Teaching Methods for Computer Science Education in the Context of Significant Learning Theories

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***Abstract*—Answers to the questions of which teaching methods are suitable for school and should be applied in teaching individual subjects and also how teaching methods support them act of learning represent challenges to general education and education in individual subjects. This study focuses on teaching methods for computer science education with respect to significant learning theories. Using an expert survey, subjects rated the importance of behavioristic, cognitivist and constructivist learning theories for 20 teaching methods. The result of the study makes it clear that the importance of learning theories for certain teaching methods in computer science education is different. Teaching methods can be assigned to learning theories and can benefit from the empirical findings of the learning theories. Moreover, the result is an important contribution to the development of a theory of teaching methods for computer science education, which is still lacking.**

***Index Terms*—Computer science education, instructional methods, teaching methods, theories of learning, act of learning.**

I. Introduction

Teaching methods play a key role in successful learning. Cognitive psychology [1], [2], neuroscience [3], [4], and more recently neurodidactics [5], [6] provide reasons for why learning with different teaching methods works better. Traditionally, learning theories provide recommendations that are the basis for the development of teaching methods. In this section we will first report on relevant findings of significant learning theories and then on teaching methods for computer science education before presenting the two-part question.

A. Significant Learning Theories

Many learning theories have been developed in the history of teaching and learning [7]-[9]. Early theories of learning date back to Plato (428-347 BC), who explains in his epistemology learning as remembrance (anamnesis, ἀνάμνησις) of ideas that the soul has seen before entering the body in a "supernatural" place and which she therefore remembers in the process of knowledge [10], [11]. Another early learning theorist is John Locke (1632-1704) – influential in behavioristic learning theory –, after whom man comes into the world as a "tabula rasa" (blank sheet). According to Locke, every behavior is learned through experience with the environment and not innate [12].

Today, three major learning theories are widely differentiated in the relevant literature on school psychology / educational psychology: Behavioristic, cognitivist and constructivist learning theory [13]-[15]. In the following, these three learning theories are described according to a uniform scheme, which goes back to [8], with additions by [15]. The scheme comprises eight criteria: Outcome of learning, demands on didactic design, principle of teaching, role of the teacher, role of the learner, role of the peers, control of the learning path, and control of the learning success.

Behavioristic learning theory. The core assumption of behavioristic learning theory (represented by Thorndike, Pavlov, Watson, Guthrie, Hull, Tolman, Skinner, et al.) is that learning is triggered by a stimulus-response chain. The result of learning are stimulus-response connections. The demand for the didactic design is the division of teaching content into small learning units. The principle of teaching is to present learning content. Teachers intervene centrally in the learning process. The learner's role is to passively receive knowledge and follow instructions without involving peers in the learning process. The learning path is determined by the teacher. The control of learning success takes place regularly after each learning step.

Cognitivist learning theory. The central thesis of the cognitivist learning theory (representatives: Koffka, Köhler, Lewin, Ausubel, Bruner, Gagné, etc.) states that learning takes place through the construction and reconstruction of cognitive structures. The learning result consists of generalizable knowledge and problem solving skills. Focus on the didactic design is the adaptation of learning material to learning prerequisites / progress. The principle of teaching consists in the transmission of learning content, supported by instructions. The role of teachers includes the didactic preparation of information for problems. The role of the learner is to actively process information, organize and reorganize information. Peers can be involved in the information processing process and then influence it. Depending on the learning progress, the learning path is controlled through external test by teachers and self-test by learners. The control of the learning success takes place regularly after meaningful learning units, integrated in learning tasks

Constructivist learning theory. The main idea of the constructivist theory of learning (representatives: Maturana, Varela, Piaget, Wygotski, Bandura, Salomon, etc.) states that learners create (construct) an individual representation of the world. The result of learning is contextualized knowledge applicable in situations. Demands on the didactic design is the integration of learning content in application contexts (situation). The principle of teaching is the *co*-construction of

Manuscript received March 12, 2019; revised May 17, 2019.
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knowledge with learners. The role of teachers is to coach learners' self-responsible and social learning processes. The role of learners involves actively co-constructing knowledge with others. Peers actively participate in the process of knowledge construction. The learning path is controlled by the learner through self-test in the context of self-effective learning. The control of learning success also takes place in the context of self-effective learning.

B. Teaching Methods

The wide range of teaching methods is almost incomprehensible. The *Center for Teaching and Learning* [16] cites 150 teaching methods, [17] more than 2,000 methods including their variations. Handbooks describing teaching methods are provided by authors such as [1], [14], [18], [19].

A useful definition of method which also represents the conceptual starting point for this study comes from Huber and Hader-Popp: “The word method is understood to mean a clearly defined, conceptually perceivable and independent, if also integrated, component of teaching.” [20, p. 3]

There is as yet no standard reference work for computer science education which extensively addresses the application of instructional methods for school. Nevertheless, the literature contains descriptions on the application of “solving problems” [21], “group work” [22], “rich tasks”, and “concept maps” [23].

Empirical findings on the effectiveness of learning are numerous. In his compilation of 800 meta-analyses into which more than 50,000 studies were included Hattie provides information on the influences on learning with respect to six domains: Contributions of the learner, the parental home, the school, the instructor, the curricula and teaching. In particular, the domain of teaching [24, chapters 9 and 10] provides information on the effectiveness of teaching methods/approaches. High effect sizes ($d > .50$) were demonstrated for microteaching ($d = .88$), reciprocal teaching ($d = .74$), feedback ($d = .73$), problem solving ($d = .61$), direct instruction ($d = .59$), mastery learning ($d = .58$), case study ($d = .57$), concept-mapping ($d = .57$), peer tutoring ($d = .55$), cooperative (vs. competitive) learning ($d = .54$) and interactive instructional videos ($d = .52$).

The search through journals and conference reports on computer science education (Journal of Educational Computing Research, Computer Science Education, ACM Transaction on Computing Education, Special Interest Group Computer Science Education Bulletin) provided findings related to computer science education in regard to constructivist teaching activities [25], the “eXtreme teaching” approach [2], holistic teaching and learning [23], the influence of instructional methods on the design of computer programs [26], the effect of games on motivation in teaching [27], the application of formal modeling [28], the effectiveness of two-person team programming [29] and the application of the experiment [30].

Recently, an empirical study on teaching methods in relation to knowledge processes during the learning process in computer science education is available [31]. The results show that certain teaching methods are especially useful for computer science education (problem-based learning, learning tasks, discovery learning, computer simulation, project methodology and direct instruction).

Although having some empirical findings on the learning effectiveness of teaching methods, there is no theory on teaching methods [32] that answer the questions 1) which teaching methods should be used in the classroom, 2) how teaching methods support the learning process, and 3) which teaching methods are suitable for which learning content.

C. Teaching Methods and Learning Theories

Teaching methods have mostly originated from the teaching practice, for example the experiment method, the Leittext method, jigsaw. On the other hand, there are (few) teaching methods that are clearly to be understood in response to learning-theoretical outcomes, such as programmed instruction in the context of behavioristic learning theory [10].

The following teaching methods explicitly address the importance of cognitivist learning theory: Concept-mapping [10], [15], jigsaw [10], problem-based learning [10], [15]. The importance of the constructivist learning theory is emphasized for the following teaching methods: Discovery learning [14], reciprocal teaching [14], problem-based learning [15], [14], [10], project method [10], learning tasks [15]. jigsaw [14]. For other important teaching methods, such as computer simulation, case study, models method, such assigments are not available, although these could also benefit from the findings of learning theories.

D. Research Questions

In regard that few reliable material is available for classifying teaching methods in the context of learning theories, two objectives are at the forefront of interest in a research project conducted at the University of Education Ludwigsburg at the Institute of Mathematics and Computer Science: 1) *Importance of learning theories for teaching methods in computer science education*: Which learning theories are significant for which teaching methods for computer science education? 2) *Recommendations of learning theories for teaching methods for computer science education*: Which recommendations for practical use in school lessons can be derived for teaching methods computer science education from the perspective of learning theories?

The following research hypothesis is linked to the two goals: "The importance of learning theories for teaching methods is different." The present study is structured as follows: Section II covers the scientific methods used with study design and procedures for data analysis. Section III gives a detailed description of the results. Section IV discusses the results and ends with conclusions.

II. Method

A. Study Design

Selection of teaching methods. After reviewing a series of handbooks on teaching methods [33]-[37], more than 50 teaching methods were available. The review was characterized by the fact that teaching methods had to withstand the test, that they could be understood as a clearly defined, conceptually extractable, independent component of the lesson.

The following two criteria were used for the final choice of the teaching methods for computer science education: 1) Use of teaching methods in STEM subjects (Science, Technology, Engineering, Mathematics), 2) empirically studied teaching methods. Based on these criteria, the following 20 teaching methods could be selected: Computer simulation, concept-mapping, direct instruction, discovery learning, experiment, case study, jigsaw, programmed instruction, Leittext method, learning tasks, learning by teaching, models method, role-play, portfolio method, problem-based learning, project method, presentation, reciprocal teaching, learning stations, and web quest.

The 20 teaching methods are described in detail in a booklet [38], which also show the historical roots of the methods.

Expert survey. The rating of teaching methods in the context of significant learning theories is a complex issue for which raters need extensive knowledge, both in teaching methods for computer science ducation and in the field of learning theories. In this study, therefore, an expert survey is conducted, which is indicated "when it is impossible to observe, measure, or experiment on the phenomenon in question using more direct methods." [39]

Experimental design. To test the research hypothesis, an RBF-3 × 20 design (Randomized Block Factorial design, 2-factorial design with repeated measures for factors *A* and *B*, see Fig. 1) is used [40].

Independent variables. Factor *A* includes the p = 3 learning theories a_1 (behavioristic), a_2 (cognitivist) and a_3 (constructivist: Factor *B* represents the q = 20 teaching methods b_1, ..., b_{20}: Computer simulation, concept-mapping, direct instruction, discovery learning, experiment, case study, jigsaw, programmed instruction, Leittext method, learning tasks, learning by teaching, models method, role-play, portfolio method, problem-based learning, project method, presentation, reciprocal teaching, learning stations, and web quest.

	b_1	b_2	b_3	…	b_{20}
a_1	s_1 s_2 s_3	s_1 s_2 s_3	s_1 s_2 s_3	…	s_1 s_2 s_3
a_2	s_1 s_2 s_3	s_1 s_2 s_3	s_1 s_2 s_3	…	s_1 s_2 s_3
a_3	s_1 s_2 s_3	s_1 s_2 s_3	s_1 s_2 s_3	…	s_1 s_2 s_3

***A* = Learning theory**
a_1 = behavioristic
a_2 = cognitvist
a_3 = constructivist

***B* = Teaching method**
b_1 = computer simulation … b_{20} = web quest

s_1 = expert #1
s_2 = expert #2
s_3 = expert #3

Fig. 1. Layout of the used RBF-20 ×3 experimental design.

Dependent variables. Dependent variable is the rating of the teaching methods regarding the three learning theories. Ratings are on a six-point scale from 0 ("no meaning") to 5 ("very important").

Operational test hypothesis. With respect to the experimental design, the independent and the dependent variables, the operational test hypothesis can be formulated as follows: "The importance of learning theories for teaching methods in computer science ducation differ operationalized by the ratings made on a six-point scale in the context of behavioristic, cognitivist and constructivist learning theories by lecturers of STEM subjects."

B. Procedure

Sample. For the expert survey, three lecturers s_1, s_2, s_3 from the University of Education Ludwigsburg in the state of Baden-Württemberg were recruited. They were asked to answer a questionnaire to rate the importance of the three major learning theories for the teaching methods in computer science ducation. The lecturers taught computer science and school psychology / educational psychology at the University of Education Ludwigsburg (Baden-Württemberg).

Questionnaire. The questionnaire consisted of a short introduction that listed the 20 teaching methods and the three learning theories (see Appendix A). For the questionnaire, the subjetcs were given a booklet ([40]; see Appendix B) in which the 20 teaching methods are described according to a uniform scheme, with a short description and an explanation, concrete execution steps, examples from the literature, which show the use of the teaching method. In addition, the subjects have been provided with a handout that describes the three learning theories according to a common schema (see Appendix C).

Task. The p = 3 learning theories and the q = 20 teaching methods were then presented in alphabetical order in a matrix, with the teaching methods in the rows and the learning theories in the columns. For each of the 3 × 20 = 60 matrix cells, the following statement had to be evaluated: "The importance of learning theory <abc> for the teaching method <xyz>." Ratings are on a six-point scale from 0 ("no meaning") to 5 (" very important ").

C. Procedure for Data Analysis

For the analysis of the data (see Appendix D), the following procedure is proposed: 1) First, the data are evaluated descriptively. 2) Then, an analysis of the inter-rater-reliability is calculated according to the RBF-3 × 20 design. 3) Finally, based on MDS (MultiDimensional Scaling), a territorial analysis is carried out to identify groups of teaching methods that are compatible with the learning theories. Analysis of the inter-rater-reliability was done by the “irr” package of R [35], the MDS was evaluated using IBM SPSS Statistics 25.0.

III. Results

A. Descriptive Findings

The *Shaded Scatterplots* shown in Figures 2 to 4 visualize the experts ´ratings (s_1, s_2, and s_3) of the 20 teaching methods regarding the three learning theories. The teaching methods are sorted according to the degree of agreement by the experts and to the importance of the learning theories.

1) Behavioristic learning theory

Fig. 2 shows that programmed instruction and direct instruction were uniformly rated high in the context of the behavioristic learning theory. Although other teaching methods (problem-based learning, discovery learning, experiment method, concept-mapping, learning by teaching, role-play, portfolio method, project method, computer simulation, presentation, learning tasks, learning stations) were rated relatively uniformly, they are in the context of behavioristic learning theory not very relevant. For the other teaching methods (models method, web quest, case study, jigsaw, reciprocal teaching, Leittext method) the experts disagree.

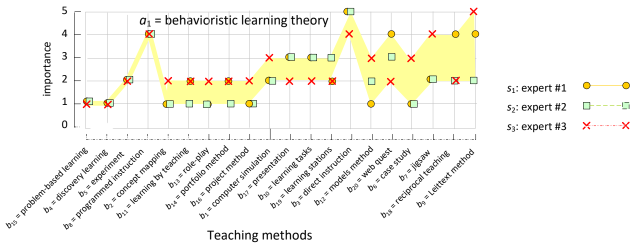

Fig. 2. Importance of the behavioristic learning theory for the teaching methods.

2) Cognitivist learning theory

Fig. 3 illustrates that the experiment method and presentation were rated high in the context of the cognitivist learning theory. Discovery learning, problem-based learning, and web quest have all been rated in the same way, but due to experts ´ratings they are not very important in the context of cognitivist learning theory. From a cognitivist point of view, the following teaching methods are considered more or less important: Concept mapping, jigsaw, role-play, and computer simulation. For the portfolio method, the models method, case study, reciprocal teaching, and the Leittext method expert # 2 rated theses teaching methods high in the context of the cognitivist learning theory, the other two experts # 1 and # 3 rated them rather low.

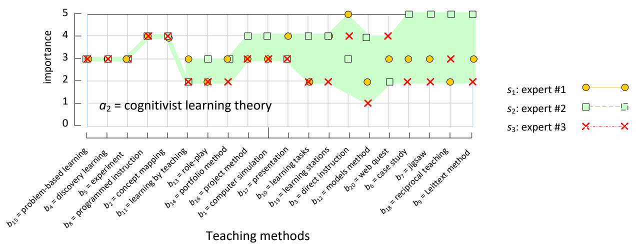

Fig. 3. Importance of the cognitivist learning theory for the teaching methods.

3) Constructivist learning theory

Fig. 4 makes it clear that discovery learning is the teaching method rated high by the experts in the context of the constructivist learning theory. The following methods have been rated high, but not quite consistent: Problem-based learning, role-play, project method, and computer simulation. Because of the low ratings of the experts, the following teaching methods do not fit the constructivist view: Direct instruction, Leittext method, and programmed instruction. For case study, web quest, and the models method, the experts disagree as to whether these methods are compatible with the constructivist point of view at all.

B. Analysis of Raters ´Agreement

To test whether the three experts agreed in rating the 20 teaching methods for computer science education regarding the three learning theories, three statistical hypotheses are formulated, which are tested at the significance level of α = .05 using *Fleiss ´Generalized Kappa* κ [41].

Statistical hypotheses. The hypotheses are:

1) the experts s_1, s_2, s_3 do not agree in rating the 20 teaching methods $b_1, b_2, \ldots, b_{20}$ in the context of the behavioristic learning theory (a_1):

$$H_0\colon \kappa = 0 \quad (H_1\colon \kappa \neq 0);$$

2) the experts s_1, s_2, s_3 do not agree in rating the 20 teaching methods $b_1, b_2, \ldots, b_{20}$ in the context of the cognitivist learning (a_2):

$$H_0\colon \kappa = 0 \quad (H_1\colon \kappa \neq 0);$$

3) the experts s_1, s_2, s_3 do not agree in rating the 20 teaching methods $b_1, b_2, \ldots, b_{20}$ in the context of the constructivist learning (a_3):

$$H_0\colon \kappa = 0 \quad (H_1\colon \kappa \neq 0).$$

Results. Table I contains the findings of inter-rater-reliability.

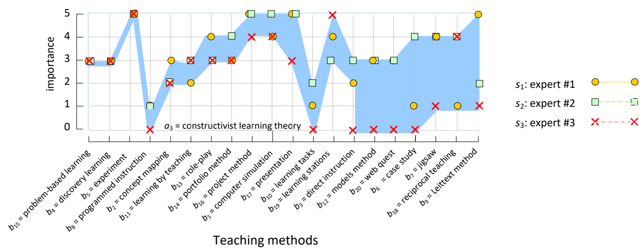

Fig. 4. Meaning of the constructivist learning theory for the teaching methods.

TABLE I: INTER-RATER-RELIABILITY USING FLEISS ´KAPPA K FOR 3 EXPERTS

Learning theories	N	k	z	p
behavioristic learning theory (a_1)	3	.194	2.72	.007
cognitivist learning theory (a_2)	3	.090	1.18	.239
constructivist learning theory (a_3)	3	.176	2.90	.004

The statistics κ to test whether the three experts agreed in rating the 20 teaching methods in the context of the behavioristic learning theory (a_1) is significant at the α-level of .05 ($z = 2.72$, $p < .007$), i.e. the corresponding H_0 is rejected in favor of H_1: The three experts agreed in rating the 20 teaching methods.

The statistics κ to test whether the three experts agreed in rating the 20 teaching methods in the context of the cognitivist learning theory (a_2) is not significant at the α-level of .05 ($z = 1.18$, $p < .239$), i.e. the corresponding H_0 is not rejected: The three experts disagreed in rating the 20 teaching methods.

The statistics κ to test whether the three experts agreed in rating the 20 teaching methods in the context of the constructivist learning theory (a_3) is significant at the α-level of .05 ($z = 2.90$, $p < .004$), i.e. the corresponding H_0 is rejected in favor of H_1: The three experts agreed in rating the 20 teaching methods.

C. Territorial Analysis

From the benchmark scale by Landis and Koch (see [41]) the strength of agreement (see the κ statistics in Table I) must be considered as slight. Thus, a more detail analysis is made by using territorial analysis.

As a data base for the territorial analysis, the alphabetically sorted 3 × 20 data matrix is used. It contains the three experts´ ratings of the teaching methods regarding the behavioristic, cognitivist and constructivist learning theories (see data in Appendix D).

For the territorial analysis two measures are used: First, the importance that the subjects have attached to the teaching methods in the context of a learning theory, and secondly the expert agreement, which is given by the standard error of the mean (shown in the value range [0, 1]). Fig. 5 illustrates the territories *as Shaded Quadrant Scatter Charts* with teaching methods in the context of the behavoristic, cognitivist, and constructivist learning theories.

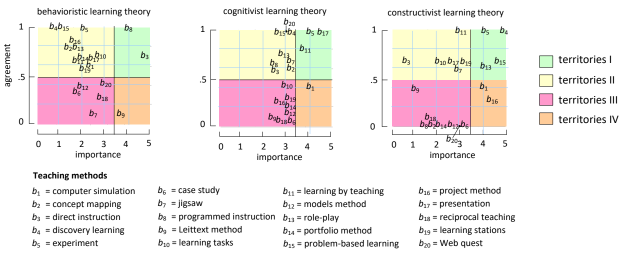

Fig. 5. Territories with teaching methods in the context of three learning theories

Territories I. These territories contain teaching methods which have been rated reliable and very significant for the learning theories. For the behavioristic learning theory: Direct instruction and programmed instruction. For the cognitivist learning theory: Experiment, learning by teaching, and presentation. For the constructivist learning theory: Discovery learning, experiment, role-play, and problem-based learning.

Territories II. These territories contain teaching methods that have been rated reliable but relatively insignificant for the learning theories. For the behavioristic learning theory: Computer simulation, concept-mapping, discovery learning, learning tasks, learning by teaching, role-play, portfolio method, problem-based learning, project method, learning stations. For the cognitivist learning theory: Concept-mapping, direct instruction, discovery learning, jigsaw, programmed instruction, role-play, problem-based learning, web quest. For the constructivist learning theory: Direct instruction, jigsaw, learning tasks, learning by teaching, presentation, and learning stations.

Territories III. These territories contain teaching methods that have been rated unreliable and relatively insignificant for the learning theories. For the behavioristic learning theory: Case study, programmed instruction, models method, reciprocal teaching, and web quest. For the cognitivist learning theory: Case study, Leittext method, learning tasks, models method, portfolio method, project method, reciprocal teaching and learning stations. For the constructivist learning theory: concept-mapping, case study, programmed instruction, Leittext method, portfolio method, and reciprocal teaching.

Territories IV. These territories contain teaching methods that some of the experts rated to be significant. Generally, they been rated unreliable. For the behavioristic learning theory this is the Leittext method, for the cognitivist learning theory this is computer simulation, and for the constructivist learning theory these are direct instruction and the project method.

IV. Conclusion

First of all, the results obtained support the research hypothesis formulated in the introduction, that learning theories differ in their importance for teaching methods in computer science education. This was shown by the expert ratings, especially for the behavioristic and constructivist learning theories.

The results make it clear that teaching methods for computer science education can be positioned in the context of specific learning theories: Direct instruction and programmed in the context of the behavioristic learning theory; the experiment, learning by teaching and presentation in the context of the cognitivist learning theory; discovery learning, the experiment, computer simulation, problem-based learning in the context of constructivist learning theory.

The results obtained confirm findings in the literature.

From the standpoint of the behavioristic learning theory, the results from the expert survey agree with those in the literature [13]. Programmed instruction is the method that can best benefit from the behavioristic learning theory.

The experiment method and the presentation are clearly assigned to the cognitivist perspective, but are rarely discussed in the literature in the context of this theory. The results on some other teaching methods (concept-mapping, jigsaw, problem-based learning) are compatible with the cognitivist perspective [14].

Teaching methods that are most clearly discussed in the literature [15] with respect to the constructivist view are discovery learning, jigsaw, reciprocal teaching, and the project method.

A. Recommendations

From the expert survey, it became clear that direct instruction and programmed instruction were given great importance in the context of the behavioristic learning theory. From a behavioristic perspective, the following additional recommendations can be used for these teaching methods in concrete lessons: Associations of learning tasks with positive events, adequate use of positive and negative amplifiers, use of models for desired behaviors [42].

The expert survey made it clear that the experiment method, learning by teaching, and presentation were very important in the context of the cognitivist learning theory. From the cognitivist point of view, the following recommendations can be made for these teaching methods: Ensuring learners' attention to the lesson, helping learners to link information with prior knowledge, organizing learning materials in a clear and organized manner [42].

The expert survey showed that the experiment method, role-play, problem-oriented learning were considered to be of great importance in the context of the constructivist learning theory. For the use of these teaching methods in concrete lessons, the following recommendations should be included: Emphasizing the value of stimulation and encouragement, promoting self-directed learning (self-motivation, learning techniques, self-test) [42].

B. Research Methodological Point of View

From a research methodological point of view, expert judgements have been used. It could be criticized that the number of three experts included in the study is too few to obtain meaningful results. This criticism can be countered that recourse to experts *a priori* reduces the variance over traditional sampling, especially in a complex task such as the rating of learning theories for teaching methods. However, the great advantage of expert judgments lies in their practicability: They are cost-effective and can be implemented quickly in research, even in complex tasks [43], [44].

C. Future Work

From the results, some important research lines can be deduced, which should be addressed in more extensive research projects. The results in this study showed that teaching methods for computer science education can be supplemented with recommendations from the literature on learning theories. To derive even more benefit from the learning theories, 1) new teaching methods for computer science education should be developed that consistently build on the findings of the learning theories, 2) new teaching methods for computer science education should be developed that address the learning processes discussed by the learning theories (e.g. knowledge construction, knowledge integration, knowledge transfer), and 3) evaluating new teaching methods for computer science education in concrete classroom settings. Important suggestions for these three research lines can be obtained from current findings in neurodidactics, such as intelligent practice, selective learning access, the importance of emotions for learning [2], [4], [39], [45], [46].

D. Theory Construction

In conclusion, the findings obtained represent an important contribution to construct a theory of teaching methods for computer science education, a system of (provisionally) empirically confirmed hypotheses on teaching methods. The starting point for this should be the results that the learning theories provide as *fundamental hypotheses*. Based on these, the empirical findings on teaching methods by [24] can then be used as *specific hypotheses*. These specific hypotheses can then be supplemented consecutively by *elementary hypotheses*, when confirmed by empirical comparisons of teaching methods in the context of computer science education (for theory construction, see [47]).

APPENDIX

A. Questionnaire

Please evaluate:

the importance of the learning theory for the instructional method

Please rate each cell on a scale of 0 to 5 (only whole numbers).

It is important that you provide 6 ratings per row.

not significant 0 1 2 3 4 5 *significant*

	Learning Theory (Explanations, *see* Handout) / **Teaching methods** (Explanations, *see* Booklet)	1. behavioristic	2. cognitivist	3. constructivist
1	Case study			
2	Computer simulation			
3	Concept mapping			
4	Direct instruction			
5	Discovery learning			
6	Experiment			
7	Jigsaw method			
8	Learning at stations			
9	Learning by teaching			
10	Learning tasks			
11	Leittext method			
12	Models method			
13	Portfolio method			
14	Presentation			
15	Problem-based learning			
16	Programmed instruction			
17	Project work			
18	Reciprocal teaching			
19	Role-play			
20	Web quest			

B. Booklet

The following example shows as an example the description of problem-based learning in the booklet [40]

15 Problem-based learning

Brief description. Problem-based learning is an instructional method enabling learners to acquire skills in the resolution of an exemplary problem; these skills can then be transferred to other applicable problem areas.

Social form: individual, group work
Duration: steps 1-5: 60´, step 6: several days, step 7: 45´
Media: a variety of media: (PC, various software)
Class stages: starting from Class 9

Execution. This instructional method consists of seven different steps: (1) *Confront.* The L. are confronted with a problem in a learning group. (2) *Posing questions.* The L. define what the problem is and formulate one to three questions. (3) *Problem analysis.* The L. generate individual explanations and hypotheses on the basis of their prior knowledge. (4) *Adjust hypotheses.* The hypotheses are adjusted within the learning group. (5) *Study questions.* The L. formulate open questions (study questions) within the learning group which must be answered in order to resolve the original problem. (6) *Acquire knowledge themselves.* The L. acquire information through self-study with which the study questions can be answered. (7) *Discuss and compare findings.* The findings on the study questions are discussed and adjusted within the learning group.

References. The L. acquire knowledge independently. The I. supervises the L. in an advisory capacity. Moust, Bouhuijs, and Schmidt (2007), Abell and Lederman (2007) as well as Brenner and Brenner (2011) wrote about this instructional method in relation to no specific educational subject.

Examples from the relevant literature. Problem-based learning as an instructional method which has been written about extensively by Rankin (1998).

Related concepts

none.

References

Rankin, J. R. (1998). *Handbook on problem-based learning*. New York: Wiley.

C. Handout for the Three Learning Theories

	behavioristic learning theory	**cognitivist learning theory**	**constructivist learning theory**
learning happens through ...	stimuli in the external world	construction and reconstruction of cognitive structures	(re-)construction of knowledge
result (s) of learning is / are	stimulus-response connections	generalizable knowledge (problem-solving skills)	contextualized, applicable in situations knowledge
demand for didactic design	distribution of teaching content into smaller learning units	adaptation presented learning material to learning requirements / progress	Integration of learning content in application contexts (situation)
principle of teaching	transmission, lectures	transmission plus instructions	co-construction of knowledge by learners
role of the teacher	intervenes centrally in the learning process	prepares information for problems didactically	coaches autonomous and social learning processes
role of the learner	passive acceptance of knowledge; Follow instructions	active processing of information, organization and reorganization of information	active co-construction of knowledge with others and oneself; active thinking, explaining and interpreting
control of peers	usually not included	not necessary, but may affect information processing	important; other learners actively participate in the process of knowledge construction
control of the learning path	external control by teachers	external and self-control depending on learning progress	self-control (in the context of self-effective learning)
control of learning success	regularly after each learning step	regularly after learning units, integrated into learning tasks	teachers share control with learners

D. Data

Learning theories	**Teaching methods**	b_1	b_2	b_3	b_4	b_5	b_6	b_7	b_8	b_9	b_{10}	b_{11}	b_{12}	b_{13}	b_{14}	b_{15}	b_{16}	b_{17}	b_{18}	b_{19}	b_{20}
behavioristic (a_1)	s_1	2	1	1	2	1	5	1	4	4	2	3	1	1	2	1	1	3	4	2	4
	s_2	2	1	1	2	1	5	4	4	2	1	3	2	1	1	1	1	3	2	3	3
	s_3	3	2	1	2	3	4	2	4	5	2	2	3	2	2	1	2	0	2	2	2
cognitivist (a_2)	s_1	5	3	3	4	2	3	3	2	2	4	3	3	4	3	3	2	4	3	4	3
	s_2	3	4	3	4	5	2	4	3	4	4	2	5	3	5	3	4	4	5	4	3
	s_3	4	3	3	4	3	2	3	2	1	3	4	2	3	2	3	2	0	2	2	3
constructivist (a_3)	s_1	4	3	5	4	4	1	4	1	1	3	3	5	4	3	5	5	2	2	3	1
	s_2	3	3	5	4	4	1	3	4	2	3	2	2	5	3	5	5	3	3	4	4
	s_3	5	0	5	4	1	0	3	0	0	3	2	1	4	0	4	3	0	0	3	4

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