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Contextual learning theory: Concrete form and a software prototype to improve early education

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Abstract

In 'contextual learning theory' three types of contextual conditions (differentiation of learning procedures and materials, integrated ICT support, and improvement of development and learning progress) are related to four aspects of the learning process (diagnostic, instructional, managerial, and systemic aspects). The resulting structure consists of 15 guidelines which are expected to improve instruction and learning across different situations. The present study was conducted to give concrete form to two general guidelines with respect to differentiation and five guidelines with respect to integrated ICT support. The products were a 'pedagogical-didactic kernel structure' and a general software prototype. In collaboration with three preschool teachers in The Netherlands, both products were used to give concrete form to a first guideline on improvement of development and learning progress in practice. This concerned an intake procedure on the estimation and use of children's entry characteristics by parents and preschool teacher. Information is given about improvement experiences in early educational practice. Further research and development steps are discussed.
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1. Introduction

Over the years, much attention has been paid to the identification of key factors in both teaching and learning which facilitate the optimising of learning processes and outcomes for learners of all abilities and dispositions (Bennathan & Boxall, 1996; Durkin, 1966; Parkhurst, 1922). That is to say, matching teaching and learning strategies, activities and resources to the particular needs of the learner and groups of learners. In particular the interaction between instructional and learning characteristics in the 'Aptitude × Treatment Interaction' (ATI) approach has been influential in this respect (Cronbach & Snow, 1977; Magnusson & Allen, 1983; Neisser, 1976). Cronbach (1983), discussing the methodological and systemic theoretical aspects of this approach, suggested that process or causal variables such as aptitude and learning preferences can be found at the level of the individual learner, while relevant external or environmental variables could be located at varying levels such as individual, small group, class, school, region or district, national, or international level. Thus learning arrangements may be regarded as consisting of sets of 'multilevel' environmental influences which are integrated in interactional multilevel learning processes and outcomes (see also Collier, 1994; Mooij, 2004a).

In this paper the term 'learning arrangements' is used to describe varying combinations of pedagogical, diagnostic, instructional, and management characteristics which are intended to support or meet the needs of specific learners in their development or learning progress. Such arrangements differ in the degree to which they motivate and fit learners, so they correspondingly differ in their capacity to realise intended individual or group learning processes and effects (cf. Jochems, 2002; Schnotz & Lowe, 2003; van Merriënboer, Kirschner, & Kester, 2003). At the national level, for example, influences on learning arrangements may exist in national curriculum or final examination norms, or in standards related to specific achievement or test procedures or requirements (Earle, 2000). Effects of these national variables are mediated by specific school, class, and teacher variables (Kemp, 2000). An example at the classroom level is the use of differentiation. Since highly academically able or gifted learners possess the potential to self-regulate their learning processes (Freeman, Span, & Wagner, 1995; King et al., 1985), differentiated learning arrangements may allow such learners to self-regulate or to be autonomous in their learning, enabling the teacher to give greater attention to learners who are less academically able (Blumenfeld, Fishman, Krajcik, Marx, & Soloway, 2000; Garnier, Stein, & Jacobs, 1997). In this way, different learning styles and aptitudes can be accommodated within the same classroom (see also Qualifications & Curriculum Authority, 2004). Adequate Information and Communication Technology (ICT) can integrate and support the different learning styles and aptitudes across different types of learning situations, in or out of school (cf. Sinko & Lehtinen, 1999).

In a review of relevant research, Mooij (2004b) constructed a 'contextual learning theory' in which multilevel educational and ICT characteristics were integrated with learning characteristics with a view to optimising the learning process. He related three types of contextual conditions (*differentiation of learning procedures and materials*, *design of integrating ICT support*, and *improvement of development and learning progress*) to four aspects of learning (*diagnostic*, *instructional*, *managerial*, and *systemic*). Taken together, the three contextual conditions and four learning aspects combined to produce 15 theoretical guidelines which were hypothesised to promote

Table 1
Theoretical guidelines to improve instruction and learning by types of contextual conditions and DIMS aspects

Learning aspect (DIMS)	Type of contextual condition		
	Differentiation of learning procedures and materials	Design of integrating ICT support	Improvement of development and learning progress
Diagnostic	(1) Identify a pedagogical-didactic kernel structure with competence (sub)domains	(1) Facilitate construction and use of a pedagogical-didactic kernel structure	(1) Use a learner's entry characteristics to assign instructional (sub)lines
Instruction	(2) Structure competence (sub)domains into (sub)skills and instructional lines	(2) Facilitate structuring, transparency, and flexible use of instructional lines	(2) Create and control prosocial relationships in and around school
	(3) Include psychometrically valid indicators to evaluate learning progress	(3) Facilitate individualised instruction, collaborative learning, and self-regulation	(3) Use collaborative didactic procedures to support learners' self-regulation
Management	(4) Organise and match flexible groups of learners and teachers/coaches	(4) Facilitate multilevel organisation and differentiated evaluation of learning	(4) Concentrate teacher coaching on those learners who most need this
System	(5) Use integrated systems for monitoring, evaluation, and administration	(5) Integrate instruction and learning in different contexts, in longitudinal designs	(5) Use multilevel indicators to improve instruction and learning progress

multilevel improvement of learning processes and outcomes. An overview of the conditions, learning aspects and the corresponding guidelines is given in Table 1.

Taken together, all 15 guidelines point towards the combination of development, implementation, and measurable improvement of multilevel instructional and learning processes and outcomes. Some of these guidelines include general or basic issues or concepts, for example the concept of a 'pedagogical-didactic kernel structure' (see Table 1, column 2, guideline 1). In contextual learning theory, this structure supports age-independent individualised evaluations with respect to different competence domains, alongside the usual age-based or normed evaluations. Within this structure, an 'instructional line' (guideline 2 in column 2) is a comprehensive set of activities or tasks which is locally designed or selected to realise specific learning processes and outcomes. A *first question for research* then focuses on the concrete form of these first two guidelines: *How does a pedagogical-didactic kernel structure look like, and how is it supposed to function with respect to instructional lines*?

The ICT design guidelines (see Table 1; column 3) specify general or basic characteristics which are applicable for different types of processes, across different types of situations. The inclusion of ICT is essential because it has the capacity to deliver targeted support for different instructional functions with respect to the learning process of different learners across different situations, e.g. assigning, monitoring, evaluation, and improvement of multilevel interactional processes and outcomes (cf. also Ayersman & von Minden, 1995; Clark & Estes, 1999). This is similar to an early concept of an 'environment-based system' which shifted the emphasis 'from the teacher teaching to the learner learning in an environment where technological aids as well as the teacher are available as resources' (Centre for Educational Research & Innovation, 1971, p. 17). A *second question for research* is directed at the concrete form of all five ICT guidelines: *What are the relevant design characteristics of integrating ICT to realise the desired support in practice*?

The improvement guidelines (see Table 1; column 4) specify person- and situation-specific topics. These refer to a range of issues including individual and group assignment and matching procedures with respect to instructional lines, pro-social and collaborative improvement, teacher's coaching, and using multilevel indicators to improve instruction and learning progress related to organisational and management transformation supported by the functioning of the other guidelines in columns 2–3. Improvement refers to concrete learners and teachers and their concrete learning and teaching or coaching arrangements, in and outside school. Early socialisation and development processes clarify that it would be most promising to begin with the potential improvement of the development and learning processes of young children, to ensure that educational innovation has a genuine and sustained effect on these processes (Byrne, 1998; Collier, 1994; Goleman, 1995; Walker et al., 1998). A *third question for research* is therefore formulated with respect to the concrete form, in preschool, of the first guideline in column 4 of Table 1: *How should a child's entry characteristics in preschool be made concrete, to begin the improvement process of development and learning in educational practice*?

The goal of this paper is to present answers to these three research questions. Moreover, some suggestions will be given about possibilities to give concrete form to the other guidelines in Table 1.

2. Method

2.1. Introduction

The first research question on characteristics of the pedagogical-didactic kernel structure and instructional lines, and the second question with respect to design characteristics of integrating ICT, were answered by the researcher team involved. The third question about the concrete form of a child's entry characteristics in preschool is the focus of the school. The context in which this research took place is The Netherlands where preschool (4–6 years) and elementary school (6–12 years) are integrated with children normally attending the same school for the first eight years of their education. Three preschools agreed to participate in this part of the study. The preschools were located in, and within a circle of about five miles around, a middle-sized town in the eastern part of the country. One preschool teacher from each preschool collaborated with the researcher team.

2.2. Concrete form of two guidelines on differentiation

An inventory was developed of Dutch diagnostic and achievement tests for youth aged 0–20 across various relevant fields including psychology, youth health, and education. Use was made of handbooks (Evers, van Vliet-Mulder, & Groot, 2000; Evers et al., 2002; Resing et al., 2002) and internet information of institutes for educational policy, educational assessment, and educational development. Each instrument or test selected was checked for reliability, concept validity, or criterion validity. If possible, normed concepts and sub-concepts which measured comparable behaviour or performances were organised into 'tree-structures' concerning competence domains and sub-domains. Where appropriate, non-normed concepts and sub-concepts were also integrated into these tree-structures.

2.3. Concrete form of a general software prototype

Discussions about the consequences of using the concept tree-structures in educational practice raised a number of important issues including the learner's experiences with different types of activities according to the four learning aspects (see Table 1; column 1):

- the structuring into competence domains and the relevance of a learner's entry characteristics (Diagnostic);
- the differentiation between scheduled or curricular activities and free activities (Instructional);
- the organisation of learners into small groups according to homogeneous or heterogeneous points of view and corresponding results (Managerial); and
- the design and potential use of software to support both teachers and learners (Systemic).

Following this, the characteristics and functioning of a general software prototype were designed and created in the form of an internet-based computer programme. The design of the software concentrated on the potential contextual support of each of the above aspects of

development and learning processes, hence the acronym 'DIMS' (Diagnostic, Instructional, and Management Systems).

2.4. Making improvement concrete in practice

The functioning and use of the software prototype in practice could probably be improved by involvement of potential users. Wilson (1999) stated that 'use-oriented' strategies 'increase the likelihood of successful implementation because they take the end user into account at the beginning design stages' (p. 13). Collaboration between research and other development specialists, and direct users like teachers, learners, and school staff, can also secure the validity of innovation processes (Blumenfeld et al., 2000; Crosier, Cobb, & Wilson, 2002; Kensing, Simonsen, & Bødker, 1998). Therefore, researchers and preschool teachers of the three preschools co-developed ideas and examples of how teachers and children might best be supported by the DIMS software, and how to transform aspects of preschool and early education step by step in an optimising direction. This collaborative stage was a first check of the design of the general software prototype and, at the same time, it was used to specify software characteristics and user interfaces relevant in preschool and early education. This method of co-development between research and preschool practice resembles a part of the development cycle of Clark and Estes (1999) which begins with descriptive and empirical research; continues with the construction of generic technology; then contextualises the technology to generate new issues for research; continues with a next cycle of development, and so on.

3. Results

3.1. Differentiation of learning procedures and materials

3.1.1. Guideline 1: Identify a pedagogical-didactic kernel structure with competence (sub)domains
With respect to development or learning processes of a learner three types of activities or tasks were specified:

- *Regular activities:* These refer to different types of activities or tasks carried out by the learner in order to play, practice, or to attain one or more skills.
- *Evaluation activities:* Activities or tasks used to measure the degree of skill of the learner.
- *Normed activities:* Evaluation activities or tasks which are measured on, or can be compared to, a national scale.

A cluster of activities or tasks which share a psychological, pedagogical, or learning attribute was defined as a *skill*. A skill (or a set of skills) is related to, or a part of, one or more specific areas of human performance. Skills are relevant in development areas or competence domains characterising for example youth health, general and developmental psychology, pedagogics, regular education, and inclusive or special and gifted education. A level of competency with respect to a skill can be normed at the national level.

The inventory of relevant Dutch instruments and tests for youth aged 0–20 resulted in a concept set of more or less hierarchically structured competence domains and sub-domains. The whole set of competence domains and sub-domains reflects a multi-disciplinary, integrated classification based on measurable skills and (sub)skills made concrete via reliable and valid instruments. The term pedagogical-didactic kernel structure (PDKS) was used to indicate the overall hierarchical structure based on normed instruments to assess related levels of competency, or skills. In addition to the normed (sets of) activities or tasks, criterion-based evaluative activities or tasks were introduced in the concept PDKS at places where skills or sub-skills were present or expected, but where no normed indicator was available. These evaluative activities or tasks were related directly or indirectly to the normed concepts or sub-concepts. This additional evaluation feature is intended to improve the specific estimation of a child's or learner's mastery of information or progress in behavioural competencies.

The resulting tentative tree-structures need implementation and validation in educational practice, however (cf. column 4 of Table 1). The present blue-print of the concept PDKS contains skills with respect, respectively, to the competence domains:

(1) language;
(2) general cognition;
(3) social–emotional performances;
(4) mathematics;
(5) physical–medical aspects;
(6) general psychological characteristics; and
(7) motor activities.

3.1.2. Guideline 2: Structure competence (sub)domains into (sub)skills and instructional lines

The most general or superordinate level is a competence domain like language, general cognition, and so on. A *skill view* presents skills in a hierarchical order according to the tree structure or model of the competence domain. The chief characteristics of a skill view are, first, that the view is *general to all instances or schools*. Moreover, the view is strictly hierarchical. Each skill except for the most general one has only one parent, which implies that a skill cannot appear more than once in the tree. An example of a skill view concentrating on a part of the language competence domain is given in Fig. 1.

No relationships or dependencies exist between skills. For example, placement of 'auditory analysis' next to 'auditory discrimination' does not mean that discrimination precedes analysis. A skill is divided into sub-skills and so on. A learner who is able to perform all sub-skills (e.g. 'auditory discrimination word' and 'auditory discrimination sound') has reached the respective skill level ('auditory discrimination').

An *instructional line* is defined as an activity scheme aiming at the realisation of a specific level of competence or skill in the context of the PDKS. In these terms, an instructional line is an activity scheme beginning or ending with an evaluation activity or normed activity. An instructional line is always linked to only one skill, but one skill can be linked to more instructional lines. An instructional line can contain one or more evaluative or
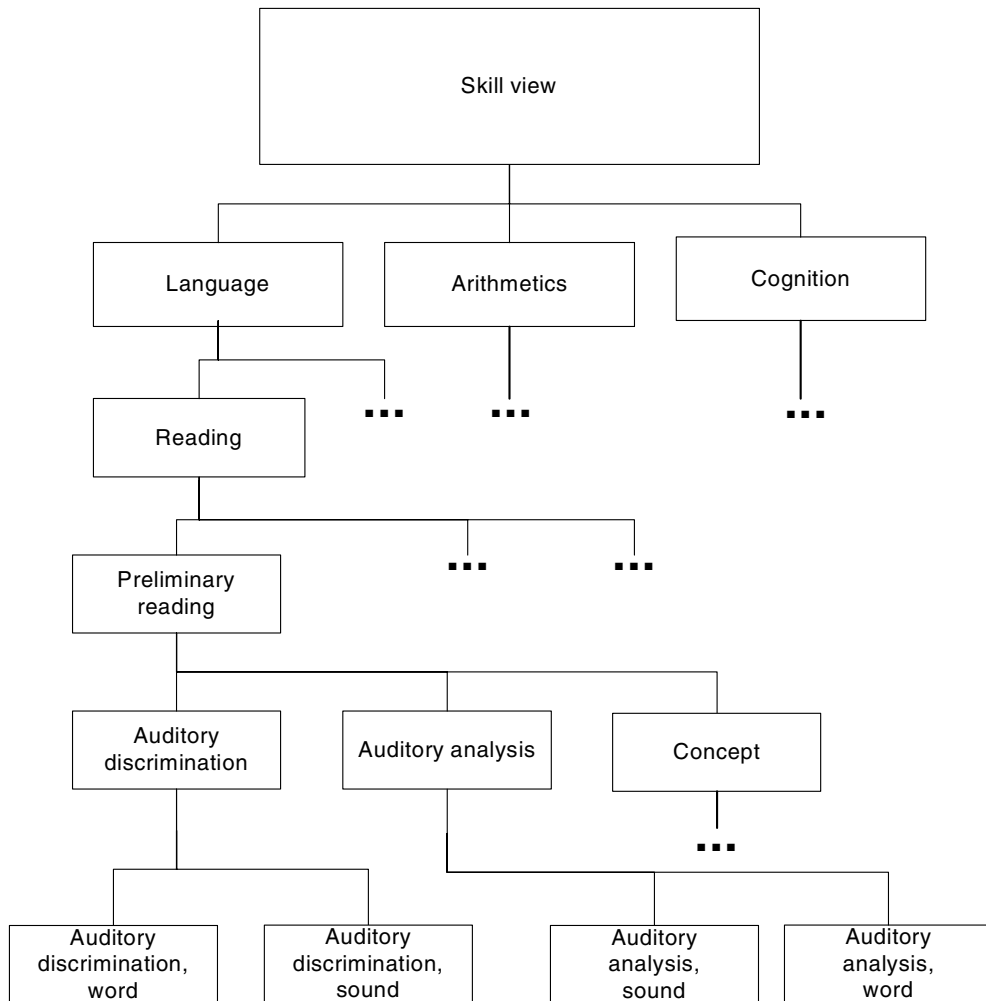
Fig. 1. Example of a skill view concentrating on a part of the language competence domain.

normed activities or tasks, to evaluate or measure the level of competency or skill of a learner.

Of course, a child or learner plays or works with activities or tasks in a local situation. An instructional line is a comprehensive set of activities or tasks which is *locally* created or selected, usually by a teacher, to realise specific learning processes and outcomes with one or more learners. Estimation or evaluation of a child's or learner's competency level or progress with respect to a specific instructional line can be carried out by either one or more evaluation activities or tasks, or one or more normed activities or tasks.

Making the guidelines 3–5 in column 2 of Table 1 concrete would profit much from the availability of relevant software and software-based interactions with educational practice. Therefore, at this time only some first suggestions are presented.

3.1.3. Suggestions with respect to guidelines 3–5

3. *Include psychometrically valid indicators to evaluate learning progress.* The PDKS has to provide a diagnostically valid, normed basis for individual or group assessment of development or learning progress and flexible integration of differences in learning. Within this framework, individual or group evaluation can for example be based on competency progress judgments of teachers, the individual child, other children or learners, the parents, or other coaches or professionals involved. Estimation or measurement of a learner's competency level or competency progress can then occur from different observation or evaluative points of view. This estimation or measurement can take place not only at the individual level but also at the levels of the small group, class or school, or even at district, national, or international community level. Such a differentiated evaluation system approach can help to avoid learners' motivation and achievement problems associated with the yearly grading system (cf. Kemp, 2000).

4. *Organise and match flexible groups of learners and teachers/coaches.* This guideline specifies that the activities represented in an instructional line have to be adjusted to the actual competency level of a learner or a group of learners, to assist next development or learning steps. This differentiation is most effective for learners at the more extreme ends of the competency continuum. The teachers may have to introduce other grouping procedures, or other types of organising learning procedures and materials, to enable continuity in learning progress for some or most of the learners.

5. *Use integrated systems for monitoring, evaluation, and administration.* Systematic monitoring, evaluation, and administration of process and result indicators of individual learners and different types of groups of learners, can help to recognise and integrate differences in development and learning in positive ways.

3.2. Design of integrating ICT support

3.2.1. Guideline 1: Facilitate construction and use of a pedagogical-didactic kernel structure

The software prototype first of all had to structure and facilitate the use of the whole set of competence domains and sub-domains based on measurable skills and (sub)skills in the concept PDKS. Furthermore, in addition to a skill view, the software also had to facilitate working with a *skill-order view*. Such a view describes relationships or dependencies *between* skills integrated in the PDKS. For example, if the learning process requires the learner to perform skill v1 in order to continue with skill v2, then the development of skill v2 is *contingent* or *dependent* on first developing skill v1. A screen dump with an example of a skill-order view is given in Fig. 2. The three skills in the rectangles to the right in the picture (sound-letter combination, or spelling; direct word recognition; and visual synthesis) are contingent on sound-letter combination or reading, which in its turn is contingent on auditory discrimination (reading) and visual discrimination (reading); this last skill is contingent on visual analysis.

The chief characteristics of a skill-order view are, first, that this view is *general to all instances or schools*. Also, a skill cannot simultaneously be a direct and an indirect condition to another skill. Dependencies exist at any level of the skill hierarchy. Dependency on a skill also means being dependent on all sub-skills of this skill. A skill cannot be dependent on its own sub- or super-skills.

Usually, many activities of children or learners are 'free activities' which means that the activities are created or chosen by the children or learners themselves. A part of these free activities, as
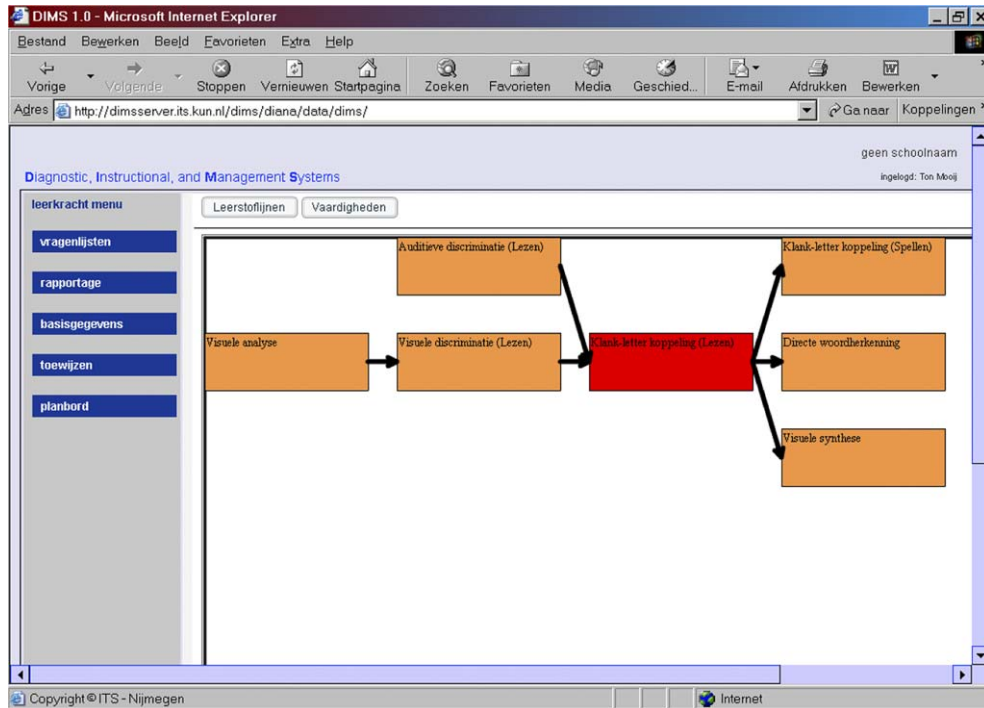
Fig. 2. Screen dump of an example of a skill-order view.

well as activities referring to specific levels of development or learning competencies, can be structured within skills of the PDKS. Linking activities to skills can be done only on the lowest level of the skill view. Such an *activity view* describes activities or tasks and their relationships with skills. Different types of activity views can exist, for different categories of users:

- Research at the national or international level creates and supports a *general activity view* consisting of the skill structure including normed activities. This view is *identical for all instances or schools*. It functions as an anchoring structure to local evaluation and regular activities. Local instances can look at this general activity view and use or extend it with local activities, but they cannot change it.
- Local instances, schools, teachers or other users take account of the input of *local regular and specific evaluation activities or tasks* which may be linked with specific skills and normed activities of the general activity view. These local activities or tasks are not grouped into a hierarchy, but their linking with normed activities of skills can support the notion of hierarchy.

3.2.2. Guideline 2: Facilitate structuring, transparency, and flexible use of instructional lines

Different specifications were developed with respect to the design of the DIMS prototype. An *activity scheme* reflects a number of regular learning activities, evaluation activities, or normed activities. A specific activity can be either optional or obligatory. A learner can skip optional

activities but not evaluation or normed activities. A same activity can be obligatory in one activity scheme and be optional in another scheme. In an activity scheme different types of relationships may exist between the activities:

- *Order:* Activity B can be attempted only after activity A.
- *Simultaneousness:* The learner chooses from among two or more alternative activities. If the activities are obligatory all of them have to be carried out, but the order may differ for different learners.
- *Selection:* Only one of two or more activities or activity sets needs to be carried out.

The prototype involves one version of the concept PDKS and the corresponding skill views and skill-order views. Any changes in a skill view or skill-order view are therefore generally reflected at the local level in *activity schemes* and *instructional lines*. At this level, schools, teachers, other coaches, or learners can use parts of the concept PDKS in their particular activity schemes and instructional lines. If such a scheme has a general or national value, it can be scaled up by research to the national level and be made available to all local instances.

3.2.3. Guideline 3: Facilitate individualised instruction, collaborative learning, and self-regulation

The linking between the skill-order view and relevant activities or tasks is not obligatory. For example, within the teacher interface the teacher can add or change learning materials and activities. A particular instructional line or activity for one learner can be made valid for another learner or another group of learners. Formation of small groups of children or learners is made possible by assigning different individuals to the same activity or instructional line. The teacher can also construct variants of instructional lines referring to different developmental levels, for example for learners who are developing in a more or less regular way, those who require special or remedial activities, or high-ability children who are progressing (too) quickly along instructional lines.

Furthermore, a teacher or group of teachers can make activity schemes which do not match with the skill-order, or assign specific activities which do not logically fit into an activity scheme or skill-order view. Also, in co-ordination with the teacher, a learner or a small group of learners can create and carry out self-chosen or self-made activities. Collaboration between learners can then be improved, and self-responsibility and self-regulation can be stimulated. These examples demonstrate that DIMS is designed to support self-regulation and self-determination of users at all levels rather than prescribing pedagogical, instructional, or educational requirements.

3.2.4. Guideline 4: Facilitate multilevel organisation and differentiated evaluation of learning

DIMS automatically logs information about activities and time on task for each of the users working with the programme. To indicate the status of instructional lines or activities (e.g. planned, currently used, ready or to be evaluated) different logos, colours and icons can be used. Evaluation activities or normed activities can also be tagged by an indicator to signal that the teacher has to assist or coach the activity. The teacher can then instruct specific individual or group work, make specific observations or tests, and so forth. Gradually, children or learners can do more and more by themselves, or regulate their own learning processes while interacting with the PDKS or specific instructional lines. Four aspects are distinguished here.

First, DIMS produces overviews of entry characteristics of a child or learner, which provides a basis for the planning of instructional lines fitting to these characteristics. Observation of activities within these lines allows the teacher to better diagnose or evaluate the entry level of competency. Further instructional lines or activities can then be created or selected. In the long run, this enduring diagnostic and continuation facility can be taken over partly by the software. At any time, however, the teacher or coach can readjust the assignments of one or more children or learners.

Second, an important design decision was to concentrate the software support on the instructional management of a child's or learner's activities. That is, DIMS provides computer support to a learner's self-regulation, planning, and evaluation of activities. Carrying out of the activities, however, is usually taking place with the real three-dimensional materials that are available in or around the classroom or school. This feature also overcomes constraints related to computer access. Computer work can of course be included in the instructional lines as one of the options.

Third, it can be expected that moderate-to-high ability children of 4, 5 or 6 years old will learn to operate DIMS quickly (cf. Mooij, 2002). These children may now and then assist other children in learning to use the programme. Slower developing children can be assisted also by other peers, the teacher, or parents. In this respect the teacher's pedagogical and didactic ability to facilitate collaborative activities between young learners is essential. In elementary and secondary education the possibilities to organise differentiated collaborative learning arrangements will be increased because of the learners' age.

Fourth, it generally is the teacher or coach who is responsible for evaluation. The software is designed to suggest and present different evaluation possibilities (e.g. individual, small group, class, school, national) to provide for a motivating, differentiated approach. In the course of time, the software will also present suggestions for future activities or instructional lines based on former results. The teacher or coach can change these suggestions at any time.

3.2.5. Guideline 5: Integrate instruction and learning in different contexts, in longitudinal designs

The flexibility in assigning individuals to groups, or groups to groups, enables multilevel organisation and differentiated evaluation almost without limits. Longitudinal information about children can be obtained from preschool playgroup situations or preschool situations, and be extended to elementary and other educational types, across different schools and situations outside schools. Teachers, parents, children or learners, school management, other professionals and researchers can then obtain multidimensional and multilevel perspectives on a learner's or group's characteristics and progress, if desired against a background of specific pedagogical-didactic support or group contexts.

3.2.6. Overview of the general software prototype

The software prototype DIMS was designed to support the functioning of the concept PDKS and the relevant curricular structuring and flexible organisational developments, at different educational levels. The general prototype has relevance to national research and curriculum development, local curriculum development or construction, and the creation or use of instructional lines by teachers, management, parents, external professionals and learners. An overview of present software functions for different types of users is given in Table 2.

Diagnostic, instructional, and management functions are presented by rows in the left of Table 2; different types of users are numbered by column from 1 to 12. The combination of diagnostic,

Table 2
Diagnostic, instructional, management, and system (DIMS) integration of learning: design of the general software prototype[a]

Aspects of learning	Specification			System integration: users related to software functions											
				Learner	Parent	External specialist[b]	Preschool teacher	Teacher	Kernel group teachers	Administration	Management school	School board	National policy	International policy	Research
				1	2	3	4	5	6	7	8	9	10	11	12
Diagnostic	Pedagogical-Didactic Kernel Structure	National	Creation												X
			Use										O	O	X
		Linking national-local													X
		Local	Use	X		X	X	X	X	X	O				
	Instructional (sub)line	Normed	Creation												X
			Use	X		X	X	X	O						X
		Evaluative	Creation			X	X	X	O						
			Use	X		X	X	X	O						X
	Questionnaire, observation list[c]			X	X	X	X	X	O	X	O	O	O	O	X
Instructional	Assignment	Instruction. (sub)line	Learner			X	X	X	O						
			Group(s)			X	X	X	O						
		Questionnaire	Learner			X	X	X	O						
			Group(s)			X	X	X	O						
	Planning and progress	Instructional (sub)line				X	X	X	O	X	O				X
		Learner(s)/ Group(s)		X		X	X	X	O						
Management	Evaluate or report results/ next steps	Learner(s)				X	X	X	O						
		Group(s)				X	X	X	O						
		Instructional (sub)line				X	X	X	O	X	O	O	O	O	X
		Questionnaire				X	X	X	O	X	O	O	O	O	X
	(New) user	Family/parent(s)			X					X					
		Learner(s)		X						X					
		Teacher(s)/ external				X	X	X		X					
		Group(s) of learners				X	X	X		X					
	Change learner/group allocation							X		X					
	Remove learner(s) or group(s)									X					
	Reset user password									X					

[a] X = realised in October 2004; O = next development.
[b] E.g. external coach, health professional. These persons use the software in collaboration with teachers.
[c] E.g. preschool entry characteristics; prosocial behaviour; teacher qualities.

instructional, and management functions with categories of users results in *system integration* realised by the general software prototype. Cells completed with 'X' indicate that the respective facility has been integrated; cells with 'O' refer to functions that will be developed next.

3.3. Improvement of development and learning progress

The concept PDKS and the general software prototype DIMS were trialed in three preschools. The improvement occurred in co-development between researchers and three preschool teachers. The collaboration began with respect to the first guideline in column 4 of Table 1. This development process and its outcomes also resulted in suggestions concerning the concrete form of the other four guidelines in column 4.

3.3.1. Guideline 1: Use a learner's entry characteristics to assign instructional (sub)lines

Both the researchers and the preschool teachers looked for an instrument to estimate the entry characteristics of children. The instrument that was selected is based upon a psychometrically controlled screening procedure, developed from quantitative longitudinal research with 966 four-year-old children just beginning to attend preschool (Mooij, 2000). The questionnaire contains seven behavioural rating categories and can be used by the parents at intake and by the teacher after the child's first month in preschool. The seven categories refer respectively to:

(1) social interaction/communication;
(2) general cognition;
(3) language proficiency;
(4) pre-arithmetic;
(5) emotional-expressive;
(6) sensory-motor; and
(7) expected educational behaviour.

In the three preschools, scores on a child's entry characteristics could be made by the preschool playgroup teacher (if the child had gone to such a playgroup), the parents, and the preschool teacher. With the aid of relevant software specifications in DIMS the items, item scores and the means of item categories were compared numerically and graphically, for parents and teachers. In addition, the results of a particular child could be compared to his or her own group or class, or to normed scores.

Use of this screening procedure was identified to help both parents and teachers in getting a clear view of a child's entry characteristics. The intake procedure seemed to assist in developing a positively oriented frame of reference between parents and teachers. The use of DIMS facilitated communication about the child and was expected to support coordination of future development and learning processes both in preschool and at home (see also Blumenfeld et al., 2000; Mangione & Speth, 1998). In addition, the outcome of this screening procedure was used to assign specific playing or diagnostic and learning activities to specific children, as a basis to further pedagogical and didactic support.

At first, this was done without using DIMS. Collaboration with the preschool teachers resulted in construction of some instructional lines based on play and development or learning aspects

which were directly applicable to preschool practice. An instructional line was for example characterised by the use of a specific logo (e.g. a simple geometrical shape for a *pre-arithmetic* line), a specific colour and a corresponding name or text. Learning materials and activities within a line were usually ordered by difficulty level, with diagnostic tools, with activities and tests included if desirable or possible. Children were allowed to independently access and return playing or learning resources. To support this self-regulated/autonomous approach to the learning activity, individual children or small groups of children could make use of a planning board (cf. also Mooij, 2002).

Working with instructional lines helped to identify difficulties in playing, developing and learning. These diagnoses allowed playing and learning to be integrated better than in previous years. This was true in particular for exceptional children. The preschool teachers felt that collaboration between the teachers, parents, and specialists from outside school, was important. These experiences convinced the teachers to use DIMS for constructing and using instructional lines. Whether the new learning arrangements do indeed differ from the old ones in their functioning with, or effects on, the young children cannot yet be indicated, however. In the future the software can easily assist to produce quantitative evaluations.

3.3.2. Suggestions with respect to guidelines 2–5

2. *Create and control prosocial relationships in and around school.* A prosocial climate was promoted by making children responsible for the formulation of positive rules of conduct. Collaborative procedures and rules to support prosocial processes can also be integrated in instructional lines for small groups (cf. Kaplan, Gheen, & Midgley, 2002; Walker et al., 1998).

3. *Use collaborative didactic procedures to support learners' self-regulation.* One of the three preschools had made real progress in having the children work in small groups. Usually, the small groups were very keen in collaborating and helping each other to manage their own playing and working. It seems that self-regulation can become self-evident for the teacher, most of the children, and the parents.

4. *Concentrate teacher coaching on those learners who most need this.* With the increasing realisation of self-regulation/autonomy on the part of children, teachers can devote greater attention to those children who need extra guidance or coaching without the progress of the other children in the class suffering.

5. *Use multilevel indicators to improve instruction and learning progress.* In the future, a systematic multilevel pattern of indicators can be developed to better diagnose, instruct or intervene, evaluate, and stimulate the progress of each learner or group in a class context. The progress can for example be evaluated against indicators based on longitudinal individual, group, class, or school means and standard deviations, or against national or international benchmarks founded in representative research.

4. Discussion

In contextual learning theory, three types of contextual conditions (differentiation of learning procedures and materials, design of integrating ICT support, and improvement of development and learning progress) are related to four learning aspects (diagnostic, instructional, managerial,

and system) of learning processes. In combination, it is anticipated that the three types of contextual conditions will build a differentiating education system which is capable of facilitating the integration and multilevel optimising of learning processes and outcomes. In this respect 15 theoretical guidelines were formulated in Table 1. Three research questions were formulated to give concrete form to eight of these 15 guidelines.

The first research question focused on two guidelines with respect to a pedagogical-didactic kernel structure (PDKS) and its relationships to differentiation of learning procedures and materials. A concept PDKS was developed with respect to tree-structured competence domains, sub-domains, skills, sub-skills, and instructional lines (see Section 3.1). This interim result assisted in answering the second research question which was directed at the concrete form of all five guidelines about the design of integrating ICT. The relevant specifications in Section 3.2 led to the construction of a general software prototype which was summarised in Table 2. On its turn, this ICT result could be used to answer the third research question concerning the concrete form of the first improvement guideline in Table 1. This third question was answered by collaboration and co-development between research and teachers of three preschools in The Netherlands (see Section 3.3). Preschool teachers used parts of the concept PDKS and the software prototype to introduce an intake procedure to parents and children, including the screening of entry characteristics normed for four-year-olds. Moreover, they began to design first instructional lines.

In changing their own preschool practice, the preschool teachers were developing new learning arrangements. By using the screening instrument the communication about children between teacher and parents was facilitated because both parties were using the same language to discuss the child. Not all parents had sufficient self-confidence to screen the own child all without support, however. In particular the parents of an oldest and/or an only child could feel themselves rather insecure and needed help from the teacher. Highly relevant in the teachers' professional learning from these changes were the observed variations in the children's development levels and learning processes. Also, actual problems or potential risk characteristics of a child could be given more attention in class, if necessary by professionals from outside preschool. The children seemed to receive more systematic – and more immediate – diagnostic or instructional support than they had received prior to the project. Given the present state of practice development, however, it is not yet possible to present systematic quantitative information on the improvement of development and learning processes or outcomes.

The collaboration between research and practice also suggested how to further evolve the present educational system into a more differentiating, ICT-based instructional management system for all learners (a 'multilevel transformation approach': see Mooij, 2004a). The next co-development steps will therefore focus on (a) the user-based development and implementation of the concept PDKS in preschool and successive educational types according to the differentiation guidelines 3–5, (b) the multilevel integration in practice of instructional lines according to the improvement guidelines 2–5, (c) the construction of corresponding user interface specifications in DIMS, and (d) the multilevel measurement and improvement of instructional and learning processes and outcomes (cf. also the development cycle of Clark & Estes, 1999).

From a transformation point of view, the main advantage of an educational system based on a PDKS is the continuous curricular support for individual learners or groups of learners in motivating educational contexts. Essential to this transformation process is the realistic, multifold positive evaluation of progress in competency level e.g. individual and small group progress,

progress relative to the small group or class, and progress relative to the age-group. In contrast, the regular Dutch pupil monitoring system only emphasises a comparison with the age-group, which in the long run usually has negative consequences for the motivation and achievement of children at risk (cf. Collier, 1994; Kemp, 2000).

It is clear that user-based co-development and implementation of both PDKS and DIMS will require a lot of work in the future. Moreover, the realisation of educational transformation is also dependent on the support of local and national educational institutions with innovation, assessment, research, coaching, or policy tasks. Successful optimising of education asks for a long-term, gradually broadening collaboration between personnel and institutions involved in educational practices and instruments, at an increasing number of levels, in subsequent educational types (see also Griffin & Beagles, 2000). However, assistance will be provided by the self-disseminating role of internet-based software, in combination with positive influences of concrete improvements as experienced by teachers, learners, school management, and parents (cf. also Murphy & Lick, 2001; Remillard, 2000).

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