

# Using Popper's Philosophy of Science to Build Pre-Service Teachers' Knowledge

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## Abstract

Over a series of influential publications, the philosopher of science, Karl Popper, developed an account of how scientific knowledge grows. This article explores the use of Popper's account, referred to here as the Objective Knowledge Growth Framework (OKGF), in order to guide the growth of professional knowledge among a group of pre-service teachers. The evidence from the study shows that this method of critical self-learning does facilitate a useful trajectory for professional knowledge growth.

**Keywords:** knowledge growth; criticism; error elimination; falsification; critical self-learning

## 1. Introduction

Critical thinking has become an educational focus at all levels of study in countries around the globe (Bailin, Case, Coombs, & Daniels, 1999), and is explicitly featured in elementary and secondary school curriculum documents where educational reforms have recently occurred (Howe, 2004). However, even though critical thinking is touted as an educational ideal, research suggests that it is not being put into practice, and traditional transmissive teaching practices abound (Paul, Elder, & Bartell, 1997; Swartz, 2004). This is due to the fact that some scholars believe: “experienced teachers are analogous to ‘master craftsmen’ ... in school-based components of their pre-service education, student-teachers should learn through gaining access to the craft knowledge of experienced teachers” (Brown & McIntyre, 1993, p. 12). They also draw on Lortie’s (1975) notion that “craft is work in which experience improves performance” and it “cannot be learned in weeks or even months” (Brown & McIntyre, 1993, p. 18). This model is based on the acquisition of a discrete set of skills during isolated and decontextualized situations which most of the pre-service and in-service teachers are most familiar with.

The educational ideal of teaching in a ‘critical manner’ refers to “teaching so as to develop in the students skills and attitudes consonant with critical thinking” (Siegel, 1980). Certainly, teaching in a critical manner necessitates that the teacher is a critical thinker. If a teacher holds critical thinking skills and possesses a critical disposition, then he or she will have the ability and desire to teach in a way that helps students attain similar skills and dispositions. Both pre-service and practising teachers have been shown to not only lack critical thinking skills and dispositions, but also lack an awareness of their deficiencies (Paul, 1993; Paul, Elder, & Bartell, 1997). Our educational institutions from elementary to graduate schools encourage dogmatism and attach little importance to critical approach. Various models such as mentoring and peer-coaching have emerged (Britton & Anderson, 2010; Pajak, 2003; Shower & Joyce, 1996; Goldhammer, 1969) to strength teachers’ knowledge, critical thinking skills and dispositions so as to affect teacher performance and student learning outcomes.

Regardless of the types of professional models, their aim is to promote teacher knowledge. Theoretical frameworks for teacher knowledge have been proposed by a number of researchers (Cochran-Smith & Lytle, 1999; Fenstermacher, 1994; Grossman, 1990; Shulman, 1987). Of particular interest here is the knowledge-in-practice perspective initiated by Cochran-Smith & Lytle (1999) which constitutes part of the most essential knowledge for teaching and is perceived as knowledge that is embedded in practice. Schon (1995) considers knowledge-in-practice grounded in professional activity. This study extends specific aspects of the knowledge in-practice by proposing the Objective Knowledge Growth Framework (OKGF), which is based on Popper’s philosophy of science. Popper (1963) argues that knowledge progresses through a process of conjecture and refutation. Thus, if practising teachers are to develop sustainable professional knowledge, perhaps they ought to adopt a framework for pedagogical reasoning that would allow them to uncover the inadequacies of their current teaching theories and methods by criticizing them and showing either that the theories have unacceptable consequences or that they do not solve the problems they have set out to solve. Furthermore, the framework gives teachers the initiative to plan and select their

own learning goals based on the assessment of their needs. Research also shows that studies carried out by researchers have little practical use to teachers and serve to perpetuate a misleading dichotomy between theory and practice (Nielsen et al., 2008). The professional development potential of OKGF in allowing teachers the autonomy to identify their own problems not only provides them with opportunities for critical thinking skill development but also allows them to question the taken-for-granted assumptions of the world of practice and of the nature of knowledge in use.

This paper first describes Popper's idea that knowledge progresses through falsification, which is the central idea of Popper's philosophy of science, and not through observations or repetitive tasks. Next, findings from pre-service teachers in a compulsory course in a teacher education program are used to illustrate how OKGF has promoted teachers' critical thinking and how such an approach has helped them successfully make decisions in new or uncertain contexts when faced with a limited amount of knowledge. Finally, a discussion on the merits and limitations of the framework as an alternative professional development model is provided.

## **2. What is Teacher Knowledge?**

The concept of a knowledge base for teaching has been extensively examined by a number of researchers (e.g., Shulman, 1987; Grossman, 1990; Elbaz, 1981; Fenstermacher, 1994; Cochran-Smith, & Lytle, 1999). It constitutes the most essential basis for teaching because it is embedded in practice (Schon, 1995). However, teachers' action needs to be sustained with reflection for knowledge to be refined and for teachers to master their craft (Schon, 1983; Danielson, 2002). Furthermore, knowledge does not grow through accumulation of ideas or theories that have been justified by observation and a process of induction. It grows when teachers try to refute their theories by drawing predictions and then conducting experimentation or tests to try to refute or falsify these predictions. The aim of OKGF is to provide pre-service teachers with a framework where they can conjecture a trial theory when faced with a problem of teaching practice, improve the trial theory by trying to refute it and subjecting it to criticism so that they can uncover its errors and inadequacies and in the process eliminate the errors that criticism has uncovered. This process thus attempts to help pre-service teachers create successful trajectories for their decisions and actions in their teaching contexts and hence enhance the advancement of teacher knowledge.

## **3. Objective Knowledge Growth Framework**

The OKGF is based on Popper's (1979) schema and his theoretical argument that individuals and organizations would do better if they were to employ a form of empirical testing in their attempt to falsify their hypotheses because there is no finite body of evidence that can prove or establish the truth of a universal hypothesis.

Although, Popper did not formulate the schema  $P1 \rightarrow TT1 \rightarrow EE1 \rightarrow P2$  to capture cognitive processes, the schema can provide pre-service teachers with a structure to build knowledge

through critically reflecting on their actions and decisions (Chitpin, 2010; Evers & Chitpin, 2005). The aim of this study is to use OKGF to explore how pre-service teachers critically think and reason when they are faced with problematic situations

The OKGF schema  $P1 \rightarrow TT1 \rightarrow EE1 \rightarrow P2$  can be expressed as follows: ‘P1’ or ‘Problem Identification’ means the problem from which we first start. ‘TT1’ represents a first tentative theory that we offer in order to solve this problem. According to Nickles (1981) a problem “consists of all the conditions or constraints on the solution plus the demand that the solution (an object satisfying the constraints) be found” (p. 109). Nickles suggests different agreed ways of solving a problem within a given set of constraints. The difference in problem strategies used lies in the prioritizing, or ranking of the constraints. For example, does one deal with the disruptive behavior of a student at the moment it occurred or later? The way the teachers rank their priorities will determine the structure of their web of belief, with the least revisable claims at the centre of the web.

Here teachers’ expectations are driven by a tentative theory (TT1) formulated based on their belief system. In this paper, the words ‘solution’, ‘hypothesis’, ‘conjecture’, ‘proposition’, ‘principle’, and ‘theory’ are used interchangeably for TTn. The OKGF requires that a bold conjecture be formulated in such a way that it can be in principle refuted. A tentative theory is thus both a conjecture that purports to solve the problem and an object that admits of testing through practice. ‘EE1’ means an error elimination process where specific propositions in TT1 or parts therein, are subject to tests that attempt refutation. If the first TT is, in fact, refuted, or found to be inadequate, we move to TT2. ‘P2’ refers to new problems that might emerge from critical reflection and testing. The schema is cyclical and is intended to converge over a succession of these “Popper Cycles” to successful theories, that is, those that solve the problems at hand.

This study seeks to understand how pre-service teachers critically think and objectively solve their problems of practice using the OKGF in new or uncertain contexts where they have a limited amount of knowledge. Given the vast amount of background knowledge that pre-service teachers hold regarding any problematic situation, there is no doubt that the number of possible constraints will be large. This means that pre-service teachers must find ways of framing the problems-solutions so that much of the background information does not interfere with their cognitive processing. This is where the subjectivity-objectivity continuum comes into play. Nagel (1986) defines the subjectivity and objectivity continuum as follows:

A view or form of thought is more objective than another if it relies less on the specifics of the individual’s makeup and position in the world, or on the character of the particular type of creature he is. The wider the range of subjective types to which a form of understanding is accessible – the less it depends on specific subjective capacities – the more objective it is. (p. 5)

That is, pre-service teachers must solve their problems or make them more epistemically progressive by effectively bracketing the background and focusing on one or two aspects of the situation as illustrated below in the data analysis section. Alternatively, they need to agree on the bodies of background knowledge. The field of

education is beset with conflicting theories and viewpoints all of which are based on observations or experiences. Merely adding to the stock the reasons why certain theories are right contributes little to pre-service knowledge growth. We need to re-orient ourselves to think in terms of rigorous attempts to refute our hypotheses instead of employing confirmation techniques.

Popper's (1957) advice for testing knowledge in social science is to engage in small scale or piecemeal change. In light of his advice, pre-service teachers are encouraged to test their hypotheses even though it can be difficult to find out which hypothesis is most responsible for which outcome and which hypotheses are relevant and which are not.

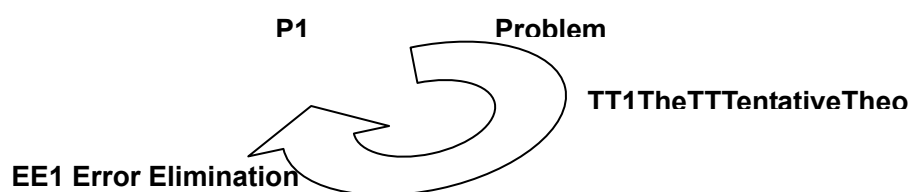


Figure 1: Schematic representation of the Objective Knowledge Growth Framework

### 3.1 Methodology

In the Assessment Module of the compulsory course entitled *Curriculum Design and Evaluation*, a 39-hour course offered at the University of Ottawa in the Fall, 2009, at the Intermediate and Senior levels, participants were introduced to Popper's schema and how to use the OKGF to solve assessment related problems in a two-hour session. A total of 76 pre-service teachers were put in groups of five or six and were asked to use the OKGF cycles to record their critical thinking in making decisions in solving an assessment related issue. All participants were asked to read the article by Chitpin & Evers (2005). They were particularly asked to explore in small groups the different ways teachers in the study went about applying the OKGF.

### 3.2 Participants

Data from this study were obtained from a group of six pre-service teachers' with no previous classroom experience who used the OKGF consisting of four cycles to document their critical thinking in making decisions on how to ensure that students evaluate themselves and/or others fairly in group work for professional knowledge growth. Participants were also given a blank OKGF cycles template. The nature of problems and theories identified by the pre-service teachers in solving the identified problems, and the errors contained in these theories is provided in summary form in Table 1 below.

Brenda's group (pseudonym) was comprised of six pre-service teachers. They were in the first semester of their program. The group was chosen for the following reason. The group had no previous classroom experiences and members were asked to document how they confronted their identified problem, what proposed theory they used to solve it, how they approached

their tentative theory to draw out the implications of the proposed theory, and how they applied it to achieve the pedagogical objective of assessing their students.

Evers (2007) reminds us that it is important to differentiate between individual learning and group learning. Much research has been conducted on both organizational learning and social epistemology (Evers, 2012). One issue is that problems can occur over group learning when groups are organized in a way that they suffer confirmation bias. When working in groups, the group needs to avoid confirmation bias while at the same time reaching an agreement as to which theory everyone can accept. Studies have shown that if one member of the group acts as a leader, his or her view will help shape the views of the other members of the group which results in efficiency reaching a group decision. The price that it entails is a rise in confirmation bias, with the group being reluctant to change their mind despite contrary evidence before them (Hutchins, 1995). In the absence of a group leader, studies have found that group members take longer to make decisions but are more willing to assess the evidence even though the evidence before them might be contrary to their expectations. Given that Brenda's group consisted of all members with no previous classroom experiences, this study attempts to find how OKGF enables members in the absence of a group leader to come to a consensus when making decisions using the OKGF.

#### **4. The Use of OKGF with a Group of Pre-service Teachers**

Brenda's group identified their first problem as: "How do we ensure that students evaluate themselves and/or others fairly in group work?" (P1). Their proposed tentative theory was to use the UbD Design Standard Stage 2: "Are a variety of appropriate assessments used to provide additional evidence of learning?" (TT1). They stated:

We look at the list of assessment principles and discussed it among ourselves and we came to the conclusion that using UbD Design Standard Stage 2 that of using a variety of assessment to provide evidence of our students learning would solve our problem because we can gather lots of information from our students using this assessment principle. If one assessment tool can't give us the answer we want, we can use another assessment tool. We can even have our students to evaluate each other. This way we are showing them how to be responsible. But we also need to take into consideration that students who are popular get high marks from their friends based on our experiences as students. So, peer evaluation has disadvantages.

Through critical discussions, they questioned the validity and reliability of such an assessment. They recounted their experiences as students and how they gave high marks to their friends not based on the quality of their work but mostly based on popularity (EE1). When the group found that the tentative theory they chose did not completely solve their problem, they did not try to seek justification by asking for evidence, proof or good reasons to support it. Instead, they showed the identified theory has unacceptable consequences. In fact, their tentative theory raised difficulties worse than what it was supposed to surmount. The group reframed their problem to that of "how do we get students to fairly assess their peer work

without inflating it?” (P2). Their tentative theory was to use the UbD Design Standard Stage 2: “Appropriate criterion-based scoring tools used to evaluate student products and performances” (TT2). They brainstormed all the weaknesses contained in their newly proposed theory and said:

Even though students are given specific criteria as to how to evaluate the work of their peers, they can still be negative towards each other if they do not like each other. Because the criterion-based assessment tells the teacher how well the student is performing on the specific goal(s) that they are being tested or evaluated on, it is possible that their peers will interpret the work to mean comparing the work of one student with another. Instead of giving full marks to a short concise answer, they can give only half of the marks because they expect a lengthier response or read a lengthier response from another peer. What do you do? (EE2)

Which became their third problem of how do we get students to evaluate their peers objectively? (P3). They applied their proposed theory taken from the *Growing Success* document from the Ministry of Education in Ontario, namely, that of “using appropriate learning activities, for purposes of instruction and meeting the needs and experiences of the students”(TT3). They brainstormed ideas as to how this tentative theory would translate into practice. They started their discussions with what is their understanding of instruction and meeting the needs of students. Through discussions, they believed that applying this principle would entail that they present the concepts of their lesson in a way that all students are able to gain varying degrees of knowledge based on their level of understanding, and that they take the following into consideration: (1) the learning styles of their students, (2) their cognitive level of ability (3) allowance for assignment based on students’ needs and (4) differentiated evaluation of their students. They said:

If we go back to how we were taught when we were in school, we all agree that we were mainly taught using the teacher- directed method of instruction and most of the time, the teacher would use only one kind of activity/work following the lesson. Most of the time the teacher would use short answer questions, multiple choices or essay questions to evaluate our understanding of the concepts presented in the lesson. One of the group members added:

I am not sure if all of us understand everything that the teacher taught us. I believe this is why some of us keep lagging behind because as the lessons progress further, the students become more and more lost and they do not let their teachers know like me in my History class. I think it is important that we use and evaluate our students using differentiated instruction and also using differentiated evaluation to evaluate our students to meet their needs. We cannot for example just use peer assessment to assess students with special needs (EE3) because the students would not know their peers learning styles. There are also issues with giving high marks. They can be lenient in evaluating their peers if they like them and if they don’t like them, they can mark them harshly, even though their peers have different needs; they might also not know how to take them into consideration. We are not saying that peer evaluation does not have

advantages. We know peer assessment when used not for final grade can provide students an opportunity to comment on and judge their peers' work. But we need to take all of this into consideration and teach our students how to do a peer assessment properly, what to look for, how to assess a work etc.

Based on the above discussions, pre-service teachers alluded to the fact that teachers need to use a variety of teaching methods to convey their subject matter and also to use different forms of assessment to assess their students if they wish to meet the needs of all students under their care. They were seen making reference to formative and summative assessment even though they did not use the terms. They were also cognizant of the fact that peer assessment can give learners an increased ability to make independent judgments of their peers' work and also of their own work. Furthermore, it provided an opportunity for them to explore the different ways of working out a problem and receiving feedback. However, they believe that students cannot be asked to do a peer assessment and expect that it will be reliable if they are not being taught how to properly complete a peer assessment. They refined their question to "How do we ensure that special needs students are being evaluated fairly?" They proposed their tentative solution by applying the assessment principle 5: "are fair to all students" from the *Growing Success* document. Table 1, below, summarizes these results.

In the discussion section, we illustrate how a group of pre-service teachers with no previous classroom experiences used OKGF to build professional knowledge.

#### 4.1 Discussion

Brenda's group has identified a problem relevant to their teaching practice. By allowing pre-service teachers to identify a relevant problem of practice, they own the problem and learning becomes more meaningful and engaging (MacKeracher, 2004).

From the list of principles given to pre-service teachers in class, they were able to choose hypotheses or tentative theories such as "...fair to all students" to help them solve their identified problems. Through critical conversations in their respective groups, they were able to rank or prioritize which tentative theory they wished to apply or experiment with. "For Popper, a genuine test of a hypothesis is a serious attempt to falsify it; if the hypothesis withstands this attempt, it is *corroborated* (but not confirmed or verified) – which means that it survives, temporarily, perhaps to face refutation tomorrow" (Phillips, 1999, p. 174).

Although OKGF is viewed as a structured professional development framework, teachers need to be trained on how to identify and articulate their theories to ensure that their tentative theories can be tested adequately against empirical evidence. Since teaching is highly sensitive to context, the tentative theories that are being tested will comprise many hypotheses that are potentially relevant to the observed outcome. The success of the teachers in learning about the issues at hand will depend on the extent to which they can identify the relevant explanatory hypotheses. Without the explanations, it is hard to tell which hypothesis is responsible for any error contained in the theory's expected outcome. In the case of the six pre-service teachers enrolled in the curriculum and assessment course that uses the OKGF to improve their professional knowledge of assessment when trying to assess their students' group work, the

continuous learning cycles of problem, tentative theory and error elimination known as Objective Knowledge Growth Framework cycles are linked in an epistemically progressive way. Furthermore, teachers must be trained to frame their problems-solutions in a way that their background knowledge does not interfere with their cognitive processing. In other words, they must be trained to effectively bracket the background and focus on one or two aspects of the situation (Chitpin, Simon & Galipeau, 2008; Chitpin & Evers, 2005) or agree on the bodies of background knowledge.

In sum OKGF offers promise in the development of teachers' professional knowledge (Cochran-Smith & Lytle, 1999) and in tailoring to address learners' needs (MacKeracher, 2004). Building on the concept of action research, OKGF promotes rigorous application of the research process and contributes to the development of theoretical teacher knowledge through practical application. Some scholars may argue that the agreed bodies of background knowledge may approximate pragmatic approaches to professional development that, in turn, may promote the utilitarian use of the research process (Biesta & Burbules, 2003). However, a major strength of the OKGF process is that the various problems-solutions cycles will, over time, converge on a satisfactory solution if one exists – provided, of course, that the error elimination aspect is implemented rigorously.

## **5. Conclusion**

In this study, we have provided an illustration of how a group of pre-service teachers with no previous classroom experiences used the OKGF to provide themselves with a structure to successfully make decisions in a new or uncertain context when faced with limited amount of knowledge. They received a two hour session on the use of the OKGF. The ways in which the pre-service teachers documented the development of their professional knowledge growth based on the OKGF is indicative of its potential, particularly when pre-service teachers connect theoretical notions of responsibility and accountability to their own practice.

Future research should be undertaken to further investigate the framework in a variety of conditions and contexts. We believe that the OKGF can guide further research and curriculum development work in the area of teacher education, teacher knowledge, and teacher professional development. It allows us to view teacher knowledge and how that knowledge informs the debate on what teachers need to know and how they might develop it in a way that would lead to professional knowledge growth.

This framework does not require a reconstruction of the existing educational arrangements before it can be implemented in class. Instead, it asks educators to be open to the theoretical underpinnings of practice and to view growth as a process of systematic elimination of errors in tentative theories. Further, it provides educators with the opportunity to give and receive rational criticism in a professional community where the goals are to improve education and to educate for improvement. We believe that the use of OKGF, as a powerful tool for critical self-learning, ought to be a central goal of teacher education. As Shulman (1987) stated:

The goal of teacher education is not to indoctrinate or train teachers to behave in prescribed ways, but to educate teachers to reason soundly about their teaching as well as to perform skillfully. Sound reasoning requires both a process of thinking about what they are doing and an adequate base of facts, principles and experiences from which to reason. Teachers must learn to use their knowledge base to provide the grounds for choices and action... Good teaching is not only effective behaviourally, but must also rest on a foundation of adequately grounded premises. (p. 13)

The findings of this study show OKGF to be a critical approach to learning for both pre-service and practicing teachers. It also allows educators to gain a grounded perspective on the issues at hand by receiving rational criticism. It preserves what works and eliminates inadequacies.

Table 1: Summary of Evidence of A group of pre-service teachers' knowledge building

| Objective knowledge framework | Frames                                                                                                                       |                                                                                                                                   |                                                                                                                                                                     |                                                                              |
|-------------------------------|------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------|
|                               | Frame 1                                                                                                                      | Frame 2                                                                                                                           | Frame 3                                                                                                                                                             | Frame 4                                                                      |
| Problem (Pn)                  | P1: How do we ensure that students evaluate themselves and/or others fairly in group work?                                   | P2: How do we get students to fairly assess their peer work without inflating it?                                                 | P3: How do we get students to evaluate their peers objectively?                                                                                                     | P4: How do we ensure that special needs students are being evaluated fairly? |
| Tentative Theory (TTn)        | TT1: UbD Design Standard Stage 2: "Are a variety of appropriate assessment used to provide additional evidence of learning?" | TT2: UbD Design Standard Stage 2: "Appropriate criterion-based scoring tools used to evaluate student products and performances". | TT3: Growing Success Principle 4: "...are appropriate for the learning activities use, the purposes of instruction, and the needs and experiences of the students". | TT4: Growing Success Principle 5: "...are fair to all students".             |
| Error Elimination (EEn)       | EE1: Students can inflate their peers' marks based on popularity.                                                            | EE2: Students can be negative towards each other if they do not like each other                                                   | EE3: It can be difficult for students to use peer assessment to evaluate their peers who have special needs                                                         | EE4:                                                                         |

## References

- Bailin, S., Case, R., Coombs, J. R., & Daniels, L. B. (1999). Conceptualizing critical thinking. *Journal of Curriculum Studies*, 31(3), 284-302.
- Biesta, G. J.J., & Burbules, N. (2003). *Pragmatism and educational research*. Lanham, MD: Rowman and Littlefield.
- Brown, S. A., & McIntyre, D. (1993). *Making sense of teaching*. Buckingham, UK: Open University Press.
- Butler et al. (2004). Collaboration and self-regulation in teachers' professional development. *Teaching and Teacher Education*, 20, 435-455. <http://dx.doi.org/10.1016/j.tate.2004.04.003>
- Chitpin, S. (2010). A critical approach for building teacher knowledge. *International Journal of Education*, 2(1), 1-14.
- Chitpin, S., & Evers, C. W. (2005). The role of professional portfolios for teachers. *Teachers and Teaching: Theory and Practice*, 11(4), 419-433. <http://dx.doi.org/10.1080/13450600500137208>
- Chitpin, S., Simon, M., & Galipeau, J. (2008). Pre-service teachers' use of the Objective Knowledge Growth Framework for reflection during practicum. *Teaching and Teacher Education*, 24(8), 2049-2058. <http://dx.doi.org/10.1016/j.tate.2008.04.001>
- Cochran-Smith, M., & Lytle, S. (1999). Relationships of knowledge and practice: Teacher learning in communities. *Review of Research in Education*, 24(1), 249-305. <http://dx.doi.org/10.3102/0091732X024001249>
- Danielson, L. (2002). Developing and retaining quality classroom teachers through mentoring. *The Clearing House*, 75(4), 183-185. <http://dx.doi.org/10.1080/00098650209604927>
- Elbaz, F. (1981). The teacher's practical knowledge: Report of a case study. *Curriculum Inquiry*, 11(1), 43-71. <http://dx.doi.org/10.2307/1179510>
- Evers, C. W. (2007). Culture, cognitive pluralism and rationality. *Educational Philosophy and Theory*, 39(4), 364-382. <http://dx.doi.org/10.1111/j.1469-5812.2007.00345.x>
- Evers, C. W. (2012). Organizational contexts for lifelong learning: Individual and collective learning configurations. In D. N. Aspin, J. D. Chapman, K. R. Evans, and R. Bagnall (Eds.), *Second international handbook of lifelong learning* (pp. 61-76). Dordrecht: Springer. [http://dx.doi.org/10.1007/978-94-007-2360-3\\_4](http://dx.doi.org/10.1007/978-94-007-2360-3_4)
- Fenstermacher, G. (1994). The knower and the known: The nature of knowledge in research on teaching. *Review of Research in Education*, 20(3), pp. 3-56.
- Goldhammer, R. (1969). *Clinical supervision: Special methods for the supervision of teachers*. New York: Holt, Rinehart and Winston.

- Grossman, P. (1990). *The making of a teacher: Teacher knowledge and teacher education*. New York: Teachers College Press.
- Howe, E. R. (2004). Canadian and Japanese teachers' conceptions of critical thinking: A comparative study. *Teachers and Teaching: Theory and Practice*, 10(5), 505-525. <http://dx.doi.org/10.1080/1354060042000243051>
- Hutchins, E. (1995). *Cognition in the wild*. Cambridge, MA: MIT Press.
- Lortie, D. (1975). *School teacher: A sociological study*. Chicago, IL: The University of Chicago Press.
- MacKeracher, D. (2004). *Making sense of adult learning*. Toronto: Culture Concepts.
- Nagel, T. (1986). *The View from Nowhere*. Oxford: Oxford University Press.
- Nickles, T. (1981). What is a problem that we may solve it? *Synthese*, 47(1), 85-118. <http://dx.doi.org/10.1007/BF01064267>
- Nielsen et al. (2008). Teachers' reflections of professional change during a literacy reform initiative. *Teaching and Teacher Education*, 24(5), 1288-1303. <http://dx.doi.org/10.1016/j.tate.2007.01.015>
- Paul, R. (1993). *Critical thinking: What every student needs to survive in a rapidly changing world*. Dillon Beach, CA: Foundation for Critical Thinking.
- Paul, R., Elder, L., & Bartell, T. (1997). A brief history of the idea of critical thinking. In *California teacher preparation for instruction in critical thinking: Research findings and policy recommendations*. Sacramento, CA: California Commission on Teacher Credentialing.
- Phillips, DC. (1999). How to play the game: A Popperian approach to the conduct of education research. In G. Zecha (Ed.), *Critical rationalism and educational discourse* (pp. 170-190). Amsterdam: Rodopi.
- Popper, K. (1957). *The logic of scientific discovery*. London: Hutchinson.
- Popper, K. R. (1963). *Conjectures and refutations*. London: Routledge and Kegan Paul.
- Popper, K. R. (1979). *Objective knowledge: An evolutionary approach*. New York: Oxford University Press.
- Schon, D. A. (1983). *The reflective practitioner: How professionals think in action*. New York: Basic Books.
- Schon, D. A. (1995). Knowing in action: The new scholarship requires a new epistemology. *Change*, 27(6), 27-34.
- Shulman, L. S. (1987). Knowledge and teaching: Foundations of the new reform. *Harvard Educational Review*, 57(1), 1-22.

- Siegel, H. (1980). Critical thinking as an educational ideal. *The Educational Forum*, 45(1), 7-23. <http://dx.doi.org/10.1080/00131728009336046>
- Swartz, E. (2004). Casing the self: A study of pedagogy and critical thinking. *Teacher Development*, 8(1), 45-65. <http://dx.doi.org/10.1080/13664530400200226>

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