

A photograph of a classroom with several children sitting at desks. In the foreground, a boy in a green shirt and a girl in a white shirt are seen from behind. Other children in red shirts are visible in the background. There are storage bins and a green box with the number '2' on it.

Silvija Markic  
Simone Abels  
Editors

EDUCATION IN A COMPETITIVE AND GLOBALIZING WORLD

# Science Education towards Inclusion

Faint, light-colored icons of a chemical structure, an atom, and the equation  $E=mc^2$  are scattered around the title text.

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**SCIENCE EDUCATION  
TOWARDS INCLUSION**

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**SCIENCE EDUCATION  
TOWARDS INCLUSION**

**SILVIJA MARKIC  
AND  
SIMONE ABELS  
EDITORS**



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*Chapter 3*

## **LANGUAGE IN SCIENCE CLASSROOMS: DIAGNOSING STUDENTS' LINGUISTIC SKILLS**

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### **ABSTRACT**

When you notice that you are not feeling well, normally you don't just take any old medicine that you have lying around. The doctor also does not prescribe random drugs to treat your malady. First, the problem is analyzed and diagnosed before any cures are attempted. Based on different projects with German science teachers, we noticed that language and students' poor linguistic skills are two of the main barriers to the teaching and learning of science in heterogeneous classrooms. Although recognizing the problem, many science teachers are insecure about how to deal with it. Furthermore, they are worried that all of the language problems found in different studies might also be the problems occurring in their own classrooms. This factor makes knowledge of exactly which linguistic skills students possess extremely important for dealing with linguistically heterogeneous classes in science. The first step in the process is a diagnosis of students' linguistic skills. But in order to perform such an analysis, teachers need to have the relevant knowledge about and competency in using diagnostics in the classroom. The following chapter will give a short overview of the literature concerning science teachers and language in heterogeneous classes, before it turns to diagnostic competence and the process of diagnosis in science lessons. Several ideas for diagnosing language skills in heterogeneous science classes will be given, as well as a few suggestions and methods for dealing with linguistically mixed classes.

### **INTRODUCTION**

The modern world is characterized by high levels of mobility among people groups. Different political, environmental and ecological influences touch peoples' lives, often

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influencing them to change how or where they live. The result is that individuals leave their homes, sometimes becoming political or economic refugees, and translocate from one country to another. Very seldom do such people speak the new language in the country where they end up. They are faced with the challenges of acclimatizing to their new environment, culture and language(s). We can directly observe these changes in our classrooms. Students from scattered parts of the world sit in the same classroom and are confronted with same content matter and teaching materials. However, each student is different and brings his or her own strengths, weaknesses, and skill sets to the learning environment. A group discussion between many science teachers in the city-state of Bremen, Germany revealed that the main noticeable differences between students are their culture and, even more pronouncedly, their knowledge of the German language. This factor seems to be the same for schools all over the world. Research in the field of linguistic heterogeneity is constantly growing and advancing all over the world (see Markic and Abels, 2014).

Observation of students' linguistic skills in the language spoken in a given country has already been shown to have different factors influencing learners' overall language skills. Collier (1987) listed the factors of (i) the student's age of arrival in the new country, (ii) the total length of residency in that country, (iii) the grade level entered in a new school, (iv) the speed of acquisition of primary reading and writing skills, (v) a person's formal educational background, (vi) the family's educational and socio-economic background, and (vii) any former exposure to the new country's lifestyle. It is interesting to note that students with poor linguistic skills are sensitive to the language, which for them is mainly a second language. However, they often have great difficulties understanding the new language and therefore possess fewer possibilities for actively participating in school lessons and thereby further developing their linguistic skills (Seedhouse, 2004). Additionally, these students have problems understanding the lesson which are independent of the learning material and teaching method employed. Teachers very often attribute less content knowledge to students with poor linguistic skills, which is not true. Experiencing this situation, many students lose motivation for the subject and cease participating in the lessons. Finally, differences between the linguistic skills of native and non-native students have been observed to grow over time.

But which languages are spoken in the science classroom? A naive separation would consist of the differentiation between the native language of the country and the jargon of science. But, it is not quite as simple as that. Next to the scientific language which needs to be learned and used in science classes, students speak everyday life languages. Such speech can differ not only from one student to another, but is also primarily dependent upon the learners' socio-economic background and/or their migration background. Additionally, teachers' language differs as well. They use educational language, which differs in many facets from the everyday language of students. In summary, science lessons contain a minimum of three different languages: (i) scientific language, (ii) everyday language and (iii) teaching language.

Different studies have shown that teachers tend to speak differently to second language learners (mainly focused on English Language Learners (ELL)). They speak more slowly to these students, telling them exactly what to do. If they ask students questions, they are mainly yes-no questions, not queries focusing on higher competences (Verplaetse, 1998). Moore (2007) showed that the teachers are sensitive to the influence of students' linguistic skills on their learning. However, the teachers in Moore's study were Native Americans who had already experienced such language issues in their own youth. Cho and McDonnough (2009) revealed in their study that even teachers with special ELL training were faced with the

difficult challenges of the language barrier and ELL students' lack of foundational science knowledge. Furthermore, Lee et al. (2009) showed that there is little to no exchange with other teachers about this topic. If the problem is discussed, educators tend to pay attention to the specific problems, but don't deal directly with them or attempt to find a cooperative solution. Bryan and Atwater (2002) have shown that science teachers don't feel personally responsible for explicit language education in the native language of the country, nor do they see the direct development of students' linguistic skills as belonging to their area of expertise. Instead they view this condition as a given stemming from outside their own subject area. The study also revealed that teachers do not have active, rigorous strategies for dealing with linguistically heterogeneous classes. Finally, Benholz and Iordanidou (2004) concluded that teachers plan their lessons for monolingual classes.

## DIAGNOSTICS IN SCIENCE LESSONS

### The Need for Diagnosing

When a person feels sick, they go to the doctor. The doctor asks the patient for the symptoms of the illness, so that a possible diagnosis can then be ascertained. In order to reach an appropriate and precise diagnosis, the doctor performs different tests such as observing body temperature, pulmonary function, blood or urine analysis, X-ray pictures, etc. After the illness has been isolated and diagnosed, the medical expert will then prescribe a regimen of treatment. The doctor must observe the patient continuously and react to inappropriate or ineffective therapeutic measures immediately until the pain and symptoms of the illness disappear.

The example above shows that diagnostics are an important instrument for the medical treatment of patients. Without diagnostics doctors have extremely limited possibilities for carrying out meaningful medical treatment. It should be noted that a good diagnosis also includes a corollary medical treatment. Furthermore, diagnostics are important not just in medicine, but also in the context of school and science lessons as well. The above example can be transferred to school situations, even if diagnosis in the classroom is much more complicated and unrelated to physical health issues.

This is why teachers in general and science teachers in particular need to intimately understand their students' needs, knowledge, interests, motivations, and also their individual skills and abilities. Educators need to consider this knowledge when planning their lessons. This is especially important due to the growing levels of heterogeneity and diversity observed in the classroom. In order to focus more intensely on linguistic heterogeneity in science classes, it is important for science teachers to both know how to diagnose students' linguistic skills and to have a plan for dealing with it, so that they can help their students more effectively participate in class.

Diagnosis stems from the Greek words "dia" and "gnosis." *Dia* means apart or separate. *Gnosis* connotes recognizing, perceiving or knowing. The original meaning of the word diagnosis therefore was to distinguish or to discern something. Diagnoses are necessary in many occupations, so that problems or difficulties can be adequately recognized and addressed.

## The Process of Diagnostics

At the beginning of a diagnosis, the diagnostician faces a problem or question which should be answered by the end of the process (Füchter, 2011). The diagnostic process can be subdivided into at least three steps:

1. *Preparation*: The reason or the cause of the diagnosis should be stated at the beginning of the process. In addition, the diagnostician should take into account the relevant questions, hypotheses, expectations, diagnostic instruments and the methods (Füchter, 2011). Jäger (2006) says that questioning and hypothesizing are essentially important for a functioning diagnosis.
2. *Data*:
  - *Data collection*: The diagnostician obtains the relevant data.
  - *Data analysis*: The collected data must be analyzed, evaluated and compared with both the theory and expectations of the diagnostician (Füchter, 2011; Jäger, 2006).
3. *Conclusion*: At the end of the diagnostic process, the diagnostician should come to a conclusion. This can be grading, planning and carrying out a forecast with supportive measures, or the development of lesson plans (Füchter, 2011; Jäger, 2006).

Heidemeier (2005) describes the diagnostic process as cyclical, since the implementation must be re-evaluated at the end of the cycle. He also describes other factors which can affect the results, e.g., scales, rating instruments, and the purposes of the rating process. Many subsequent cycles of diagnostics can and should be performed, since new questions may arise during the process. Klug, Bruder, Kelava, Spiel, and Schmitz (2013) presented a 3-step cyclic process in their model of the diagnostic process (Figure 1): pre-actional (judgment calls, methods and quality criteria), actional (gathering information, acting systematically) and post-actional (feedback, promotion). In this case points 2.1 and 2.2 (see enumeration on top) are summarized in one dimension (Klug et al., 2013). The intermediate steps of the diagnostic process help teachers in the planning and implementing of pedagogical-didactical diagnosis.

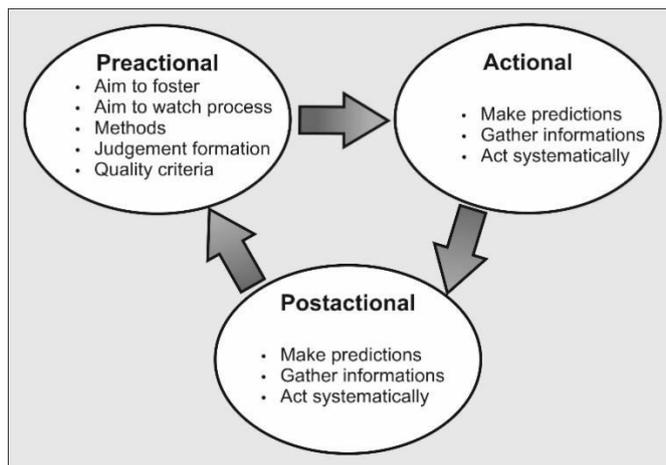


Figure 1. Cyclical process of diagnostic. (adapted from Klug et al., 2013)

Von Aufschnaiter et al. (2015) warned that different understandings of diagnostics arise (or have arisen in the past) because no systematic differentiation exists for separating the object of diagnostics from the methods and the target. Therefore, four different kinds of diagnostics in a school context could be worked out by the authors from the current position of research:

- *Status diagnostics*: A learner's present competence or present characteristics should be evaluated at a specific time. This can be carried out at different time points, either at the beginning, middle or end of the learning process. In general, the methodology is not limited, but usually employs pen-and-paper tests. The aim of such diagnostics is not unequivocal. On the one hand it can be used to test starting points, but it can also examine the end results of learning (von Aufschnaiter et al., 2015).
- *Process diagnostics*: The process of diagnostics tries to evaluate different ways of solving a given task. In this case, competencies are also identified with a focus on the process of finding solutions, e.g., the different challenges students face or the coverage time for a topic. These methods are limited, since the process itself must be recorded. Video recording or thinking out loud are both helpful methods. The aim of process diagnostics is mainly the evaluation of the changes taking place during a process. This includes an offer of support, if needed. Because the answers are collected at the end of the solution process, status diagnostics are included in the process diagnostics, too (von Aufschnaiter et al., 2015).
- *Change diagnostics*: In change diagnostics, at least two diagnostic methods are compared with each other to reach a conclusion about any changes in competence (growth, stagnation or decrease in skills). Depending on which kind of diagnostic is chosen (status- or process-diagnostics), the relevant instruments are selected based on this choice. The comparison of two status diagnoses can lead to different results, as can comparison of two process-based diagnoses. The aim is the triangulation of the data (von Aufschnaiter et al., 2015).
- *Course (progress) diagnostics*: This type of diagnostic attempts to evaluate the changes taking place between at least two different treatments and to reasonably explain the resultant changes. Therefore, this kind of diagnostic expands upon change diagnostics, with a special view towards the processes themselves. Video-, audio-recordings and direct observations can all be used (von Aufschnaiter et al., 2015).

## Diagnoses in School Context

During the last few years diagnostics have become increasingly popular in both general and science education research (Chandrasegaran, Treagust, and Mocerino, 2007; Klug, 2011; Vogt and Rogalla, 2009; Wagner, Göllner, Helmke, Trautwein, and Lüdtke, 2013). However, even in early 1980s diagnosis and diagnostic skills were already being mentioned in the research literature (Coladarci, 1986; Gillespie, 1991; Shulman, 1986). The connection between diagnostics and a higher level of teaching and learning effectiveness is very highly correlated (Fischer et al., 2014).

Furthermore, the importance of a particular type of diagnostic is discussed very differently in science as compared to an educational setting. If teaching diagnostics or teachers' diagnostic skills is discussed in a school context, these concepts appear together with: 1) the handling of heterogeneity (Grossenbacher, 2010), 2) inclusion (Florian and Black-Hawkins, 2011), 3) the teaching creation of the lesson plan (Vogt and Rogalla, 2009), 4) the individual support of students (Barke, Hazari, and Yitbarek, 2009), 5) the diagnosis of learning disabilities (Williams, 2013), 6) discussing misconceptions in science education (Barke et al., 2009), 7) addressing teachers' competence and knowledge (Loughran, Berry, and Mulhall, 2006) or 8) with the mention of linguistically-sensitive lessons (Markic, Broggy, and Childs, 2013).

Generally, a diagnosis includes all diagnostic activities which evaluate the conditions and the skill set of the individual or group learner, which can be observed during a planned teaching and learning processes. Diagnostics also includes analyzing the learning processes and evaluating learning outcomes, with an aim at optimizing individual learning. Furthermore, diagnostic activities also cover the placement of students into certain learning groups or individual support programs. Thus, the process of diagnostic consists not only of evaluating and analyzing students, but also preparing and developing mechanisms to support and advance them in their efforts (Ingenkamp and Lissmann, 2008).

In a school context two directions are normally described: 1) the pedagogical-psychological diagnosis and 2) the pedagogical-didactical diagnostic (Figure 2).

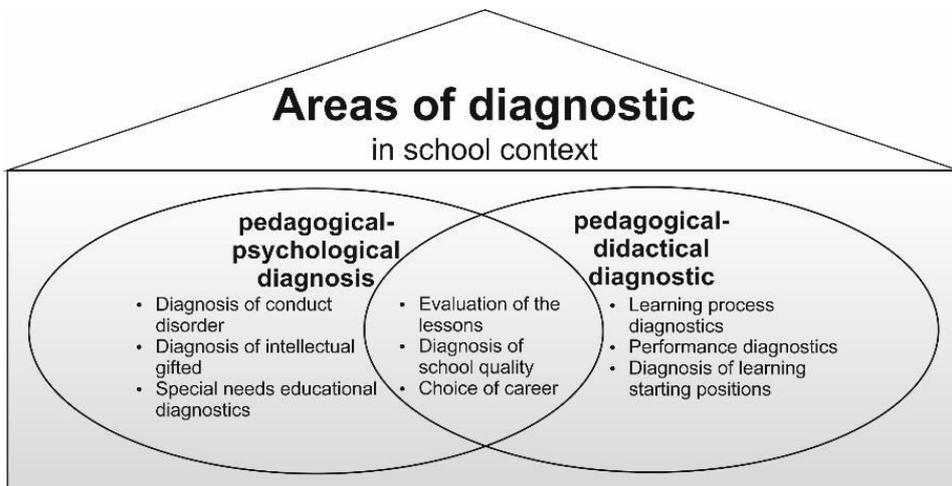


Figure 2. Areas of diagnostics. (adapted from Fächter, 2010)

Pedagogical-psychological diagnostics include the discovery of learning difficulties, behavioral disorders or lacking intellectual skills. Pedagogical-didactical diagnostics covers the diagnosis of learners' starting points, their specific learning processes and student performance. In general, both areas of diagnostics will influence the school lessons, however the pedagogical-didactical diagnostics is the form generally carried out by the teacher. The pedagogical-psychological diagnostics tends to be carried out by outside specialists. These two different task settings cannot be unambiguously considered separately. For example, both the diagnosis of lesson plans and the diagnostics of social and cognitive-emotional ability can

either be assigned to the pedagogical-didactical or to the pedagogical-psychological arena (Füchter, 2011).

Finally, teachers need to diagnose permanently in their classes. In their educational daily lives teachers must understand and review the social relations among their students, the positive achievements and negative difficulties among learners, students' skills, and learners' specific needs in a given situation (e.g., any necessary additional materials or specific inquiries). Daily diagnostics performed by teachers in the classroom for their pupils is often undertaken implicitly and does not rely on theoretical knowledge (Hesse, 2014). Bromme (2005) stated that implicit diagnostic is primarily used in the lessons. This can be useful, because teaching is very complex and teachers lack both sufficient time and the capacity for explicit diagnostics. An exact judgment is a costly thing which cannot consistently, repeatedly and easily be performed for each and every learner on an ongoing basis, due large class sizes and resource constraints. The three quality criteria for a test instrument (objectivity, reliability and validity) do not exist in this type of diagnosis. Instead non-quantifiable, interpersonal skills such as gut feeling, a close knowledge of the individuals in the class, and a grasp of the ever-shifting dynamics in large learning groups take precedence in making informed, effective decisions. Unfortunately, such interpersonal skills are largely ignored in most university teacher training programs. Yet teachers also have the power to directly affect the assessment of their students either negatively and positively (Hesse, 2014).

The following classical errors of assessment and perceptions can be listed:

- a) *Pygmalion effect*: If a teacher is friendlier to one student than to the others, this affects the student's self-confidence and behavior. Students with positive expectations from teachers are supported more often or obtain additional help when dealing with special tasks. They tend to be favored (Hesse, 2014). Jussim (1989) showed that there is a connection between the assessment of students' effort and their marks.
- b) *Primacy effect and recency effect*: These effects both imply that the information received both before and after the diagnosis have a large influence on assessments either at the beginning or end of observations, conversations or in education generally (Murdock, 1962 cited by Brodie and Murdock, 1977).
- c) *Halo effect*: This effect was described for the first time by Thorndike in 1920 (Fiscaro and Vance, 1994). The dominant characteristics of one person are so strong that they affect other issues which need to be diagnosed. An achievement-oriented student is often viewed as highly intelligent and highly motivated.

Assessments are influenced by tendency errors or evaluative sets as well:

- *Leniency and severity effect*: The diagnostician (here the science teacher) gives bad marks to a student. The reason may be that the teacher's popularity should not sink among the students or because the teacher orients student performance to the teacher's standards (Stuart-Hamilton, 2007).
- *Central tendency effect*: This effect is seen when evaluation is aimed at the middle group on a bell curve and no extremely good or extremely poor grades are awarded to anyone in the group (Stuart-Hamilton, 2007).

- *Reference error*: Here one characteristic of a single person is transferred onto the entire group, making the diagnosis subjective, e.g., slow or problematic students color the perception of the entire class (Hesse, 2014).

In contrast to implicit diagnostics, there are also explicit (or professional educational) diagnostics, which should be high-quality instruments. Explicit diagnostics tries to transfer scientific constructs, methods and instruments to the diagnostics at school, so that mistakes are minimized.

## Occasions for Pedagogical-Didactical Diagnostic

Pedagogical-didactical diagnostics can be used with flexibility in lessons and in school in general. Basically, there are two possible main focuses for this kind of diagnostic exist: *final assessment of learning processes* and *lessons-related performance diagnosis* (see Figure 3; Schrader, 2013).

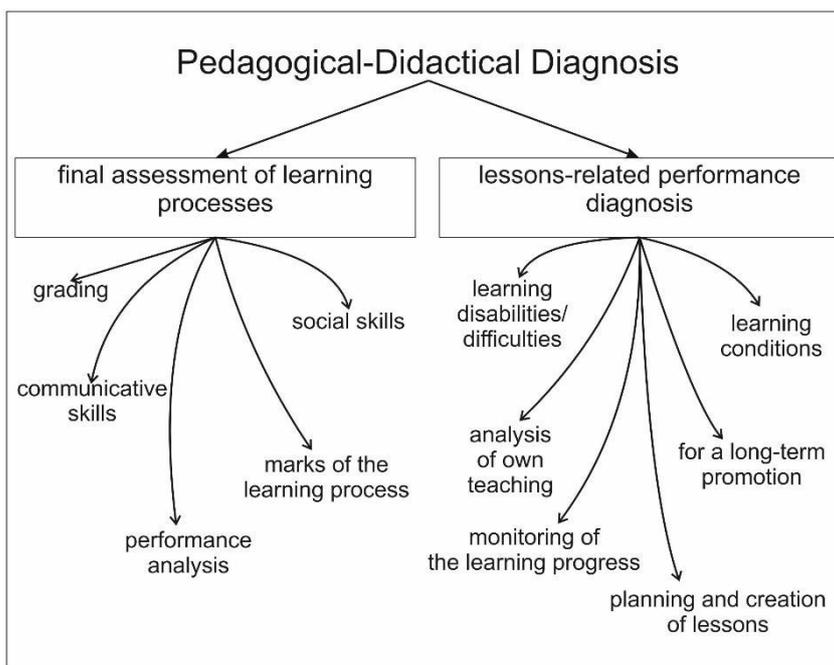


Figure 3. Structure of the pedagogical-didactical diagnosis.

The first type of diagnostic is designed to measure students' learning success and to grade them at the end of a teaching unit. Marks are used for assigning authorizations (certificates) or by the selection purpose linked with it (e.g., an occupation that requires special or extra training or study). Thus, these results can have long-term consequences for students (Brookhart, 2011). Student achievement can be measured by diagnosing learners' cognitive levels (Füchter, 2011). In addition, achievement can be also diagnosed on the basis of the learning process and the learning path, e.g., formative assessment (Heritage, 2010).

Additionally, diagnostics can be used to examine students' social and communicative skills. In any case, the educator's personal assessment, evaluation and the assignment of marks should be double-checked by other people (Hesse, 2014). The quality criteria should be strongly considered when evaluating the significance of the diagnostics (Füchter, 2011).

The second focus (lessons-related performance diagnosis) attempts to monitor and to optimize teaching and learning processes (Nitko and Brookhart, 2007). Education must be oriented toward students' knowledge base, their preconceptions and skill sets. All of these must be adapted in the lesson (adaptation). This kind of diagnostic is very important when teaching students with different linguistic skill levels, different cultural backgrounds (see also chapter of Essex in this book) or special needs (see also chapter by Abels and Minnerop-Haeler or Supalo in this book). Measurements can either be long-term and focused on larger teaching units (macro adaptation) or short-term and focused on a single lesson (micro adaptation) (Schrader, 2013). The measures can vary:

- *Assessment of learning conditions*: Learning conditions include factors such as foreknowledge, intelligence, learning strategies, learning motivation and learning-relevant emotions. These conditions correlate in varying degrees with learning success. Especially in hierarchical school disciplines like chemistry, language or mathematics, knowledge gaps can affect future learning outcomes decisively. A detailed diagnosis of the learning situation and conditions is important for a new class or whenever a change in educational courses occurs (Füchter, 2011).
- *Diagnosis of the initial position for longer-term support and promotion*: Students' knowledge and their skills are examined differently to eliminate any important or fundamental gaps (e.g., lacking reading ability or mathematical skills for science education) over a longer period. Adequately supporting students in their efforts can be done only by an exact diagnosis (Hesse, 2014).
- *Diagnosis of learning disabilities and learning difficulties*: The main focus here is the analysis of the causes for difficulties, lack of foreknowledge or skills. Here, scientifically developed assessment methods are often used which contain sub-scales of specialist skills in order to achieve valid results about the students. Because existing problems should be solved, the diagnostician should ensure that the students receive positive feedback (What can the student do well?) (Schrader, 2013).
- *Control and monitoring of the learning progress*: During the lessons, the teacher should positively supervise the learning progress of students so that this controls learning (Schrader, 2013). Shepard (2001) states that this kind of diagnostic cannot uphold the high quality criteria, but he also suggested that teachers should use already developed observation and interview formats.
- *Diagnosis for the own lesson*: For the planning and the creation of lessons, teachers should know the individual abilities, interests, social abilities, working behaviors and personal motivations of their students. This allows them to flexibly and effectively adapt their lessons (e.g., efficient methods and group constellations in the class) to the group (Hesse, 2014). The approach called adaptive teaching by Vogt and Rogalla (2009), for example, tries to orient teaching on students in this manner.
- *Analysis and development of teachers' own teaching*: Until now the current discussion of diagnostics has focused mainly on the students. But the reason for a

learner's failing or the origin of some misconceptions can also be placed at the feet of lessons themselves (Barke et al., 2009). This is why teachers should constantly evaluate themselves and their lesson planning as well. Students can offer feedback to their teacher, so that the teacher receives insight into the lessons from the perspective of the learners (Schrader, 2013). Through analysis of their own lessons, teachers can develop and optimize them and the planning process (Hesse, 2014). In many modern schools, teachers use simple, effective and quick feedback methods such as "10-finger feedback" (zero = very bad, 10 = excellent) or short oral feedback rounds with or without visual aids (for example, laminated red, yellow and green paper strips) to ask for negative, neutral or positive feedback from a class. In many instances a simple question thrown out to the group suffices to uncover ideas which normally would never see the light of day. For example: "What can we do to make this lesson better the next time around?" or "What was too fast/too slow, interesting/boring, relevant/irrelevant, etc. this time?" Learners are usually not just passive consumers of an educational product produced by an expert, but also critical thinkers when it comes to evaluating the learning process from their side of the school bench. And free information costs teachers absolutely nothing but a few minutes of time at the end of the lesson. It also serves to strengthen the interpersonal bonds of respect, team-spirit, responsibility, share-holding and admiration which need to exist and grow between all participants in a successful learning group.

## Diagnostic Competence

Diagnostic competence is an essential characteristic of a professional teacher. In order to obtain a proper diagnosis in school of factors like students' linguistic skills in language heterogeneous classes, the teacher must possess the relevant diagnostic skills and qualifications such as knowledge about adequate methods and instruments which can be used to answer a certain question.

However, the effectiveness of such competency has been little studied to date (see Abell, 2007; Hattie, 2009; Loughran, Mulhall and Berry, 2008). For dealing with the knowledge level (or professionalism) of teachers, the concepts of Pedagogical Content Knowledge (PCK), Content Knowledge (CK) or Pedagogical Knowledge (PK) are usually cited. The PCK construct is widely employed in science education research. It was first mentioned by Shulman (1986). Later, Shulman (1987) arranged teachers' professional knowledge in seven categories. Many models use three of Schulman's seven dimensions (PCK, CK and PK) and then extend or differentiate this "trichotomy" (Abell, 2007; 2008; Frey and Jung, 2011; Loughran et al., 2008; Park and Oliver, 2007). Starting from this basis, different PCK models are discussed in science education research (e.g., Frey and Jung, 2011; Loughran et al., 2006).

Finally, PCK also includes knowledge about students' foreknowledge and an explicit understanding of students' individual characteristics, including how to define and diagnose such factors (see Loughran et al., 2006). Four of the six categories from the differentiated hexagon model of PCK by Park and Oliver (2007) include aspects of pedagogical diagnosis. Therefore the construct of diagnostic competence can be recognized in the PCK from Shulman (1987), Loughran et al. (2006) or Park and Oliver (2007). Diagnostic competence cannot merely be described as a subcomponent of PCK. Krauss et al. (2004) defined

diagnostic competence as not just one competence, but rather as multiple facets of competencies. However the terms “diagnostic competence” and “diagnostic skills” have long ago established themselves in the research literature (Krauss et al., 2004).

Schrader (2013) describes teachers' diagnostic competence in two parts. It is (i) an ability to successfully cope with tasks which appear and (ii) a construct possessing the qualities of an exact diagnosis (Schrader, 2013). Thus, the focus is here on the quality of the diagnostic. This explains why diagnostic competence has mainly been studied in view of the exactness or correctness of a diagnosis since the 1970s (Klug, 2011; Perry, Hutchinson, and Thauberger, 2008). Which competencies, partial competencies, knowledge components or abilities a teacher must possess, however, are not described in Schrader's definition. In a model developed by Klug et al. (2013) partial steps in the diagnostic process are described. These steps are defined as spheres of activity. Many models of diagnostic competence (e.g., Klug, 2011) differentiate inadequately between the object of study and the methodology employed (von Aufschnaiter et al., 2015).

Jäger (2006) defines diagnostic competence by using of six partial competencies. However, he called them knowledge. The sixth one – psychodiagnostical competence – is described as a general competency and comes from the field of psychology. Thus, in a school context this competency is not needed. The other five competences listed are:

1. *Competence knowledge* – the diagnostician has sufficient knowledge to be able to answer a specific question. If the teacher does not possess this, then he or she must either extend his knowledge or ask a more competent person for assistance.
2. *Conditional knowledge* – knowledge about the given background of one person, influences that affect their experiences or cause certain behaviors. In addition this includes knowledge of such effects and their possible manifestations in a given survey.
3. *Technological knowledge* – the ability to select the most appropriate data collection and analysis methods for diagnostic questions.
4. *Knowledge of change* – knowledge development which includes the application of strategies dealing with changing the learner experience and/or the behavior of those involved in the interactions.
5. *Knowledge of the comparison* – knowledge about the classification of behavior with a comparative group (Jäger, 2006).

Jäger (2006) views the first competence as important only for psychologists, but Fächter (2011) disagrees. For him this competence is very important for teachers, because this protects them from becoming trapped by unnecessary, further issues. Thus in a diagnosis of dyslexia, for example, the teacher would employ and trust a professional in an area outside of his or her own area of expertise to reach a proper decision.

## DIAGNOSING IN LANGUAGE HETEROGENEOUS CLASSES

### Instruments for Diagnosing Language in Science Classes

As mentioned at the beginning of this paper, language and linguistically heterogeneous classes are perceived as a huge barrier to teaching science effectively. However, it is vital to know which language skills students possess and, even more specifically, which obstacles hinder students from completely understanding the language spoken at school, in order to teach science in such classes.

Methods like concept cartoons can be used as language diagnostics. More information about this can be found in Ryan and Childs or in O’Leary in this book. Other diagnostic instruments are questionnaires, different forms of feedback, and thinking aloud (see Noh, Jeon, and Huffman, 2005). Hattie and Timperley (2007) have stated that feedback is a strong factor which influences learning and performance. The influence can be either positive or negative. Complex instruments (like audio- and video-recordings) are uncommon in school life, since teachers don’t have the time and organizational resources in the everyday life at school (Klinger, 2011). Such methods often require the explicit permission of parents in written form to be legal, which entails the added headache of preparing a parent letter and enduring the (often torturous) waiting period until all the pupils in the group have turned the completed form in to the teacher.

In the next section, different possibilities for diagnosing students’ language skills will be given. The Joint Committee on Standard for Educational and Psychological Testing (1999) describes standards which should be valid for diagnosis. The International Test Commission (2013) has also published guidelines for test application. If these standards are adhered to at school, one can expect high quality in the results. The standards can be transferred to other methods, but should not be discussed further.

Thus, the ideas presented in following section are not official, standardized tests, but can still help a teacher to achieve an overview of the starting point for planning her/his lessons.

### Multiple-Choice Questionnaire

Originally, multiple-choice-questions were developed to diagnose students’ misconceptions (Chandrasegaran et al., 2007; Treagust, 1988). Students were required to find the right answer out of four or five possible answers. This idea can be transferred to diagnosing language. Different aspects of language can be tested by multiple-choice questionnaires, e.g., the direct or indirect articles used in German/French/Italian or the conjugation of verbs with the proper endings in these languages (Figure 4).

The test tube, ...

- a. in where I put the fluid was broken.
- b. in what I put the fluid was broken.
- c. which I put the fluid in was broken.
- d. where I put the fluid was broken.

Figure 4. An example of a multiple-choice question.

## Cloze Test

Traditionally, a cloze test is used for the assessment of native and second language learning and instruction. It is an assessment based on a written text where certain words (or part of the words) are removed. The students are then asked to replace the missing words or the part of the words. Thus, by using cloze tests teachers can evaluate their students' ability to understand both context and vocabulary and to identify the correct words (or parts of words) which are missing (Nielsen, 2011). An example is given in Figure 5 (see also chapter by Childs and Ryan in this book).

How to use a burner?  
First, you ne\_\_ to turn of the gas and igni\_\_ the burner with the striker. If you want to cont\_\_ the temperature of the flame, adjust the vol\_\_ of gas and air that enters the burner. You can cont\_\_ the gas flow is by rotating the small valve at the base of the burner. You can cont\_\_ the airfl\_\_ is adjust\_\_ by open\_\_ or closing the holes at the end of the barrel of the burner.

Figure 5. An example of a cloze test for testing students' linguistic skills.

## Concept Maps

A concept map is a diagram that portrays the suggested relationships between concepts or words (Chang, 2002; Davis, 1994). In linguistically heterogeneous classes it is good to use such maps not only to see if students understand the connection between different contents (like reduction and oxidation), but also to find out if and how well students can express this connection. Here it is interesting to note which level of language competency is employed when describing the connection. Furthermore, this approach can provide valuable clues as to which grammar obstacles the students are facing. In addition to language, concept maps can also be used to diagnose students' observations during experiments, their activities during team work, and the level and quality of student-teacher interaction. It is important that the students are familiar with this method and that they understand its meaning and relevance. Therefore, it is important to explain concept maps to the pupils and practice using them before using them officially.

## Self-Diagnostic

The students can diagnose themselves independently or mutually. Students' self-diagnoses can be aided by the teacher by introducing self-assessment formats, checklists, or diagnostic tests (Füchter, 2011) or through the creation exercises for exams by the learners themselves (Topping, 2009). Orsmond, Merry and Reiling (1996) showed that peer-assessment can influence students' learning effectively and, furthermore, that this can influence the learning process positively.

Students can be asked to write a text about a certain topic. Then other students check the text for spelling, grammar and content errors and explain any corrections that they had to

make. People are generally more adept at finding other peoples' errors than they are at identifying their own.

## **DEALING WITH LANGUAGE HETEROGENEITY IN SCIENCE CLASSES**

As mentioned above, one of the steps in the diagnostic process is reaching conclusions and implementing support structures for students in science classes. Several methods are discussed below to show how science teachers can deal with linguistic heterogeneity in the classroom (see also Henderson and Wellington, 1998 or Markic et al., 2013).

### **Listing the New Words**

After introducing new vocabulary words in class, it helps if students list all of the words covered in the lesson on the board (or on a poster). This can be supplemented by pictures, symbols and explanations in different languages. The method makes sure that students can correctly spell the words, know their meaning, and wherever possible, know something about the structure of the words. They can also return to the word lists if they forget how to spell the word, etc., which acts as a fail-safe mechanism and confidence-builder, especially in younger learners. This is also effective as an aid for homework or tasks which should be carried out outside of the classroom or school.

### **Practicing New Words**

Implementation of new terms should be followed by multiple, repeated use. In foreign language lessons, for example, learners often require dozens or even hundreds of repetitions to correctly memorize and master new vocabulary or grammar structures. Different games (see chapter by Childs and Ryan in this book) and exercises should follow directly after the introduction of new terms. The games should also make sense, but be short and succinct. Training through homework assignments may help when supported by short repetitions at the beginning of each single lesson or even face-to-face recitations among the students. Such activities can also be strengthened and made into positive learning habits by the introduction of such strategies as making learning card catalogs, using flash card games, and the creating a personal cheat-sheet which is discarded directly before an exam or quiz.

### **Field of Words**

A field of words is a disordered arrangement of words or parts of sentences about one specific topic (see Figure 6). For students with weak language skills, some words or parts of the sentence can also be connected. However, students are required to put the words in order, connect them, and finally write a sentence and then a whole text. This approach is helpful, because both the articles for the nouns and the irregular verb forms are used in the exercise.

This method is good for pupils who are familiar with the grammar of the language spoken in school, but whose vocabulary is still underdeveloped. It mirrors the exercises frequently used in foreign language lessons which jumble sentences together, then ask the learner to find the correct word order for the sentence.

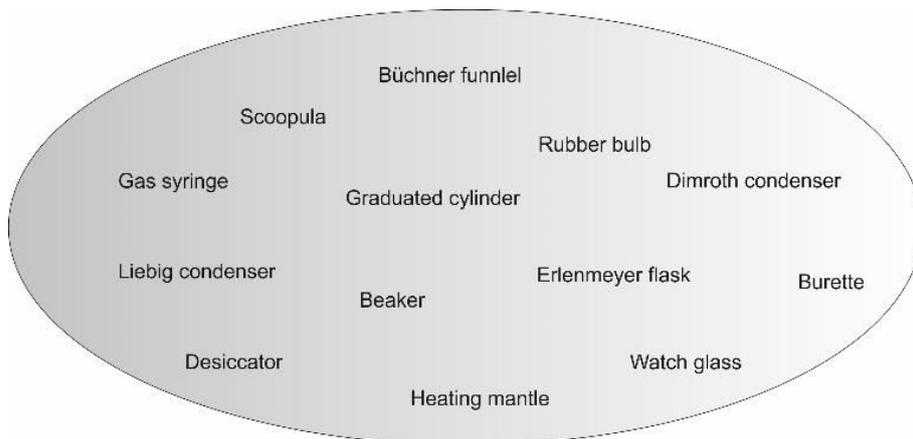


Figure 6. Field of words.

## The Beginning of the Sentence

Writing a sentence is often incredibly difficult for many students, however, the most difficult part is usually starting the sentence. Learners typically struggle with combining the first words of a sentence in a meaningful sequence. By providing pupils with the beginnings of sentences, the teacher can help them to write a sentence on their own, express their opinion, and show their knowledge about the topic. However, the beginning of the sentence also indicates what the expected content will be, since many languages place the stress of the sentence on the element which is presented first. For example, there is an important difference in stress in the sentences: “Yesterday I ate pizza.” and “I ate pizza yesterday.” due to the position of the words (time of occurrence versus the action itself). Such factors help learners develop a “gut feeling” for what is expected in the particular language they are trying to master. The number of words given at the beginning of a sentence should depend on the students’ level of linguistic competency. Sometimes it is enough to give the first word of the sentence. It stimulates progress and serves as an incentive to organize the words in the student’s head. In other cases, it is necessary to give an entire phrase or even half-sentence. Sometimes it is even important to give the endings of sentences and let the pupil (especially younger or inexperienced ones) the support of knowing that there are beginnings and endings for every sentence that they must “solve” to arrive at the correct answer. This can be extremely important in cases of learning disability or the trauma of “new country, new culture, new school, new class, new language” which so often accompany children of all ages with migration backgrounds for many years after they immigrate into a new setting.

## **Block-Diagram**

In a block-diagram the different parts of a sentence (noun, pronoun, verb, conjugation, adverb, and adjective) are provided. Students can use these parts to compose sentences in the proper sequence and, in doing so, they can express their ideas and personal knowledge in adequate form. Furthermore, it is possible to include a column with appropriate scientific terms as an aid. However, this can be flexibly decided by the teacher, depending on the learner's cognitive level. The block-diagram is especially useful for training students in specific syntactic constructions linked to scientific terms. It is important to note that the parts of the sentence given in a block-diagram are not parts of specific sentences. The words are intended to help students to build their own sentences. The block-diagram helps learners when the word is "missing" while they were verbalizing their own observation and knowledge.

## **CONCLUSION**

It is obvious from the above discussion that diagnostics in school are an essential part of the educational system. Knowledge won through such tools can only enrich lessons and aid students in advancing their personal knowledge and levels of educational success. The diagnostic process can either be carried out by science teacher or by a professional researcher, especially when it comes to a pedagogical-psychological diagnosis. In order to perform implicit diagnoses, science teachers also need to possess diagnostic knowledge, which needs to be developed during teacher training programs (Tolsdorf and Markic, in print).

However, diagnostics in school are also critical. It can easily be understood if teachers are generally not performing diagnosis in their lessons, since diagnosing each student in each class takes time and resources. This becomes particularly problematic when educators must teach very large numbers of students or are faced with high levels of substitute teaching. Especially for the case where pedagogical-psychological diagnosis is necessary, experts are needed (e.g., special need support or language support). Unfortunately, only very few schools and/or school systems have colleagues with such capabilities. Even if experts who possess the relevant instruments and strategies for diagnosis are available, the question remains as to how much experience they possess and what knowledge they have acquired which can aid in specifically supporting students in science lessons. One solution might be the cooperative work of teachers with different expertise and backgrounds in a mutually-supportive setting. Markic (2011; 2012) has already shown in her study of science teachers and German-Second-Language teachers that cooperative work in developing teaching and learning materials shows promise. This approach offers a way to create motivating and attractive learning environments, which allow science teachers to help their students not only to learn chemistry, but also to improve their knowledge and competency in the German language.

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