38 Teaching the Language of Technology: Toward a Research Agenda

Gerald van Dijk and Maaike Hajer

Abstract

At all levels of technology education, language plays an important role. This chapter combines insights from applied linguistics, the philosophy of technology, and the pedagogy of technology to explore characteristics of the specific language requirements of technology and the way in which students can be guided in the intertwined development of subject and language. More than traditional grammar, Systemic Functional Linguistics offers tools to describe the language of technology as a multimodal resource for meaning making, including textual (oral and written) and graphical modes. Elaboration of writing tasks that are closely related to "designing" and "systems thinking" reveals that language demands can only be understood from a content perspective. These demands depend on choices for pedagogy and orientations to technology education: vocational skills training could ask for writing tasks describing procedures, while orientations toward technological literacy could result in texts that discuss the impact of technologies on societies.

The chapter further outlines content and language integrated approaches and discusses their potential for teaching technology, taking into account the specific position of learning at the edge of school and workplace. What these approaches have in common is that technology and engineering teachers need knowledge about language that can be considered part of pedagogical content knowledge. The chapter concludes with a broad outline for further multidisciplinary research and development.

G. van Dijk (✉)
HU University of Applied Sciences Utrecht, Utrecht, The Netherlands
e-mail: gerald.vandijk@hu.nl

M. Hajer
HU University of Applied Sciences Utrecht, Utrecht, The Netherlands

Malmö University, Malmö, Sweden
e-mail: maaike.hajer@hu.nl

M.J. de Vries (ed.), *Handbook of Technology Education*, Springer International Handbooks of Education, DOI 10.1007/978-3-319-44687-5_40

Keywords
Design • Genre • Language • Systems

Contents

Introduction

Technology is often perceived as a school subject that has relatively little to do with language (Van der Velde 2010). Kimbell and Stables (2008), however, point out that designing, which is considered core content in technology, involves interaction between mind and hand. Thinking and learning in technology, as in other school subjects, involves language. This chapter first describes general key features of the language of technology in authentic contexts and school contexts. Secondly, approaches toward integration of language development in subject pedagogies are described, and their potential for technology teaching is being discussed. Finally a research agenda is proposed.

General Characteristics of the Language of Technology

A simple sentence can be used to clarify a few characteristics of knowledge in technology and the language that is used to construct such knowledge.

> The printer must be capable of printing A4 paper.

The artifact name "printer" says something about the purpose of the artifact, its functional nature. "A4" refers to a norm that has been collectively decided upon in the paper industry for reasons of efficiency (Vaesen 2013). Furthermore the description is only valid for this particular instance, where a printer needs to be designed for a specific context. In more general terms, this sentence represents knowledge in technology that is descriptive, normative, part of collective decision-making, and context dependent, rather than aiming for universal truths, which are all characteristics of knowledge in technology (Meijers and Kroes 2013). Rossouw et al. (2011) conducted a Delphi study and identified "design" as one of the core concepts in technology, along with systems, modeling, resources, and values. If this is indeed basic to technology's conceptual framework, then the language of technology should reflect this framework. This will be illustrated later in this chapter for "designing" and for "systems."

A fundamental question, which is addressed by philosophers of technology, is whether all knowledge in technology can be expressed in language. Arguably, "knowing how" can be seen as a kind of "knowing" that cannot be expressed in words, unlike "knowing that" (Ryle 1949). Ryle argues that the kind of "knowing" that is involved in tying a complex knot (p. 56) is nonpropositional, as it cannot fully and certainly not effectively be explained in words alone. Whether this assertion is true or not, it serves as a warning that language should not be foregrounded in all instances of learning in technology, even though "knowing how" and "knowing that" are often developed simultaneously (Norström 2014).

Language is not necessarily limited to verbal, written language. Linguists (Kress et al. 2001) and researchers in technology education (Banks and Barlex 2014; Kimbell and Stables 2008; Middleton 2013) would agree that the language of technology is multimodal in the sense that it includes graphic representations as a mode. Ferguson (1994) asserts that engineering heavily depends on nonverbal understanding and that graphic representations are equally, if not more important than text. In an example about the design of a "liquid level controller" for oil wells, Ferguson explains how parts working together realize the controlling function of the system. He uses a cross-sectional diagram and 106 words with numerical references to the diagram (Ferguson 1994, p. 33). Clearly a combination of text and graphic modes is needed to explain how the system works.

Another important mode is oral language, for instance, in face-to-face meetings between designers discussing qualities of a design (Allan 2013). Boundaries between different modes of communication are increasingly blurred as a result of the advent of new communication technologies (Lemke 2006), but for the purpose of this chapter, we distinguish between oral and written modes, the latter including graphic modes. In the next section, fundamentals of linguistics are used to present a more precise description of language demands inherent in technology education.

Linguistics and Subject-Specific Language

Often terminology is regarded as emblematic for the language of a subject (Phillips and Norris 2009). But there is more to language in technology than isolated technological words that denote tools, components, materials, or concepts. Traditionally, linguists distinguish between levels in language systems as phonology (sounds), morphology (word forms), syntax (sentence structure), and text structure. Semantics describes how meaning is expressed by using these grammatical elements. From the 1970s, the focus on language structure was criticized by linguists, who argued that communicative competence includes not only grammatical knowledge but also knowledge about how language systems are used in social contexts (De Oliveira and Schleppegrell 2015; Leung 2005). From this period, sociolinguistics studied the interplay between language use and its functions in educational, professional, and other contexts, often with regard to social class and power relations.

The attention to specific characteristics of subject-specific registers, as of technology and engineering, has been pushed by a need for professional language courses for adult professionals entering the English-speaking world. A different branch of applied linguistics, "English for Specific Purposes" (*ESP*) focuses on "needs of learners and analyses language demands in terms of grammar, lexis, register, study skills, discourse and genre" (Dudley-Evans and St-John 1998, p. 4). ESP-oriented research, for instance, yielded an analysis of communicative events that engineers face in high-tech industry (Spence and Liu 2013) and an analysis of how engineering students express affect and agency in their writing (Archer 2008).

A theory of language, less dominant than traditional grammar, is Systemic Functional Linguistics (*SFL*). It integrates language forms and meaning making with social contexts. SFL does so by starting from the functions or purposes for which people interact in different types of oral and written texts, called "genres" (Halliday 2004). Examples of genres include descriptions, narratives, explanations, and instructions. The way meaning is created is analyzed from three angles. First, "field" denotes what language in context is about. Second, "tenor" expresses how roles and relationships between writer or speaker and reader or listener shape the text. Third, "mode" describes choices for oral, written, or graphic representations and text coherence. SFL-based analyses have shown to be relevant for studying language in professional school contexts where specific genres can occur such as an instruction to make a kite (Derewianka 1990). Such instructional texts are described in terms of text organization, types of verbs and tense, "linking words," and examples where such instructions are used (Rose and Martin 2012). SFL offers tools to grasp the specific characteristics in a more functional way, because of its focus on language use as a social practice. However, no comprehensive SFL-based studies in the field of technology have been found so far.

Language Demands in Technology Education

We need to distinguish language inherent in knowledge in technology from language demands in technology education. Orientations to technology education vary greatly (Norström 2014), and these orientations influence language demands. If vocational skills training is the primary orientation, writing tasks may primarily target describing procedures and relevant applications of the skill in particular situations as well as students' insight into their own progress in mastering the skill. The latter would require the students to be able to write reflective texts in a highly personalized voice, most likely using the first-person singular form. Another orientation would be toward technological literacy (ITEA 2007) and could result in tasks involving discussing the impact of technologies on societies like reading texts on the use of drones by journalists.

Furthermore, technology education is a practice of its own, which comes with discourses and language demands reflecting educational as well as authentic technological practice. For writing in science, Hand and Prain (2012) distinguish in a review study between the genre perspective and the *writing to learn* perspective (p. 1376). In genre pedagogy, an induction perspective is emphasized, whereby students read, analyze, and produce authentic texts grounded in the sociocultural practices of the discipline. By doing so, they are enculturated, and at the same time, the language patterns in these prototypical texts serve as a model to organize thought in a disciplinary way. The "writing to learn" perspective results in writing diverse text types that do not necessarily resemble disciplinary genres. Drawing on research into effective conditions for learning, Hand and Prain (2012) state that "students need to write in diverse ways for different readerships to clarify understanding for themselves and others" (p. 1375). Distinguishing between these perspectives provides clarity for researchers and teachers, but in teaching, they may appear combined. The same distinction can be made for oral genres. Students in technology education are not only enculturated in ways of talking that are intrinsic to authentic practices. They are also expected to participate in pedagogic discourse unique to schools, such as exchanges between students and the teacher about a design problem, a discourse with its own linguistic demands (Christie 1998).

In spite of the acknowledgement of the importance of language in technology education, no linguistic analyses were found of language demands in specific content domains of technology. For the concept of "systems," for instance, Klasander (2010) mentions the existence of ontological, epistemological, environmental, and control language, but his work does not extend to linguistic analysis at the level of whole texts, paragraphs, sentences, and words. The same holds for "designing" (Kimbell and Stables 2008; Barlex 2007). These two core concepts (Rossouw et al. 2011), designing and systems, will now be used to illustrate how pedagogy of technology and linguistics can be used in combination, to achieve a better understanding of language development in technology education.

Designing

Kimbell and Stables (2008) developed models for design portfolios as a means to promote and assess "designerly thinking." The questions that students answer in their portfolios stimulate the interaction between mind and hands. Students are, for instance, required to explain how their design could be improved to cater for specific needs of potential users. As such, these portfolios fit the above-described "writing to learn" perspective. This approach to writing in design education has indeed proven to foster "designerly thinking" (Kimbell and Stables 2008). However, such portfolios can be seen as pedagogic genres, resembling professional designers' texts only to a limited extent. A student's entry in his digital design portfolio illustrates this point: “First thing tomorrow I will get my model out and then get some tubing [. . .]” (Kimbell and Stables 2008, p. 132). The student uses a highly personal voice (tenor), which is functional given the objectives behind the portfolio as mentioned above but which is not appropriate in, for instance, an architect’s portfolio, meant to inform potential clients. Text organization in a student’s design portfolio that forefronts the learning process will also be different from text organization in a professional design portfolio.

Barlex (2007) argues for “cultural authenticity” in design texts and for a “minimally invasive approach,” in which writing tasks do not unnecessarily interrupt the design process. Culturally authentic components of a design portfolio can be a “job bag” and a product description. A job bag is a loose collection of sketches, photos, and notes that the student finds useful to retrieve ideas during later design activities. A product description could take the shape of a folder for an audience of potential customers for the product, in which the writer would be less visible than in Kimbell and Stable’s design portfolio. To assess “designerly thinking,” without interfering with the design process too strongly, Barlex suggests that writing tasks include short justifications of a few design decisions. A justification can be seen as an argumentation, which is a genre that has been explored extensively by linguists (Rose and Martin 2012).

“Systems”

Development of students’ thinking in terms of “systems” can be promoted by setting a task that results in a product that includes graphic representations and text, for instance, about an electrical system in the house. The product will typically include a description of the function of the system, a description of its components, an explanation of the way the components work together to achieve the function (Norström 2014; Svensson and Ingerman 2010), and a reference to system boundaries (Klasander 2010). A part of the explanation could deal with maximum power load: “If more apparatus are switched on, the current adds up, because it is a parallel circuit.” The word “because” is a “cohesive device” to mark cause-and-effect relations as part of the explanation (Rose and Martin 2012). It is also noteworthy that this student may have understood that the personal pronoun “I” would not be functional in this particular explanation. The explanation uses scientific theory, which is supposed to be objectified, universal, and therefore written in an authoritative rather than a personal tone (Rose and Martin 2012). Another feature of the explanation is the use of specialized vocabulary, such as “current” and “parallel circuit.” Depending on the educational context, students need to understand and produce specialized technology vocabulary, even though the bandwidth for the correct use of concepts is sometimes larger in technology than in science as a result of technology’s aim for usefulness rather than for universal truths (Norström 2014).

So far we have used core content in technology education, designing, and systems, to give examples of language demands. Similarly, language demands associated with other core concepts, modeling, resources, and values (Rossouw et al. 2011) could be distinguished. Such analyses contribute to formulating specific language objectives as part of a language and content integrated approach in technology education. The question now arises how technology teachers can plan and support student development of the language of technology.

Planning for Subject-Specific Language Development

Integration of language development in content areas has its roots in the education of second-language learners. Cummins (1979) related second-language learners' school success to their command of "Cognitive Academic Language Proficiency" (*CALP*) that is to be distinguished from "Basic Interpersonal Communication Skills" (*BICS*). This distinction is still used (Leung 2014), though it is characterized more as a continuum than as a dichotomy (Gibbons 2009). Table 1 lists and illustrates the differences between BICS and CALP.

The development of CALP would require a prolonged period of guidance and careful instruction. Different organizational models addressed the question where this guidance could best be located. The "content-based approach" of language learning (Brinton et al. 1989) regards content of school subjects as a starting point for program development for intermediate and advanced second-language learners. Language and content teachers play different roles in these models, from which "sheltered instruction" is of specific interest for this chapter. Here, content teachers prepare their lessons by explicitly formulating language objectives, using a range of specific instruction techniques to deliver content (Echevarria et al. 2013).

Table 1 BICS and CALP

	Characteristics (Cummins 1979; Leung 2014)	Example (Gibbons 2002)
BICS	Meaning is familiar within context	*We tried a pin . . . a pencil sharpener . . . some iron filings and a piece of plastic . . . the magnet didn't stick to the pin*
	Immediate situation at hand provides cues for meaning	
	Familiar forms of language, more oral-like	
	High-frequency words	
CALP	Nonroutine meaning expressed through language, without cues from immediate situation	*A magnet is an object that produces a magnetic field. This magnetic field is responsible for the force that pulls on other magnetic materials, such as iron, and attracts or repels other magnets*
	Unfamiliar forms of language	
	Low-frequency words	
	Complex syntax, more written-like	
	Abstract expressions that are not common in everyday conversation	
	Understanding and producing CALP is associated with academic progress	

Second-language acquisition theory accounts for the main headings of sheltered instruction teaching strategies: providing comprehensible input, opportunities for oral and written language production in classroom interaction, and provision of feedback. Examples of sheltered instruction, specifically for technology education, have been described by Van Dijk (2011). A considerable body of literature on science education argues for such an integration of language and content pedagogies (Wellington and Osborne 2001); some studies demonstrate their effectiveness (Hand and Prain 2012). Practical examples can also be found within the context of Content and Language Integrated Learning (*CLIL*) in foreign language programs. Students can be offered writing frames as prestructured outlines for their lab reports; they are offered explicit activities on science vocabulary or reading strategies to focus their attention while reading for meaning in science schoolbook texts (Vollmer 2006).

Gibbons' (2009) "high challenge-high support" approach can be placed in this family of content and language integrated approaches. Gibbons shows how teachers in subject areas can plan scaffolding language learners from oral, contextualized language through oral academic tasks into the written academic language along a mode continuum. Another approach is SFL-based genre pedagogy (Bawarshi and Reiff 2010; Rose and Martin 2012) in which teachers take a steering role in explicitly teaching the language of text types. In a teaching-learning cycle, introducing new subject knowledge to the group is followed by explicit deconstruction of texts and explication of language features. A phase of joint construction, led by the teacher, is followed by independent writing. Thematic content receives attention throughout the process, at times specifically focusing content representation in texts using SFL-based analytic tools.

These approaches have in common that subject teachers need knowledge about language (*KAL*) (Love 2009). Van Dijk et al. (2016) found that giving specific feedback on students' use of language in science and technology requires KAL to be relevant from the perspective of the content, viable, and complete enough to aid teaching in specific areas of the subject. KAL in this sense is seen as part of pedagogical content knowledge (Shulman 1986).

A Language-Sensitive Pedagogy of Technology

In this section, the potentials of content and language integrated teaching for technology are elaborated upon. This will lead to an outline for future research in this field. The paragraph structure follows Hajer and Meestringa's (2015) content and language integrated approach, which centers around "integration of content and language objectives," use of context, interaction, and high support in understanding and producing the language of a school subject.

Content and Language Learning Objectives

In order to plan for students' learning, teachers need to be able to distinguish language as part of their learning objectives. These explicit language objectives can be shared with students, at a level that is comprehensible and meaningful for them, in order to make them aware of what is expected in terms of language comprehension and use and integrate these objectives in the evaluation of students' learning.

The Role of Context

The meaning of words depends on context. Reference to contexts can aid understanding, successful use of technology concepts, and the transition from BICS to CALP. An additional and more sociocultural perspective on context takes account of the situation and the culture in which whole texts are used (Gilbert 2006; Rose and Martin 2012). Examples from authentic discourse practices can be used to illustrate how the context shapes a text. Information about solar panels is, for instance, presented differently in a folder aimed at consumers as compared to a textbook. Using authentic texts, both oral and written, from daily life and from vocations and elaborating on the way the context shapes the text make working with texts more meaningful (Allan 2013; Rose and Martin 2012).

Promoting Interaction and Language Production

Technology education is rich in opportunities for interaction that promote language development, both between the students and the teacher and between the students themselves. Interaction is inherent in design activities that are often collaborative in nature, both in authentic practice (Meijers and Kroes 2013) and in schools (Fox-Turnbull 2016). In her chapter in this volume, Fox-Turnbull highlights the role of intercognitive conversation plays in technology education. However, this does not automatically result in pedagogy that fosters language proficiency (Damhuis and De Blauw 2011). Planning for challenging and scaffolded interaction, in which students are stimulated to use disciplinary language, is a core feature in different content and language integrated approaches.

In paragraph "Language Demands in Technology Education," examples of writing tasks in technology education have been given. However, the learning environment is not always suitable for writing, and students may be apprehensive to write, because they perceive technology as a practical subject. For reasons we have outlined above, this perception is not entirely conducive to learning, even though we acknowledge the vital role of practical work. Students' awareness of the potential of writing for learning, aimed at conceptual understanding or at producing disciplinary genres, is required to broaden the focus on more than just superficial aspects of writing (Ellis et al. 2006). This calls for the teacher to share pedagogic motives behind writing (and drawing) tasks.

The Need for High Support

Gibbons (2009) offers a range of teaching strategies, which scaffold students' oral and written language use toward an academic, subject-specific language. "Writing frames" (Lewis and Wray 1998), for instance, provide a skeleton of a text and thereby scaffolding texts organization and sentence construction. Such support may, for instance, target the students' ability to produce specialized forms of reasoning in technology. If, for instance, learning objectives include the ability to justify a design decision (Barlex 2007; Kimbell and Stables 2008), a simple writing frame could take the shape: *I decided to use . . . against corrosion, because . . .*

Mastering specialized vocabulary can be supported by the use of diagrams and schemes, such as graphic organizers and concept maps, showing how concepts in technology are related. The provision of explicit feedback on language is another central form of support in content and language integrated approaches. In order to become proficient in the language of technology, students furthermore need to be exposed to high-quality examples of this language (Rose and Martin 2012). Textbooks and digital sources offer examples of multimodal technology language that can be deconstructed in class. Research in science education, however, warns us that textbooks do not necessarily model language as it is used in authentic practice. Textbooks in science need to explain content with students as an audience, which results in a genre that has limited resemblance with authentic genres. This problem might exist in technology education too. If so, textbooks need to be developed to include model texts. Alternatively, teachers can complement textbooks with (adapted) primary literature (Phillips and Norris 2009), such as a professional product description, or a justification for a design decision. Such texts can then be made accessible for students, by giving language support, and serve as model texts.

Challenges for Vocational Education

Vocational and engineering education has its own challenges with regard to a language-sensitive pedagogy of technology. Learning does not only take place in school but also at the workplace, which to some extent coincides with the theory-practice divide (Kilbrink 2013). Institutional boundaries create challenges for learning but also a learning potential (Akkerman and Bakker 2011). Collaboration between teachers and workplace coaches is needed in the area of the student's language development, aiming for a common understanding of the level of domain-specific language proficiency that is needed at the workplace. Collaboration is also useful for the construction and use of learning materials that can function as boundary objects (Akkerman and Bakker 2011) between these institutional contexts. An example of a boundary object is an internship report. Both teachers and coaches at the workplace can clarify what language is expected, in terms of general language characteristics as spelling and grammar but also in terms of specialized technology language. Again, in this collaborative effort, a focus can be used on text organization that is purposeful for sections of the text, multimodality, specialized vocabulary, and a functional tenor.

Further Research

In this chapter, a brief characterization has been given of the language of technology and a content and language integrated pedagogy of technology. Collaboration between researchers from applied linguistics, researchers in the pedagogy of technology, and teachers is required to uncover more systematically what is special and vital about oral and written language of technology. From such insights, curriculum design studies can show how students can learn to master both language and subject at different stages of education, with respect to different orientations such as vocational education, design education, and technological literacy. Such studies could also focus on the way the language of technology is modeled in curricula, by the teacher, or through multimodal teaching resources.

Multidisciplinary collaboration can also generate examples of interventions that are content specific and that help students to master the language of technology. Research should also address teacher development on this specific theme and study how teachers can learn to apply such pedagogy, both in initial teacher education programs and through professional development programs. Given the complexity of the matter, programs are only likely to be successful if they span a prolonged period of time and if the level of knowledge about language needed is relevant and viable for content teachers (Holmberg 2009).

This chapter aimed to contribute to the identification of a research agenda that takes the intricate relationship between technology and language into account and that aids the development of a language-sensitive pedagogy of technology. Increasingly diverse student populations, as well as calls for twenty-first century skills, that can be seen as a combination of literacies indicate the urgency of this research agenda in the foreseeable future.

References

Akkerman, S., & Bakker, A. (2011). Boundary crossing and boundary objects. *Review of Educational Research, 81*(2), 132–169.

Allan, E. G. (2013). Multimodal rhetorics in the disciplines: Available means of persuasion in an undergraduate architecture studio. *Across the Disciplines*, *10*(2). Retrieved 21 Mar 2017, from http://wac.colostate.edu/atd/articles/allan2013.cfm.

Archer, A. (2008). 'The place is suffering': Enabling dialogue between students' discourses and academic literacy conventions in engineering. *English for Specific Purposes, 27*(3), 255–266.

Banks, F., & Barlex, D. (2014). *Teaching STEM in the secondary school: Helping teachers meet the challenge*. London: Routledge.

Barlex, D. (2007). Assessing capability in design & technology: The case for a minimally invasive approach. *Design and Technology Education: An International Journal, 12*(2), 49–56.

Bawarshi, A. S., & Reiff, M. J. (2010). *Genre: An introduction to history, theory, research and pedagogy*. Indiana: Parlor Press.

Brinton, D. M., Snow, M. A., & Wesche, M. B. (1989). *Content-based second language instruction*. Boston: Heinle & Heinle Publishers.

Christie, F. (1998). Science and apprenticeship, the pedagogic discourse. In J. Martin & R. Veel (Eds.), *Reading science: Critical and functional perspectives on discourses of science*. London: Routledge.
Cummins, J. (1979). Cognitive/academic language proficiency, linguistic interdependence, the optimum age question and some other matters. *Working Papers on Bilingualism, 19*, 121–129.
Damhuis, R., & De Blauw, A. (2011). High quality interaction in science and technology education. In M. De Vries, H. Van Keulen, S. Peters, & J. Walma van der Molen (Eds.), *Professional development for primary teachers in science and technology* (pp. 199–215). Rotterdam: Sense.
De Oliveira, L., & Schleppegrell, M. (2015). *Focus on grammar and meaning*. Oxford: Oxford University Press.
Derewianka, B. (1990). *Exploring how texts work*. Newtown: Primary English Teaching Association.
Dudley-Evans, T., & St-John, M. J. (1998). *Developments in English for specific purposes: A multi-disciplinary approach*. Cambridge, UK: Cambridge University Press.
Echevarria, J., Vogt, M. E., & Short, D. (2013). *Making content comprehensible for English learners: The SIOP model* (4th ed.). Boston: Allyn & Bacon.
Ellis, R., Taylor, C., & Drury, H. (2006). University student conceptions of learning science through writing. *Australian Journal of Education, 50*(1), 6–28.
Ferguson, E. S. (1994). *Engineering and the mind's eye*. Cambridge, MA: MIT Press.
Fox-Turnbull, W. (2016). The nature of primary students' conversation in technology education. *International Journal of Technology and Design Education, 26*(1), 21–41.
Gibbons, P. (2002). *Scaffolding language, scaffolding learning. Teaching second language learners in the mainstream classroom*. Portsmouth: Heinemann.
Gibbons, P. (2009). *English learners, academic literacy, and thinking: Learning in the challenge zone*. Portsmouth: Heinemann.
Gilbert, J. K. (2006). On the nature of 'context' in chemical education. *International Journal of Science Education, 28*(9), 957–976.
Hajer, M., & Meestringa, T. (2015). *Handboek taalgericht vakonderwijs*. Coutinho: Bussum.
Halliday, M. A. K. (Ed.). (2004). *The language of science*. London: Continuum.
Hand, B., & Prain, V. (2012). Writing as a learning tool in science: Lessons learnt and future agendas. In B. J. Fraser, K. G. Tobin, & M. R. CJ (Eds.), *Second international handbook of science education* (pp. 1375–1384). New York: Springer.
Holmberg, P. (2009). *Tid att lära genre. Utvärdering av "Språket i skolans ämnen och skolans ämnen i språket"*. Malmö: Resurscentrum för Mångfaldens Skola.
ITEA. (2007). *Standards for technological literacy: Content for the study of technology* (3rd ed.). Reston: International Technology Education Association.
Kilbrink, N. (2013). Transfer of learning through integration of theory and practice in technical vocational education. In H. E. Middleton & L. K. J. Baartman (Eds.), *Transfer, transitions and transformations of learning* (pp. 69–84). Rotterdam: Sense.
Kimbell, R., & Stables, K. (2008). *Researching design learning: Issues and findings from two decades of research and development*. Dordrecht: Springer.
Klasander, C. (2010). *Talet om tekniska system: Förväntningar, traditioner och skolverkligheter*. Linköping: Linköpings Universität.
Kress, G., Jewitt, C., Ogborn, J., & Tsatsarelis, C. (2001). *Multimodal teaching and learning: The rhetorics of the science classroom* (p. 223). London: Bloomsbury.
Lemke, J. (2006). Towards critical multimedia literacy: Technology, research, and politics. In M. McKenna, D. Reinking, L. Labbo, & R. Kieffer (Eds.), *International handbook of literacy & technology* (2nd ed., pp. 3–14). Mahwah: Erlbaum.
Leung, C. (2005). Convivial communication: Recontextualizing communicative competence. *International Journal of Applied Linguistics, 15*(2), 119–144.
Leung, C. (2014). Researching language and communication in schooling. *Linguistics and Education, 26*, 136–144.
Lewis, M., & Wray, D. (1998). *Writing across the curriculum: Frames to support learning*. Reading: Reading and Language Information Centre, University of Reading.

Love, K. (2009). Literacy pedagogical content knowledge in secondary teacher education: Reflecting on oral language and learning across the disciplines. *Language and Education, 23* (6), 541–560.

Meijers, A. W. M., & Kroes, P. A. (2013). Extending the scope of the theory of knowledge. In M. J. De Vries, S. O. Hansson, & M. AWM (Eds.), *Norms in technology* (pp. 15–34). Dordrecht: Springer.

Middleton, H. E. (2013). Representation in the transition from novice to expert architect. In H. E. Middleton & B. LKJ (Eds.), *Transfer, transitions and transformations of learning* (pp. 109–122). Rotterdam: Sense Publishers.

Norström, P. (2014). How technology teachers understand technological knowledge. *International Journal of Technology and Design Education, 24*(1), 19–38.

Phillips, L., & Norris, S. (2009). Bridging the gap between the language of science and the language of school science through the use of adapted primary literature. *Research in Science Education, 39*(3), 313–319.

Rose, D., & Martin, J. R. (2012). *Learning to write, reading to learn: Genre, knowledge and pedagogy in the Sydney school*. Bristol: Equinox.

Rossouw, A., Hacker, M., & De Vries, M. J. (2011). Concepts and contexts in engineering and technology education: An international and interdisciplinary Delphi study. *International Journal of Technology and Design Education, 21*(4), 409–424.

Ryle, G. (1949). *The concept of mind*. New York: Hutchinson's University Library.

Shulman, L. S. (1986). Those who understand: Knowledge growth in teaching. *Educational Researcher, 15*(2), 4–14.

Spence, P., & Liu, G. (2013). Engineering English and the high-tech industry: A case study of an English needs analysis of process integration engineers at a semiconductor manufacturing company in Taiwan. *English for Specific Purposes, 32*(2), 97–109.

Svensson, M., & Ingerman, A. (2010). Discerning technological systems related to everyday objects: Mapping the variation in pupils' experience. *International Journal of Technology and Design Education, 20*(3), 255–275.

Vaesen, K. (2013). Artefactual norms. In M. J. De Vries, S. O. Hansson, & A. W. M. Meijers (Eds.), *Norms in technology* (pp. 119–136). Dordrecht: Springer.

Van der Velde, D. (2010). Co-development of language and technological literacy. In M. J. de Vries (Ed.), *Positioning technology education in the curriculum* (pp. 180–188). Rotterdam: Sense Publishers.

Van Dijk, G. (2011). Learning language, learning technology. In M. J. de Vries (Ed.), *Positioning technology education in the curriculum* (pp. 165–178). Rotterdam: Sense Publishers.

Van Dijk, G., & Hajer, M. (2016). Specifying knowledge about genres for science teachers: An inventory for practical report writing developed in science teacher training, Orlando: American Association for Applied Linguistics (AAAL).

Vollmer, H.J. (2006). Language across the curriculum. Presented at an intergovernmental conference on languages of schooling: Towards a framework for Europe. Strasbourg: Council of Europe.

Wellington, J., & Osborne, J. (2001). *Language and literature in science education*. Buckingham: Open University Press.