Research into learning to learn through the assessment of quality and organization of learning outcomes

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This article examines the problem of learning to learn from the perspective of research on the organization and quality of students’ knowledge. This approach is based on the assumption that students’ learning competencies can be studied through the analysis of the outcomes of schooling. The article synthesizes findings of a long-term research programme assessing the development of components of propositional and procedural knowledge, and relationships between them. A model was devised classifying indicators of school outcomes on four levels: (1) teachers’ grading; (2) objective knowledge tests; (3) indicators of quality of knowledge (application, understanding); and (4) higher order thinking skills. A set of tests and questionnaires were administered to Year 7 and Year 11 students in two consecutive projects; then, relationships between them and differences between the two cohorts were analysed. As results indicate, a number of points in schooling should be changed in order to improve schools’ impact on learning to learn, for example, inadequate feedback given by grading, and shifting attention from reproductive to productive learning. The instruments developed in this programme assess science application, science misconception, mathematical understanding, historical reasoning, and inductive, deductive, spatial and critical reasoning. They can also be utilized for monitoring learning to learn.

Keywords: Assessment; Learning to learn; Organization of knowledge; Quality of learning outcomes; Thinking skills

Introduction

It is generally accepted that learning to learn is a complex concept (Hautamäki et al., 2002). There is no single interpretation of it, as several views exist on how it should be interpreted. Two main types of interpretation include a narrower and a broader one (Waeytens et al., 2002). In this article I accept the broader interpretation and argue...
that, in order to make educational systems more supportive, the learning processes in which students are engaged should be modified at a number of points.

One of the most striking experiences of schooling is that students learn a lot at school: they master a large body of knowledge but they are unable to apply it outside their educational contexts. In many cases, the application of knowledge is limited to the school subject in which it was acquired. This problem is not at all new. During the long history of formal education, a perennial question has persisted: ‘how should we teach our students in schools in order to provide them with valuable and applicable knowledge?’ The *Non scholae, sed vitae discimus!* slogan has remained an ideal that has never been reached, either in ancient or modern times. In modern societies, where lifelong learning is a demand, the vision concerning the application of knowledge should be extended to another dimension: schools are expected to prepare students to be successful in a rapidly changing social environment; in brief, to apply their knowledge in the unknown future.

The concept of ‘learning to learn’, as it is known in the literature, especially in the early formulations of the idea, implies that students should learn more. On the other hand, everyday experiences as well as rigorous investigations indicate that students spend a large amount of time learning, and they are able to reproduce textbook knowledge if it is measured by knowledge tests strictly based on curricula. Therefore, in order to make students better at learning, the outcomes of school learning have to be analysed, and those features of school practice which prevent schools from accomplishing their expected mission in this domain have to be identified.

This approach was adopted by a group of researchers at the University of Szeged when a long-term research programme was launched in the early 1990s with the aim of a comprehensive evaluation of the outcomes of school learning. It began with preliminary investigations and continued with two complex projects entitled ‘School knowledge’, with major data-collection waves in 1995 and 1999. This was followed by another wave to assess the development of abilities and skills most relevant in the context of lifelong learning (1997–2002). These cross-sectional assessments were carried out on nationally representative samples involving 5–10,000 students per cohort.

The results and implications of these studies initiated further studies, with more focused investigations of some crucial issues related to the quality of learning outcomes. Finally, a long-term longitudinal study was launched in 2003 on nationally representative samples in three cohorts to investigate causal relationships between the characteristics of early development and success in later school learning. Although the whole research programme is not directly aimed at studying the issue of learning to learn, this body of interrelated investigations allows us to look into this paradigm.

The present article provides an overview of the main findings from the perspective of learning to learn. First, the projects related to the organization and quality of students’ knowledge will be reviewed, and since these projects applied a complex system of variables, they will be described in detail. Then, the most recent projects and work in progress will be summarized, indicating how the focus of research has
shifted to integrate further questions of learning to learn. Finally, implications will be discussed.

**Theoretical and research background**

Two main types of indicators signal problems with students’ abilities to learn. One obvious sign is that children do not learn, or they do not learn enough. This kind of problem is mainly related to the affective domain, mostly to interest and motivation. The other, mostly cognitive problems are experienced when students actually learn—in terms of spending a lot of time with learning—and they are able to reproduce what they have learnt in certain conditions, but the result of learning is inappropriate; the knowledge is quickly forgotten, good for nothing, or way below expectations. The two types of problem are usually in causal relationship with each other. At the beginning of schooling, most children are naturally interested in learning and motivated to master new knowledge; however, if they are regularly forced to learn something irrelevant and incomprehensible for them, they gradually lose motivation and interest.

Thus, the first problem that triggers research into the issue of learning to learn is that students do not learn well. The problem with their knowledge—that is not trivial and deserves scientific analysis—is not related to quantity of knowledge, but a problem of quality. This issue has been conceptualized in several ways.

The research presented here was mostly influenced by theoretical frameworks identifying two types of knowledge, procedural (abilities and skills) and propositional (declarative, e.g. facts, information) knowledge, and the examination of their relationships. It is generally assumed that one of the main functions of abilities and skills is processing (e.g. analysing and organizing) declarative knowledge. Therefore, their development is a precondition of successful learning and their low level hinders learning and results in poor quality of knowledge.

Several research paradigms offer guidelines for the identification of the most important skills and abilities which play a central role in organizing knowledge. The psychometric tradition (with intelligence research at its core) emphasizes general cognitive abilities (for a synthesis see Carroll, 1993). From this paradigm, those general abilities that were supposed to have a major contribution to knowledge accumulation and knowledge utilization in new situations were taken into account: inductive reasoning and analogical reasoning. These abilities were studied in our research programme and their development and functions were assessed in several contexts. The development of inductive reasoning was assessed on smaller (Csapó, 1997a) and countrywide representative samples (Csapó, 2001) and in projects examining the organization of knowledge.

Another important source are the Piagetian and Neo-Piagetian traditions; from these a constructivist view of learning and some areas of operational reasoning was adopted. Those operations that, under normal circumstances, appear at an early stage of development are particularly important. Such operations are class inclusion, seriation, classification, multiple classification and combinatorial operations and, in the later stages of development, operations of propositional logic. These operations
are essential in identifying elements of learning materials, discovering relationships between them, and understanding the meaning of complex sentences; therefore, if they are not developed well enough, meaningful conceptual learning is impossible. (Several projects carried out in this paradigm are published in an edited volume by Demetriou et al., 1992).

Some models attempt to integrate the results of these two paradigms and include a third influential paradigm, the information-processing approach. One of the most elaborated and empirically tested models is developed by Demetriou (2004).

One obvious implication of these relationships between procedural knowledge and learning is that skills and abilities, essential for successful learning, should first be enhanced, if they are not developed well enough when they are to be used. Many developmental programmes were inspired by this simple relationship, acknowledging the importance of preliminary knowledge in terms of abilities and skills. Improving thinking and learning skills has long been considered a central mission of schooling (see Glaser, 1984; Bransford et al., 1985); however, empirically tested methods rarely progressed beyond the experimental phase.

Most research and developmental programmes concerning teaching and learning thinking skills (see Hamers & Csapó, 1999) aimed at providing students with the skills necessary for further learning. From our point of view, content-based training is especially relevant, since it uses teaching materials for composing developmental exercises. These techniques of devising training materials are often called enrichment, infusion or embedding. Besides developing students’ crucial general abilities and thinking skills, they improve understanding of the content of teaching materials (Csapó, 1990, 1999). For example, the CASE programme (Cognitive Acceleration through Science Education—see Adey & Shayer, 1994; Adey, 1999) utilizes science materials for improving students’ general cognitive abilities.

Studies on improving students’ general abilities and some specific thinking skills that play critical roles in school learning have direct consequences for learning to learn. Our experiments aiming to develop students’ operational abilities (e.g. logical and combinatorial reasoning) in the context of teaching disciplinary knowledge (grammar and science in 4th grade, chemistry and physics in 7th grade) have clearly shown that training empowers students with the skills necessary to comprehend the structure of learning materials. Developing reasoning skills ‘on the spot’, in the context of learning disciplinary knowledge, removes the obstacles that hinder successful learning (Csapó, 1990, 1992, 1997b, 2003). For example, improving students’ logical abilities in specific exercises using statements of the teaching material helps them to understand sentences otherwise incomprehensible to students whose logical abilities are not developed enough without training (Vidákovich, 1996).

In the context of learning to learn, ‘dynamic’ experimental studies complement ‘static’ research studying the structure and quality of knowledge in a more direct way. This latter approach has often been conceptualized by distinguishing two different kinds of learning that result in different quality of knowledge. The first is more natural, often incidental, and it takes place in authentic contexts, based on interest and intrinsic motivation, usually outside school or in other formal instructional
settings. Although the knowledge acquired in these circumstances may be limited, it is immediately applicable in the appropriate context. The second type is school learning, when students are supposed to master a large volume of knowledge, but they go through the instructional processes along a prescribed agenda, independent of their interest, motivation and, very often, of their prior knowledge.

A number of terms are used for this problematic process (e.g. rote learning), and its compartmentalized result consisting of isolated elements called scholastic or inert knowledge (Bereiter & Scardamalia, 1985). This is far from the ideal of meaningful conceptual learning building knowledge on proper prior knowledge and deep structural understanding.

In our research we coined the term school knowledge for the outcomes of school instruction. The aim of the programme was to examine what school knowledge comprises in reality and where real learning processes on the rote learning—meaningful learning scale can be placed. Results have been presented at several conferences (Csapó, 1996, 1997c) and published in journal articles and in two comprehensive volumes in Hungarian (Csapó, 1998a, 2002). In this article I summarize the results of this research and draw its conclusions for learning to learn.

**Studies on the quality and organization of students’ knowledge:**

**framework, research questions and overall design of projects**

These projects intended to devise methods and instruments to characterize the quality of school learning and to identify areas where improvement is most needed; therefore, a large system of variables was applied. We developed a framework that organizes the indicators of the outcomes of schooling into a system of variables that describe students’ knowledge at four levels.

At the first level, grades given by the teachers were collected. These are indicators of students’ achievements that both students and their parents first face. Depending on the general culture of schooling, the preparation of teachers and the evaluation technique available, the reliability of grading practice may vary to a great extent. It may depend on local school values and the subjective value judgement of the individual teachers. This is the most important feedback that orients students in their learning, shapes their self-concept, attitudes and motivation, and influences parents’ decisions concerning their children’s future. Therefore, the first research question was related to the quality of feedback provided by teachers’ grading. This was conducted by correlating grades with other variables.

At the second level, objective knowledge tests of school subjects were applied. Since the same tests were administered to all participants, these data resulted in indicators that are independent from the local variety of school expectations, value systems and teachers’ subjectivity. These tests were based on school curricula and mapped the knowledge represented in textbooks and other learning materials into tests. Since they asked questions in the context of a given subject in the same way in which students are usually tested and are expected to demonstrate their knowledge at school, their results are indicators of how well schools meet their external goals.
The second research question is related to the knowledge tests: how much subject matter students master at school and how it is distributed over students and schools (i.e. how large are the differences between students and schools).

At the third level, tests go beyond the immediate reproduction of subject matter knowledge. They examine the quality of their knowledge: how consistent it is, how well students understand what they have learnt, how they can apply it in new contexts that are different from where it was mastered. These tests were constructed on the basis of general claims concerning schooling, stating that schools should provide students with knowledge broadly applicable beyond school in private and later professional life. In relation to this issue, the third research question examined the quality of knowledge mastered at school.

At the fourth level, students’ general cognitive skills (and some learning-related affective attributes) were assessed. First of all, those thinking skills were included that play an important role in learning, understanding, knowledge transfer and application processes, and that are important in self-development. For the two latter levels, theoretical resources and empirical results of modern cognitive research were utilized.

To place the problem into a developmental context, the assessments were carried out in two age groups. In the framework of a cross-sectional design (beyond the subject matter specific knowledge tests), the same tests (the third and fourth levels) were administered to Year 7 (age 13) and Year 11 (age 17) students. These two cohorts represent crucial points of schooling, since they precede the closing phase of primary and secondary education by one year. During the four years between these two points students are supposed to master a great deal of learning materials, and schools have a lot of time and opportunities to develop students’ applicable knowledge and general skills. The fourth research question is related to changes in the quality of knowledge and development of general skill; it can be answered by comparing the results of the two age groups.

Both projects—the one in mathematics and sciences and the other in the humanities—were carried out by a research team, where each member was responsible for certain areas—developing the instruments and performing in depth analyses of the given area. Beyond the main research questions listed above, a number of other particular issues were also examined. The main publications that resulted from these specific analyses will be cited in connection with the instruments.

**Methods**

**Participants**

The samples for the projects were drawn from Szeged and its metropolitan area. Szeged (about 150,000 inhabitants) is one of the largest towns in the south-east of Hungary, with diverse primary and secondary schools and higher educational institutions. National surveys show that student achievements in the schools of Szeged and its neighbourhood are close to the national average and sometimes surpass it.
For the study of age differences, samples were selected from two age groups. The Year 7 sample was drawn from the elementary schools and it was considered representative for the whole population of this age group. The Year 11 sample was proportionally selected from two types of four-year secondary schools (grammar schools and comprehensive schools) that prepare students for entry to higher education. Since vocational school students were not involved in the survey, the 11th grade sample represents only students attending four-year high schools. The number of students in each sample exceeded 500.

Sampling units were whole classes proportionally selected from the schools of the area for a proper representation of different school types. School classes as units were also used in some data analyses. Sampling and data analysis procedures were identical in the two consecutive studies and in both cohorts.

**Instruments and design of data collection**

Due to limitations in educational research (students can be tested only in a few areas, in a relatively short period), data were collected in two phases using the same model. One focused on mathematics and science (MS); and another examined humanities and social studies (HS). Some instruments and questionnaires were used in both surveys in order to check the stability of findings and the consistency of results, whereas other instruments were specific for the given project. In the following description of the instruments the acronyms MS and HS indicate the projects in which instruments were applied in the survey. Figure 1 summarizes the system of variables for the MS study, while Figure 2 visualizes the HS study. Besides the tests, a general questionnaire was also administerd to students to collect an extensive set of background data.

**Grades (MS, HS).** In Hungary a five-point scale is used for grading students’ school achievements: 1 means ‘fail’ and 5 is ‘excellent’. At the end of each semester, students

![Figure 1. The system of variables in the mathematics and science (MS) project](image)
receive a summative grade in all school subjects that reflects their global achievement during that period. These grades were collected in all main subjects (mathematics, chemistry, physics, biology, Hungarian literature, Hungarian grammar, history and foreign languages).

Knowledge tests. These tests were summative measurement tools covering students’ knowledge mastered during a school year. They were compiled by independent experts and were administered at the end of the school year. Mathematics (MS), chemistry (MS), physics (MS), biology (MS), Hungarian literature (HS), history (HS) and English as a foreign language (HS) tests were administered in the surveys. The main principle of constructing knowledge tests was that they measured students’ knowledge in the same contexts where they mastered it.

Understanding and application. These instruments were designed to assess the quality of knowledge: how well it was understood and could be applied. The tests were designed by utilizing a number of recent cognitive issues (e.g. conceptual change, science misconceptions, history misconceptions, modes of representation, transfer of knowledge). At this level we administered a Science application test (MS) validated and used previously (see B. Németh & Csapó, 1996; Csapó, 1997a; B. Németh, 1998, 2000). It consists of thirty-five items that can be solved by applying knowledge of everyday problems learned in science subjects. The Mathematics comprehension test (MS) contains problems that can be solved only if students have a deeper understanding of corresponding areas of mathematics (Dobi, 1998). A Science misconceptions task battery (MS) was used to study students’ conceptual development and conceptual consistency; from among the seven tasks of the battery, two were borrowed from the literature and five were devised for our studies (Korom & Csapó, 1996; Korom, 1997a, 1997b, 1998, 2000). As these different tasks do not cover a consistent body of knowledge, they do not form a single test. However, relationships between the achievements on these tasks were strong enough to represent them as a single variable in further computations.
The History-related reasoning test (HS) comprised twelve tasks and was constructed according to similar principles (Szebenyi & Vass, 2002). These instruments were designed to examine students’ misconceptions and were evaluated both qualitatively and quantitatively. A questionnaire was administered to examine students’ text production strategies (HS) and participants wrote a composition (Text creation test—HS) that was analysed by both qualitative and quantitative techniques (E. K. Molnár, 2000, 2002). An English language competence (HS) test measured students’ language skills in lifelike contexts (e.g. a letter-writing task; see Bukta & Nikolov, 2002). The Visual arts test battery (Spatial reasoning test, Visual environmental test, Art taste test—HS) includes a number of tasks tapping into spatial abilities and recognition of styles (Kárpáti, 2002).

Higher order thinking skills, motivation, self-concept. The Inductive reasoning test (MS) consists of a verbal analogy, a number analogy and a numbers series sub-tests (Csapó, 1997a, 1998b). In the HS project only verbal analogy sub-scales were used. The Deductive reasoning test (MS) involves the basic operations of propositional logic (Vidákovich, 1996, 1998). The Probabilistic/correlative reasoning test (MS) examines how children perceive probabilistic relationships (Bán, 1998), whereas the Critical thinking test (HS) requires critical and evaluation-type reasoning (L. Molnár, 2002).

Background variables. A questionnaire about participants’ parental education, self-esteem, future plans and other factors that may influence their achievements was administrated to each sample (MS, HS), while two further questionnaires enquired into students’ motivation and academic self-concept (Józsa, 2002).

Results and discussion

The two projects resulted in a rich description of the quality of school knowledge. I will summarize some of the relevant findings according to the research questions.

Immediate feedback that orients students’ learning: characteristics of teachers’ grading practices

This included the way students learn to learn at school, that their study habits change over time and that their learning-related attitudes develop in strong relationship with feedback received from their teachers. Since grades play a determining role in students’ careers, teachers’ grading practices were analysed at three levels. In the student-level analyses, the correlations were computed between students’ grades in school subjects and other variables. These analyses showed what the real basis of teachers’ grading was. The grades correlated with achievement test results to varying degrees: they were acceptably high in mathematics and sciences (0.5–0.6), but quite low in social studies; the lowest correlation was found in history (0.28) and
literature (0.25) in Year 11. Much lower, in many cases insignificant correlations, were found with other cognitive variables, including ones indicating understanding or applicability of knowledge in the same area; for example, in Year 11 the correlation between chemistry grade and science application test was low (0.23—see B. Németh, 1998), whereas no relationship was found between history grade and historical reasoning (—0.05—see Szébenyi & Vass, 2002).

Between-class analyses indicated large differences between school subjects (correlations were computed between means of classes: see Table 1). For example, Year 11 mathematics teachers grade their students very similarly, as the correlation between the class means of mathematics grade and mathematic test result is high, while in other subjects (e.g. in Year 7 history and in Year 11 literature) teachers’ grading is less consistent.

Within-class correlation coefficients (correlations were computed for every single class) were much lower than the above ones. These data indicate that many teachers lack a professional value system that would give a firm basis for evaluating students’ knowledge.

**Distribution of students’ subject matter knowledge**

Results of knowledge tests indicate that students mastered a large portion of the materials represented in their textbooks; the means usually varied around 50 per cent. These results confirm the hypothesis that students learn what they are expected to learn.

On the other hand, there were large variations between students, and the way they differ from each other indicates several problems. Large differences were found between the means of school classes, and also between students according to the level of education of their parents and other indicators of family socio-economic status. These results were later confirmed by the PISA (OECD, 2004) and international comparisons indicate that these types of differences are especially high in Hungary, therefore problems behind this phenomenon are more serious than in other countries.

<table>
<thead>
<tr>
<th>Subject</th>
<th>Year 7</th>
<th>Year 11</th>
</tr>
</thead>
<tbody>
<tr>
<td>Biology</td>
<td>0.67</td>
<td>–</td>
</tr>
<tr>
<td>Physics</td>
<td>0.59</td>
<td>0.61</td>
</tr>
<tr>
<td>Chemistry</td>
<td>0.63</td>
<td>–</td>
</tr>
<tr>
<td>Mathematics</td>
<td>0.75</td>
<td>0.92</td>
</tr>
<tr>
<td>English as a foreign language</td>
<td>0.52</td>
<td>0.58</td>
</tr>
<tr>
<td>Literature</td>
<td>0.46</td>
<td>0.25</td>
</tr>
<tr>
<td>History</td>
<td>0.27</td>
<td>0.42</td>
</tr>
</tbody>
</table>

*Source: Data are summarized from Csapó, 1998a, 2002.*
The major impact of family background means small school impact, and from the point of view of learning to learn, this indicates that students’ learning is probably less shaped by schools than by other environmental factors.

**The quality of students’ knowledge: application, understanding and thinking skills**

A detailed analysis of the other cognitive test revealed further problems that can be related to students’ inadequate learning. For example, the science application test indicates that students can hardly interpret some basic scientific facts in everyday contexts (B. Németh, 1998). School learning fails to replace misconceptions with sound scientific knowledge (Korom, 1998; Szébenyi & Vass, 2002). Mathematics is not well understood and students cannot solve simple problems if they go beyond the well-practised routines, even if they are simpler than the regular textbook problems (Dobi, 1998). Students cannot solve tasks embedded in communicative situations, although they perform well on vocabulary and grammar tests (Bukta & Nikolov, 2002).

Analyses that studied the relationships between the cognitive variables, for example cluster analyses, indicated that students’ knowledge is divided into two independent bodies: one mastered and applied within school learning contexts and another one originating from everyday experiences. The first one is correct from an academic, disciplinary point of view, but not usable outside the school context, and the other is more pragmatic but often leads to false generalizations; transfer is limited in both cases. Correlational analyses also revealed the major role inductive and, especially, analogical reasoning play in learning.

These results indicate a number of inadequacies in students’ learning that may be related to inefficiencies in school instruction that condition students for memorization and reproductive learning. These indications of poor learning strategies by Hungarian students were later also confirmed by the PISA study (OECD, 2003).

**The impact of schooling on the development of general abilities and thinking skills**

The most striking results of these projects were the ones that revealed how slowly general cognitive skills develop; some of them even decrease during the years of schooling. The results of some tests (identical for the two cohorts) are summarized in Table 2.

The proportion of changes over the four years of schooling varies broadly from test to test. In general, development is very slow. In two cases (correlative reasoning and visual environment), changes are negative. The more students study at school, the less they are able to recognize and accept probabilistic relationships.

**Effects of schooling on affective variables**

Another negative tendency was observable concerning affective variables. Three sets of data were available in these studies on affective variables. The background
questionnaire contained questions on how much students liked to learn each subject. In most cases, students in Year 11 showed more negative attitudes than students in Year 7; English as a foreign language was the only exception. This problem was later examined with the same technique over a broader age range (from Year 5 to Year 11), and the results were similar: physics is the least, chemistry the second least popular subject (Csapo ´, 2000). Both mathematics and biology are more popular, so there must be something wrong with the teaching of these two science subjects. The negative attitudes towards chemistry and physics indicate that students are forced to learn them without finding pleasure in them. Such practices are damaging for learning to learn; therefore, these distracting features should be identified and eliminated.

In the HS study, a mastery motivation test was administered to both cohorts. The same negative tendency was observed: Year 11 students were consistently less motivated than their younger schoolmates (Józsa, 2002).

General conclusions and implications for learning to learn and areas for further research

In our interpretation, the problems addressed by the issues of learning to learn are related to the quality, and not to the quantity, of the knowledge students master at school. On the other hand, these problems can be conceptualized so that the quality of knowledge can be characterized by quantitative measurable indicators. Such indicators have to be related to the understanding, organization, transferability and applicability of knowledge. Furthermore, learning results in better knowledge if it is supported by an elaborated affective system—which can also be characterized by quantitative indicators. This approach implies that learning competencies are not mastered in a single straightforward way, but that they are shaped by a broad range of developmental influences to which learners are exposed during their activities in and out of school. In the projects presented here, we have identified a number of problems related to the quality of learning experiences and the accuracy
and adequacy of feedback students receive from their school environment—
predominantly, their teachers.

Since the problems which hinder meaningful conceptual learning that results in
well-understood transferable knowledge are manifold, there is not a single solution
to treat them. Teaching and learning processes in school must be changed in a
number of ways. One major problem is that skills, especially students’ general
information processing skills, are not practised in the context of the learning of school
subjects. Therefore, the experiments on developing thinking skills using the embedded
approach have been extended to other areas. For example, analogical reasoning was
developed in biology materials, and the effects of training were also detected in terms
of deeper understanding and better mastery of disciplinary knowledge (Nagy, 2006).
Further experiments are in progress to improve younger students’ inductive reasoning
skills.

Further research is needed into the application of knowledge in new situations. Based
on the models of knowledge transfer and the interpretation of complex
problem solving (CPS) as application of existing knowledge to novel situations,
assessment instruments were devised that can be applied in the context of teaching
disciplinary knowledge. Such a test battery was developed by using science and
mathematics materials (Gy. Molnár, 2001, 2006). As for improving CPS, experi-
ments are being prepared for problem-based learning.

Another set of problems concerns the organization of propositional knowledge,
concept development and misconceptions. Previous assessments were extended and
further instruments were devised to monitor concept development and to promote
conceptual change (Korom, 2005). Further research was initiated to apply concept
maps both for assessing and representing students’ knowledge structures and to
device training exercises to make their learning more meaningful (Habók, 2004). An
experiment is presently in progress in this area.

As was realized at several points in the research, a major difficulty is related to
the evaluation of students’ knowledge. To solve this problem a number of instru-
ments have been devised to assess the quality of students’ knowledge and to monitor
their development. To improve the feedback students receive from their teachers,
we should further differentiate and enrich the evaluation technique and instru-
m ents; thus, a variety of formative and diagnostic tests is needed. Furthermore,
since teachers are the most important resources of school instruction, better
preparation of teachers and more elaborated knowledge about student learning is
required.

Finally, empirical studies have resulted in a theoretical generalization that
synthesizes different approaches to identify and classify the goals of schooling and
the organization of knowledge (Csapó, 2004).

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