment. Instructors and researchers too are not

blinded for the intervention in most studies.[58]
The social sciences, and more specifically educational research, recognize that it is not always possible or necessary to have randomized control studies. The limitations on performing adequate statistical analysis are also widely acknowledged. Educational research is mostly qualitative in nature, as it is influenced by the setting in which it occurs: 'the context of discovery', comparable with observational research in the medical domain. For the context of discovery, case reports and cohort studies can be effective. Most of the time, such research explores attitudes, behaviour, and experiences. Qualitative methods only produce information on the particular cases studied, and any more general conclusions are only hypotheses.
There is a difference between the 'context of discovery', and the 'context of justification', comparable with interventional research in the medical design.[59,62,63] For studies in the context of justification, a null hypothesis (H_0) has to be tested. For this kind of quantitative research, randomized controlled trials generally represent the most effective method. Quantitative research generates statistics which form the basis for accepting or rejecting H_0. Quantitative methods can be used to verify hypotheses formulated on the basis of the conclusions arrived at using qualitative methods.[64-66]
Chapters 4 and 7 describe observational research, as in the 'context of discovery', where variables cannot be, or are deliberately not, controlled by the researchers. The studies described in Chapters 3, 5, and 6 can be placed in the 'context of justification'. These are controlled studies.

Research design and data analysis in CPR and AED educational research
In medical research, superiority can be tested by comparing a new treatment with a standard treatment or with a placebo treatment.[67] For this type of quantitative research, H_0 has to be tested with the aim of accepting or rejecting it. If H_0 states that method A is better than method B (A > B), this calls for an experiment with sufficient power to demonstrate this superiority. The superiority of method A is accepted when the "null hypothesis" is accepted with a level of certainty that is generally taken to be 97.5%, corresponding to a two-sided P value of 0.05.
If the hypothesis (H_0) states that method A is equal to method B (A = B), we need to show by means of an appropriate experimental design that the effect of a new intervention is not worse than that of an accepted intervention by more than a specified margin. This is called a non-inferiority design.[68]
In studies where training methods are compared, the hypothesis might be that method A and method B are equal. So we need a non-inferiority design, intended to show that the effect of a new training method (e.g. e-learning) is not worse than that of a control (e.g. instructor-led training) by more than a specified margin.[64] The new method of training may be desirable due to such factors as cost, duration, or simplicity.[69]

Implications of the results

The results of the re-analysis of the data from Chapters 5 and 6 with a non-inferiority analysis as performed in this chapter, (Table 3) and the results in Chapter 3, demonstrate that instructor-led training remains the most favourable training method to date.

The studies presented in this thesis are all focused on the effect of a range of interventions (DVD training with and without scenario, poster-based training, and web-based training). Most of them compare the effects of one or more of these interventions with the effects of a standard intervention (instructor-led training as recommended by the European Resuscitation Council.[70])

These studies confirm that the current method of instructor-led training is, indeed, a good approach to take when teaching people life-saving techniques (see Chapters 3 and 4). But the results of the studies presented in Chapters 5, 6 and 7 show that it is not significantly better than other methods. The results of the different studies make it clear that additional studies of how and why we use certain training methods are necessary in order to optimize the quality of the training. Considering the immense life-saving potential of laypersons being able to perform CPR and AED, learning CPR and AED skills should be part of normal life,[71] people should be trained when they are at secondary school as part of the standard curriculum, at work, at sports and hobby clubs and in day-to-day settings. Modern personal training manikins and training AEDs provide such opportunities.

It is not likely that manikins and instructors will disappear from CPR and AED training in the near future. The essence of such training is that learners receive enough hands-on practice and simple instruction without distracting background information, and that they are able to learn and practise at their own pace.

It should be taken in consideration that there might be a difference between CPR and AED skills. It is known that the psycho-motor skills of CPR are complex,[20,21] and it can be speculated that the use of an AED is less complex, as the AED prompts rescuers what to do. In most studies it was found that even after six, seven or twelve months rescuers still attach the electrodes in an acceptable area. But it is also found that a delay in delivering a shock occurs.[22,23]

The studies in this thesis have made clear that more research in CPR and AED education is needed to design optimal training methods. Based on the results of the studies it can be speculated that BLS courses should at least consist of a demonstration, hands-on practice and scenario training. It seems that there are many options in which teacher, student and educational material have different, but always interactive roles. Also the end points

for quality may differ and could include quantity (how to train the largest number), quality (how to achieve optimal training results), efficacy (a combination of quality and quantity) and retrieval in real life situations.

Future research topics

Although our initial studies suggested that the alternative methods resulted in equal quality of training compared to the instructor-led training, the study featured in Chapter 3 showed that instructor-based training can still be considered the standard. This opens up a wide field of research in relation to CPR and AED education. As a consequence of our studies, the following topics are worthy of exploration:

- To find out why people
  - are hesitant to start CPR and use an AED;
  - ignore the presence of an AED;
  - are not motivated to learn CPR and AED skills;
  - are afraid to administer BLS (and to find out how address this fear).
- To find solutions to achieving a good balance between self training and instructor assessment or additional skill training.
- To determine how attitude and behaviour can be taught.
- To answer the questions:
  - How can self-learning designs be applied in relation to a student who lacks motivation?
  - To which reduction can self learning lead for the instructor led training?
  - How can CPR training courses be taught in such a way that the learner is given the opportunity to interact with other learners about how to provide life-saving help?
  - Is there a difference in collaborative learning when students have different levels of prior knowledge (peer vs. tutor)?
  - Can CPR and AED courses be more simply constructed as a cost-cutting measure?
  - Can CPR and AED courses be more simply constructed as a way of saving time?
  - Do CPR and AED instructors require domain knowledge (knowledge of physiology, anatomy of breathing and circulation, no understanding of the scientific background to the current resuscitation guidelines)?

References

1. Bandura A. Social foundations of thought and action: A social cognitive theory. Englewood Cliffs- New Jersey, Prentice Hall 1986.
2. Dillon RF. Issues in Cognitive Psychology and Instruction. In Dillon R, Sternberg R (Eds.), Cognition and Instruction. Orlando, Academic Press 1986. Pp 1-12.
3. Slavin RE. Educational Psychology: Theory into practice. Boston, Allyn and Bacon 1994.
4. Schunk DH. Learning Theories - an educational perspective. Upper Saddle River, Pearson-Merrill Prentice Hall 2004.
5. Sweller J. Cognitive load theory, learning difficulty and instructional design. Learning and Instruction 1994;4:295-312.
6. Sweller J, Chandler P. Why some material is difficult to learn. Cognition and Instruction 1994;12:185-233.
7. Fitts PM, Posner MI. Human performance. Belmont: Brooks Cole 1967
8. Anderson JR. The architecture of cognition. Cambridge, MA: Harvard University Press 1983.
9. Bruner J. The Process of Education. Cambridge, Harvard University Press 1960.
10. Kolb D. Experiential Learning. New Jersey: Prentice Hall 1984.
11. Duffy T, Lowijck J, Jonassen D, Welsh T. Designing environments for constructive learning. Berlin, Springer Verlag 1991.
12. Grabinger S. Rich environments for active learning: In Jonassen D (Ed.). Handbook of research for educational communications and technology. London, Prentice Hall 1996. Pp.665-692.
13. Murphy E. Constructivism: From Philosophy to Practice. Canada, Elizabeth Murphy. (Accessed 14 March 2010, at http://www.ucs.mun.ca/~emurphy/stemnet/cle.html)
14. Kromann CB, Jensen ML, Ringsted C. The effect of testing on skills learning. Med Educ 2009;43:21-7.
15. Kromann CB, Bohnstedt C, Jensen ML, Ringsted C. The testing effect on skills learning might last 6 months. Adv Health Sci Educ Theory Pract. 2009 [Epub ahead of print, DOI 10.1007/s10459-009-9207-x].
16. Haskell RE. Transfer of Learning. Cognition, Instruction, and Reasoning. San Diego: Academic Press 2001.
17. Barnett SM, Ceci SJ. When and where do we apply what we learn? A taxonomy for far transfer. Psychological Bulletin 2002;128:612-37.
18. Barnard JK. The effects of a near versus far transfer of training approach on trainees' confidence to coach related and unrelated tasks. Doctoral dissertation, Ohio State University, 2005.
19. Brekwoldt J, Schloesser S, Arntz HR. Perceptions of collapse and assessment of cardiac arrest by bystanders of out-of-hosptial cardiac arrest (OOHCA). Resuscitation 2009;80:1108-13.
20. Flint LS, Billi JE, Kelly K, Mandel L, Newell L, Stapleton ER. Education in adult basic life support training programs. Ann Emerg Med 1993;22:468–74.

21. Assar D, Chamberlain D, Colquhoun M, Donnelly P, Handley AJ, Leaves S, Kern KB, Mayor S. A rationale for staged teaching of basic life support. Resuscitation 1998;39:137-43.
22. Woollard M, Whitfield R, Smith A, et al. Skill acquisition and retention in automated external defibrillator (AED) use and CPR by lay responders: a prospective study. Resuscitation 2004;60:17–28.
23. Woollard M, Whitfield R, Smith A, et al. Optimal refresher training intervals for AED and CPR skills: A randomised controlled trial. Resuscitation 2006;71:237–47.
24. McCombs B L, Whisler JS. The role of affective variables in autonomous learning. Educational Psychologist 1989;24: 277-306.
25. Cameron J, Pierce WD. Reinforcement, reward, and intrinsic motivation. A meta-analysis. Review of Educational Research 1994;64: 363-423.
26. Ryan RM, Deci EL. Self-determination theory and the facilitation of intrinsic motivation, social development, and well-being. American Psychologist 2000;55: 68-78.
27. Deci EL, Koestner R, Ryan RM. Extrinsic rewards and intrinsic motivation reconsidered once again. Review of Educational Research 2001;71:1-51.
28. Robert Sebastian Hoke RS, Handley AJ. A reference basic life support provider course for Europe. Resuscitation 2006;69:413-9.
29. Platz E, Liteplo A, Hurwitz S, Hwang J. Are life instructors replaceable? Computer vs. classroom lectures for EFAST training. J Emerg Med. 2009 [Epub ahead of print, DOI 10.1016/j.jemermed.2009.08.030].
30. Parnell MM, Larsen PD. Poor quality teaching in lay person CPR courses, Resuscitation 2007;73:271-8.
31. Hoke RS, Chamberlain DA, Handley AJ. A reference automated external defibrillator provider course for Europe. Resuscitation 2006;69:421-33.
32. Vygotsky LS. Mind in society: The development of higher psychological processes (Cole M, John-Steiner V, Scribner S, Souberman E, Eds. and Trans.). Cambridge, Harvard University Press 1978:79-91.
33. Lewin K. Defining the “Field at a Given Time.” Psychological Review 1943;50:292-310
34. King, A. Facilitating elaborative learning through guided student generated questioning. Educational Psychologist 1992;27:111-26.
35. Van Boxtel C, Van der Linden J.L, Kanselaar G. Collaborative construction of conceptual understanding: interaction processes and learning outcomes emerging from a concept mapping and poster task. Journal of Interactive Learning Research 1997;8:341-61.
36. Kumpulainen K, Mutanen M. The situated dynamics of peer group interaction: an introduction to an analytic framework. Learning and Instruction 1999;9:449-73.
37. Thurman J, Volet SE, Bolton JR. Collaborative, case-based learning: how do students actually learn from each other? J Vet Med Educ. 2009;36:297-304.

38. Earl GL. Using cooperative learning for a drug information assignment. Am J Pharm Educ. 2009;73:132.
39. Chung EK, Rhee JA, Baik YH, A OS. The effect of team-based learning in medical ethics education. Med Teach. 2009;31:1013-7.
40. Riley KA, Stoll L. Leading communities: purpose, paradoxes and possibilities. London, Institute of Education 2005.
41. Johnson DW, Johnson RT. An educational psychology success story: Social interdependence theory and cooperative learning. Educational Researcher 2009;38:365-79.
42. Gagné, E., Yekovich, C. & Yekovich, F (1993). The cognitive psychology of school learning. New York: Harper Collins.
43. Reeves TC, Reeves PM. Effective Dimensions of Interactive Learning on the World Wide Web. In Khan B (Ed.), Web-Based Instruction, Englewood Cliffs N.J. : Educational Technology Publications, 1997 (pp. 59-66).
44. Kamel Boulos MN, Maramba I, Wheeler S. Wikis, blogs and podcasts: a new generation of Web-based tools for virtual collaborative clinical practice and education. BMC Medical Education 2006, 6:41 (Accessed 28 March 2010 at http://www.biomedcentral.com/content/pdf/1472-6920-6-41.pdf).
45. Trangenstein PA. Electronic toolkit for nursing education. Nurs Clin North Am. 2008;43:535-46.
46. Chamberlain DA, Hazinski MF; European Resuscitation Council; American Heart Association; Heart and Stroke Foundation of Canada; Australia and New Zealand Resuscitation Council; Resuscitation Council of Southern Africa; Consejo Latino-Americano de Resuscitación. Education in resuscitation. Resuscitation. 2003;59:11-43.
47. Perkins GD. Simulation in resuscitation training. Resuscitation 2007; 73: 202-11.
48. Spooner BB, Fallaha JF, Kocierz L, Smith CM, Smith SC, Perkins GD. An evaluation of objective feedback in basic life support (BLS) training. Resuscitation 2007;73:417-24.
49. Isbye DL, Meyhoff CS, Lippert FK, Rasmussen LS. Skill retention in adults and in children 3 months after basic life support training using a simple personal resuscitation manikin. Resuscitation 2007;74:296-302.
50. Isbye DL, Høiby P, Rasmussen MB, Jesper Sommer J, Lippert FK, Ringsted C, Rasmussen LS. Voice advisory manikin versus instructor facilitated training in cardiopulmonary resuscitation. Resuscitation 2008;79:73—81.
51. Nishiyama C, Iwami T, Kawamura T, Ando M, Yonemoto N, Hiraide A, Nonogi H. Effectiveness of simplified chest compression-only CPR training for the general public: A randomized controlled trial. Resuscitation 2008;79:90—6.
52. Iacoboni M, Woods RP, Brass M, Bekkering H, Mazziotta JC, Rizzolatti G. Cortical mechanisms of human imitation, Science 1999;286:2526–8.
53. Lindsay M. Oberman LM, Hubbard EM, McCleery JP, Altschuler EL, Ramachandran VS, Pineda. EEG evidence for mirror neuron dysfunction in autism spectrum disorders. Cognitive Brain Research 2005;24:190–8.

54. Di Pellegrino G, Fadiga L, Fogassi L, Gallese V, Rizzolatti G. Understanding motor events: a neurophysiological study, Exp Brain Res 1992;91:176–80.
55. Rizzolatti G, Fogassi L, Gallese V. Neurophysiological mechanisms underlying the understanding and imitation of action, Nat Rev Neurosci 2001:2:661–70.
56. Whitfield RH, Newcombe RG, Woollard M. Reliability of the Cardiff Test of basic life support and automated external defibrillation version 3.1. Resuscitation 2003;59:291—314.
57. Piaggio G, Elbourne DR, Altman DG, Pocock SJ, Evans SJW. Reporting of noninferiority and equivalence randomized trials: An extension of the CONSORT statement. JAMA 2006;295:1152-60.
58. Cochran-Smith M, Zeichner KM (Eds). Studying teacher education: The report of the AERA Panel on Research and Teacher Education. Mahwah, NJ, Lawrence Erlbaum 2005.
59. Sibbald B, Roland M. Understanding controlled trials. Why are randomised controlled trials important? BMJ 1998;316:201.
60. Lachin JM, Matts JP, Wei LJ. Randomization in clinical trials: conclusions and recommendations. Control Clin Trials 1988;9:365-74.
61. Bosker RJ. Naar meer evidence based onderwijs! [Towards more evidence-based education!] Pedagogische Studiën 2008;85:49-51.
62. Raudenbush SW. Learning from attempts to improve schooling: The contribution of methodological diversity. Educational Researcher 2005;34: 25-31.
63. Mann CJ. Observational research methods. Research design II: cohort, cross sectional, and case-control studies. Emerg Med J 2003;20:54-60.
64. Marshall C, Rossman G. Designing qualitative research. Newbury Park, CA, Sage 1980.
65. Merriam SB. Case study research in education: A qualitative approach. San Francisco, Jossey-Bass 1988.
66. Creswell JW. Research design: Qualitative & quantitative approaches. Thousand Oaks, CA, Sage Publications 1994.
67. D'Agostino RB Sr, Massaro JM, Sullivan LM. Non-inferiority trials: design concepts and issues - the encounters of academic consultants in statistics. Stat Med. 2003;22:169-86.
68. Laster LL, Johnson MF. Non-inferiority trials: the 'at least as good as' criterion. Stat Med. 2003;22:187-200.
69. Christensen E. Methodology of superiority vs. equivalence trials and non-inferiority trials. Journal of Hepatology 2007;46:947-54.
70. Baskett PJF, Nolan JP, Handley AJ, Soar J, Biarent D, Richmond S. European Resuscitation Council Guidelines for Resuscitation 2005; Section 9. Principles of training in resuscitation. Resuscitation (2005) 67S1, S181-9.
71. Waalewijn RA. Out-of-hospital circulatory arrest: factors determining the outcome; Amsterdam resuscitation study (Arrest) 2 and 3. Amsterdam, Internal publication 2002: Chapter 10.