



# The Uses of the Term Hypothesis and the Inquiry Emphasis Conflation in Science Teacher Education

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Tabel 1. A summary of the different customs of using the term ‘hypothesis’ in four cultural institutions relevant for science teacher education.

Cultural Institution	Customary use of ‘hypothesis’
1. Scientific research	‘Hypothesis’ refers to a tentative explanation, from which predictions can be derived, and that connects to a more comprehensive theoretical framework.
2. Pure science courses	The term ‘hypothesis’ is not commonly used or discussed in laboratory tasks and inquiry oriented activities.
3. Science education courses for teachers	‘Hypothesis’ means a guess about an outcome, and is frequently used (but not discussed explicitly) in laboratory tasks and inquiry oriented activities.
4. School science	‘Hypothesis’ means a guess about an outcome, and is frequently used (but not discussed explicitly) in laboratory tasks and inquiry oriented activities.

# The Uses of the Term Hypothesis and the Inquiry Emphasis Conflation in Science Teacher Education

## Abstract

This paper examines the use and role of the term 'hypothesis' in science teacher education as described by teacher students. Data was collected through focus group interviews conducted at seven occasions with 32 students from six well known Swedish universities. The theoretical framework is a sociocultural and pragmatist perspective on language and learning, introducing the notion of pivot terms to operationalise language use as a habit and mediated action. We describe three different customs of using the term 'hypothesis' within four cultural institutions that can be said to constitute science teacher education in Sweden. Students were found to habitually use the term hypothesis as meaning a guess about an outcome. This is contrasted to the function of this term in scientific research as a tentative explanation. We also found differences in how this term was used between the pure science courses given by the science departments of universities and science education courses taken only by teacher students. Findings also included further support for school students hypothesis fear reported in an earlier study. It is discussed how these findings can obstruct learning and teaching about the nature of scientific inquiry. Constructivist theories of learning are suggested as a possible origin of these problems. The findings are also related to curricular reform and development.

## Introduction

In the current debate on curriculum development in science education, two notions stand out: scientific literacy and inquiry. Scientific literacy has been discussed in depth by Roberts (2007) who distinguishes between what he calls Visions I and II of curriculum aims in science education. Simply put, Vision I involves an emphasis on science as a body of knowledge in its

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3 26 own right, whereas Vision II puts an emphasis on science as a part of human culture and  
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5 27 society at large. In either case, for someone to be scientifically literate, an understanding of  
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8 28 scientific inquiry is fundamental. That is to say, an understanding of how scientific  
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10 29 knowledge about the world is generated through processes of scientific investigation.  
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13 30 However, despite many reform efforts teachers continue to be unclear about the meaning of  
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15 31 inquiry in science education (Anderson, 2007; DeBoer, 1991). In part this may be due to the  
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17 32 fact that the term inquiry is used to refer both to a pedagogical strategy for teaching science,  
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19 33 and as a content for students to learn (Bybee, 2000). The educational goals associated with  
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21 34 inquiry as a content have been described by Lederman (2004) as learning to do inquiry and  
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23 35 learning about inquiry. It is learning about inquiry that is arguably the more important goal for  
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25 36 the advancement of scientific literacy.

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29 37 Learning about the nature of scientific inquiry (NOI) includes many dimensions. One  
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31 38 important dimension can be for learners to understand the basics of hypothesis testing through  
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33 39 the use of controlled experiments. The method of controlled experiments is central in many  
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35 40 natural sciences, but it is not the equivalent of ‘the scientific method’ (Beveridge, 1961), and  
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37 41 many scholars agree that this notion seriously misrepresents science (Rudolph, 2002;  
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39 42 Windschitl, 2004). In fact, learning about the method of the controlled experiment may be an  
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41 43 important step in understanding that this is one particular type of method used in science. In  
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43 44 the present study we focus on the use and role of hypotheses in science and science education  
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45 45 as an important sub-dimension of learning about scientific inquiry.

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47 46 We have in a previous study described teachers’ selective traditions in relation to  
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49 47 scientific inquiry in secondary schools (Gyllenpalm, Wickman, & Holmgren, 2010). Our  
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51 48 results indicated that teaching activities that teachers describe as being inquiry-oriented are  
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53 49 not explicitly connected with a targeted knowledge in terms of learning about inquiry. This is  
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55 50 problematic, as it has been shown that an understanding of the nature of scientific inquiry is

not gained merely by participating in inquiry activities, but that these issues must be addressed and reflected upon explicitly (Lederman, 1999; Schwartz, Lederman, & Crawford, 2004; Windschitl, Thompson, & Braaten, 2008a). In analysing the tradition of laboratory work in Swedish secondary schools, we found that teachers seemed to conflate methods of teaching (i.e. inquiry as a pedagogical approach) and methods of scientific inquiry (i.e. the targeted knowledge when learning about inquiry) (Gyllenpalm, Wickman, & Holmgren, 2009). This included failing to distinguish between the concepts of hypothesis and prediction and using hypotheses as pedagogical tools for teaching the results of science thus further obscuring learning about scientific inquiry. In this article, we call this conflation of means (methods of teaching) and ends (methods of scientific inquiry) in science teaching for the inquiry emphasis conflation. The purpose of the study reported on in this article was to investigate if the results from our previous study would be corroborated by interviews with another group of informants (i.e. teacher students instead of experienced teachers). In addition this different group of informants also allowed us to examining the role teacher education in Sweden might have in reproducing the inquiry emphasis conflation.

### Theoretical Framework

In this study we take a sociocultural and pragmatist perspective on language and learning. The focus of sociocultural theory is to explicate the relationship between social, historical and cultural contexts on the one hand, and individual action on the other (Wertsch, 1998). In the analysis presented here the particular cultural contexts are those of school, university education and scientific research, which we will refer to as cultural institutions (Rogoff, 1990; Säljö, 2005). Cultural institutions are relatively stable systems of human relations, communicative patterns, physical artefacts, activities, routines and other types of social arrangements on various levels of complexity that stabilize social interaction and that humans

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3 76 learn to relate to and act within (Säljö, 2005). They include both bureaucratic and material  
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5 77 dimensions as well as more informal systems of practice (Rogoff, 1990). Institutions are in  
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8 78 this way systems of established and embedded social rules that structure social interactions,  
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10 79 although the rules are not always explicit and compelling in a definite way (Hodgson, 2006).  
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12 80 The modifier ‘cultural’ refer to that these institutions also embody cultural values and  
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14 81 purposes (Rogoff, 1990), and have been shaped by their particular historical and contingent  
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16 82 developmental path (Wertsch, 1998).  
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19 83 The relationship between cultural institutions and individuals’ actions within these can  
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21 84 be approached by analysing mediated action and habits. Mediated action refers to an agent  
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23 85 acting by means of, or mediated by, cultural artefacts (Wertsch, 1998), with the most  
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25 86 ubiquitous cultural artefact being language (Säljö, 2005). Mediational means both provide  
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27 87 affordances and constrains (Wertsch, 1998) for how we communicate, act and think. Our uses  
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29 88 of language, including particular distinctions and divisions, is to a large extent habitual  
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31 89 (Wickman, 2006). By habits we mean predispositions and tendencies for certain kinds of  
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33 90 actions in certain situations (Dewey, 1930), and not strictly repetitive behaviour in a  
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35 91 biological sense (Cohen, 2007). Institutions are upheld by the habits of individuals,  
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37 92 simultaneously as institutions and the mediational means they provide, shape individuals  
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39 93 habits (Dewey, 1930; Hodgson, 2007; Maréchal, 2010). We call these collectively shared  
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41 94 habits, that characterise cultural institutions, customs (Dewey, 1930; Cohen, 2007). Being  
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43 95 socially transmitted, habits require the attention and will of the agent while learning them, but  
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45 96 once established they tend to function without explicit reflection. Nevertheless, habits can be  
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47 97 made the object of explicit deliberation, which is a first step in changing habits, and the  
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49 98 transformation of habits for coping with new situations can be conceptualised as learning  
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51 99 (Rorty, 1979; Wickman, 2006).  
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### 101 *Cultural Institutions and Science Teacher Education*

102 Four different cultural institutions have emerged as relevant in describing and analysing the  
103 results presented here: scientific research, pure science courses, science education courses for  
104 teachers and school science. These cultural institutions are interrelated but they can be briefly  
105 described individually as follows. Scientific research refers to basic or applied research at a  
106 university or the equivalent with the aim of increased or better knowledge of natural processes  
107 and phenomena. Pure science courses refer to courses given by a science department at a  
108 university, often led by an active researcher, and with no particular orientation towards  
109 teacher education. This type of course tends to focus quite exclusively on introducing students  
110 to a well-established body of scientific knowledge. Science education courses for teachers, on  
111 the other hand, are given by the teacher education department or the equivalent, and are often  
112 led by teachers with a lot of experience from teaching science in schools. This type of course  
113 often has the dual purpose of teaching students science and simultaneously teaching them  
114 how to teach science in schools (sometimes called ‘parallel processes’), although the  
115 emphasis between these two purposes may vary. School science is here science as a school  
116 subject in secondary and upper secondary schools.

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### 118 *Language use and the meaning of words*

119 A pragmatist perspective on language means that instead of seeing language as an outer  
120 expression or representation of an inner mental state, as is usually the case in cognitive  
121 perspectives, the meaning of words or any utterances are to be found in their use and  
122 consequences (James 1907/1995; Wickman, 2006; Wickman & Östman, 2002). This means  
123 that words do not have an essential or universal meaning but must be understood as part of an  
124 activity, context, or what Wittgenstein called a ‘language-game’ (Wickman, 2006). To  
125 understand a word is at the same time to know how to play the language-game it is a part of.



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3 126 Also, language can, to a large extent, be understood as functioning through habits and  
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5 127 customs. In language-games the use, and thus meaning, of words are usually not questioned  
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8 128 but are typically understood as part of a practice as a whole (Hardwick, 1971). The fact that  
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10 129 most utterances ‘stand fast’, i.e. are not question by the individuals participating in an activity,  
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13 130 is a necessary condition for communication (Wickman & Östman, 2002; Wittgenstein, 1968).  
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15 131 This means that to learn a language-game is not simply to know the use of certain words but  
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17 132 also means the acquisition of habits of using these words as part of an activity (Wickman,  
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19 133 2004). In order to reflect upon the customs (i.e. shared habits) of the major cultural institution  
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22 134 relevant to science teacher education, it is therefore relevant to study and make explicit the  
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24 135 particular uses of language that are associated with them.  
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27 136 We define a pivot term as a single word or term that can be used to highlight how two  
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29 137 or more different cultural institutions and their associated language-games overlap or  
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31 138 intersect. It can metaphorically be described as a term on which one can balance two such  
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33 139 systems - a common point around which they can be said to revolve. A pivot term thus relates  
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35 140 to some central aspect of two or more activities, or language-games, with distinctively  
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37 141 different purposes, resulting in the word having radically different meanings and connotations  
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39 142 in these activities. If the customs of using a particular term differs significantly between two  
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41 143 cultural institutions it may be described as a pivot term. The same pivot term may thus  
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43 144 mediate quite different action in different activities. Pivot terms are special compared to other  
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45 145 words, only because they can be positioned to provide a point of leverage for analytically  
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47 146 separating two or more activities. This is not an essential or universal quality of a certain class  
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49 147 of words, but a description of a role or function that a term may play when comparing its  
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51 148 customary use in relation to the different purposes of different cultural institutions. Analysing  
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53 149 the use of potential pivot terms is thus a way to operationalise how specific words can play a  
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55 150 central role in mediating action.  
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152 *The Use of 'Hypothesis' in Scientific Research*

153 The possible pivot term analyzed in this paper is 'hypothesis' and its use in the cultures that

154 meet in science teacher education. In the results section we present empirical data on its use in

155 the cultures that teacher students are directly involved in. However, to examine how these

156 uses are related to the aim of teaching teacher students about inquiry as it is carried out in

157 scientific research, a comparison needs to be made with its use in scientific research.

158

159 The word 'hypothesis' is commonly used in science to refer to a tentative explanation related

160 to some observed phenomena (Chalmers, 1999). A hypothesis is not a single prediction

161 (McComas, 1998) but a suggestion about how the data is connected (Wilson, 1990). Often, it

162 is a proposition about a correlation or causal mechanism. What follows are three examples of

163 hypotheses from recent scientific research. All examples are taken from articles published in

164 *Nature* in the year 2000 (Hansson, 2006).

165 1. Neurotransmitter receptors of type D5 differ from those of type D1 in having special

166 functional interactions with  $GABG_A$  receptors.

167 2. Certain gravel depositions in Hawaiian coastal slopes were created in a single event by giant

168 tsunamis.

169 3. Super conductivity will arise in  $C_{60}$  at high temperatures if it is hole-doped.

170 These hypotheses all have in common that they in different ways state tentative explanations,

171 with reference to causal or functional relationships, of natural phenomena. Example one

172 proposes as "functional interaction", example two how a geological feature was "created" (i.e.

173 caused) and example three proposes "hole-doping" as a factor that might cause the

174 phenomenon of "super conductivity" under certain conditions. Furthermore, they all refer to

175 theoretical concepts (e.g. superconductivity, neurotransmitter, gravel deposit) that have

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176 meaning only in relation to a more comprehensive theory and research programme of some  
177 kind. Example three may superficially be mistaken for a prediction. If one only considers  
178 grammatical form, this may be true, in a sense, but the key here is the second part, ‘if it is  
179 hole-doped’. This refers to a cause or explanation of the predicted superconductivity in this  
180 particular case. For this explanation to make sense, the hypothesis must be connected to a  
181 more comprehensive model relating the particulars of  $C_{60}$  within the even more  
182 comprehensive theory of solid state physics. This implies that a hypothesis cannot stand  
183 alone, and that the theory or research objective to which it is related is needed to separate a  
184 scientific hypothesis from a groundless guess about an outcome or arbitrary fortune-telling  
185 (McComas, 1998).

186 It can be questioned whether hypotheses play an important role in all forms of scientific  
187 research (Hansson, 2006). However, it is definitely widely used in the way described here in  
188 science studies, which is the field of scholarship in which the nature of scientific inquiry  
189 (NOI) is systematically studied and described.

191 *Research Question*

192 The objective of this article is to examine the uses of the potential pivot term ‘hypothesis’ and  
193 analyse the possible consequences of these for science teacher education. In particular the  
194 research questions are:

- 195 1. How do science teacher students use the word ‘hypothesis’ and describe its function when  
196 discussing examples of laboratory tasks in their own university education?  
197 2. In what ways are the customary ways of using the word ‘hypothesis’ different in the  
198 cultural institutions that constitute science teacher education in Sweden?

The first research question is addressed by presenting and analysing transcripts from the focus group interviews, while the second question is addressed analytically based on the findings related to question one.

## Method

In order to obtain information about the characteristic customs of teacher education in a manner that was not too artificial, and simultaneously hear a large number of informants from a range of backgrounds, focus group interviews were chosen as the method of data collection. This approach was inspired by Volante and Earl (2002), who used focus groups to explore teacher students understanding of the conceptual orientations of their own teacher education programmes and practicum experiences, and also Hurtado, Carera, Lin, Arellano, and Espinosa (2009), who used focus groups to study university students experiences with the culture of science.

## *Sample Selection*

Six well-known universities were chosen to obtain a broad representation of teacher education programmes in Sweden. The target group was teacher students who specialised in natural science for secondary schools and who were approaching the end of their education. In all seven focus group interviews were conducted with a total of 32 students and 3 to 6 participants in each group at the following universities: Gothenburg University, Malmö University, Mälardalen University, Stockholm University, Umeå University and Uppsala University

## *Focus Group Interviews*

The focus group interviews were orchestrated to situate the conversations in a context similar to the type of conversations that teacher educators may have with their students. This was

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3 224 done by asking students to bring concrete examples of laboratory work from their own  
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5 225 university education and discuss these in terms of educational purposes. The interviews lasted  
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8 226 on average 1.5 hours and were conducted by the first author, according to the following  
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10 227 structure:  
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12 228 1. Introduction and presentations  
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15 229 2. Focusing exercise: ranking the purposes of laboratory tasks  
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17 230 3. Students tell about their own examples of laboratory work  
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20 231 4. ‘Pedagogical methods and theories’ are compared with ‘Natural scientific methods and  
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22 232 theories’  
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24 233 At the beginning of the interview, the researcher repeated the information that the students  
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26 234 had been given before the meeting and described the overall objective and how data was  
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28 235 going to be used. During the interviews, an interview guide was used (Appendix A) to help  
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30 236 call attention to and focus on relevant themes of discussion.  
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34 237 A focusing exercise is described by Bloor, Frankland, Thomas, and Robson (2001) as  
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36 238 ‘an attempt to concentrate the group’s attention and interaction on a particular topic’ (p.43). In  
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38 239 our case, this was done by asking the students to agree upon a ranking of seven statements  
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40 240 about the main purposes of laboratory work in their university education, as perceived by  
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42 241 them (Appendix B). The statements were inspired by Roberts’s seven curriculum emphases in  
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44 242 science education (Roberts, 1982). During the exercise, the students were asked to explain  
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46 243 their reasoning as they worked on the task and to refer back to concrete examples from their  
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48 244 own education. The exercise took approximately 30 minutes to complete.  
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52 245 After the focusing exercise, each of the examples provided by each student was  
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54 246 discussed. These mainly consisted of laboratory reports or instructions. The students were  
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56 247 asked individually to elaborate on the context in which the example was situated in their  
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58 248 education, and to relate it to the list of purposes discussed during the focusing exercise. As a  
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final topic for the interview, two sheets of papers were distributed with two different topics or themes (Appendix C) and the students were asked to discuss these in relation to the focusing exercise and their own examples.

The objective of these preparations and tasks was to create conditions favourable for engaging conversations, which we hoped would provide many natural opportunities to elaborate on the meaning and use of inquiry related terms such as 'hypothesis'. It was not our intention to elicit the students' views on the nature of the purpose of laboratory work or how 'pedagogical theories' might differ from 'natural scientific theories'. These themes were instead used as heuristics to help create meaningful, content rich and focused conversations. We feel that over all we succeeded with this and several students commented after the interviews that they had found the event both inspiring and educative.

### *Analysis of Data*

All focus group interviews were transcribed verbatim and then proofread to ensure a high quality of the transcribed record. The transcripts were then coded in terms of the general topics of the interviews as well as sections relating to the use of the term 'hypothesis'. This provided an overview of the material. In the next step, the transcripts were re-coded in more detail, with a focus on the use and mentioning of the term 'hypothesis' using the Transana software for qualitative data analysis. All episodes containing references to hypotheses were printed and sorted in subcategories in order to find the common themes described in this article. The most representing transcripts have been chosen to be presented and commented upon in the Result section. The transcripts are translations from verbatim Swedish transcripts to English. Great care has been taken to stay as close as possible to original sense of the wording, but the transcripts in Swedish also contain many grammatically odd formulations as transcribed talk often does.

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Results

Here we present data from the focus group interviews to highlight the significant themes that emerged from the analysis of the use the pivot term ‘hypothesis’. All of the names of the students are pseudonyms, and the names of the universities are anonymous, but consistently denoted by letters.

*The Dominant Use of “Hypothesis” in Teacher Education*

Although the word ‘hypothesis’ was used in different ways by the teacher students in this study, the use completely dominated the interviews was to equate a hypothesis with a proposition about ‘what you believe will happen’ when performing a laboratory task, i.e. a guess about an outcome. This is in line with how teachers were found to use this word in a previous study (Gyllenpalm et al., 2009), and also in line with how the use of this word in school science has been described elsewhere (Baxter & Kurtz, 2001). Other uses such as equating a hypothesis with a research question, an assumption that can be tested and as a tentative explanation, were mentioned at a few rare occasions, but cannot be considered to be representative of the prevailing custom. Below is an example of this seemingly natural and spontaneous meaning given to the term by most students:

1. Sara: Hypothesis? Hypothesis is what you believe is going to happen in the experiment.
2. Klara: Yes.
3. Sara: That’s what you’re supposed to come up with before if it is a hypothesis…  
*(University D)*

Students using the word 'hypothesis' as a guess about an outcome were also asked if they had noted the fact that this equates a hypothesis with a prediction. This was clearly not something the students had considered, as exemplified in the following quote:

4. Interviewer: It sounds somewhat like a prediction as well.

5. Johan: Yes, well, yes perhaps you could better say that's what it is. It is nothing...

6. Interviewer: Is this something that you have distinguished between or talked about?

7. Several: No

8. Johan: You know it's not directly, it's not like we have formulated our own hypothesis to be able to see if there is any difference, it's more like we have... I guess our, our hypothesis was to be formulated, what do you think is going to happen with the one that's in darkness and the one that is in light, and what does it depend on? So I guess that's what we have written.

*(University C, Group 2)*

The last comment by Johan refers to a take-home laboratory task in which the students were to perform an experiment to test how two different treatments (one environment with sunlight and one without) affected the growth of a plant. This was part of a science education course for teachers. As exemplified here, the use of a hypothesis as a guess about an outcome dominated the focus group conversations. There were no indications of the students having noted that this use conflates a hypothesis with a prediction.

#### *Absence of Hypotheses in Pure science courses*

The custom of having students formulate their own hypotheses as guesses about the outcome of a laboratory task in school science is in stark contrast to the customs of the pure science courses. In these courses, talk about hypotheses is rare and it is normally not an important concept in laboratory tasks.



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9. Interviewer: Well, now I don't think that there were any of these examples that you mentioned that began with some hypothesis?

10. Jan: We haven't had a lab like that.

11. Petra: We haven't had a lab like that, no.

*(University E)*

Whereas it can easily be seen in the complete interview transcripts that the two above quotes explicitly refer to pure science courses, it is inferred from the context in the next two quotes. As this distinction was found to be important only after analysing the interviews, it was not addressed explicitly during the interviews.

12. Klara: Yeah, but it's just that you rarely get to, I mean there are no hypotheses in that way; instead you often get to do lab tasks in which you know what will happen if you mess up, sort of. There is a correct result in some way. And that ... Yes ... then there isn't really a hypothesis and then you don't work with hypotheses in that way.

*(University F)*

These quotes illustrate that in the pure science courses, there is little use for or even mentioning of hypotheses. Previous research has also shown that in pure science courses, laboratory tasks are usually highly structured and recipe like (Hult, 2000). The absence of hypotheses in laboratory tasks in pure science courses is also accompanied by what seems to be a rather low emphasis on discussion about the nature of science and the nature of scientific inquiry in general. In the quote below, Klara is referring to item number seven in the focusing exercise when she concludes that they have not discussed the nature of scientific inquiry:

13. Interviewer: The scientific method, what would that be?

14. Mattias: It's what they say...

15. Klara: It's what they always talk about, but no one wants to define.

16. Sara: Nobody wants to explain it, no.

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3 347 17. Klara: And it's really important that we know.  
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5 348 (five turns further down)  
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8 349 18. Klara: And in that case, if number seven has to do with that, I definitely think that we  
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10 350 don't get into that when we do laboratory tasks and experiments at all.  
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12 351 19. Camilla: No  
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14 352 (*University D*)  
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17 353 Although hypotheses are rare in pure science courses, there were examples discussed during  
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19 354 the interviews that can be said to involve hypothesis testing more explicitly. Again, it is not  
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21 355 always clear if the distinction between pure science courses and science education courses for  
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23 356 teachers can be applied in all of these examples. In any case, they constituted rare and more  
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25 357 comprehensive tasks in which the students were given more freedom and responsibility to  
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27 358 conduct their own inquiry projects.  
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30 359 20. Lalla: The only lab task, or whatever you should call it, it was this scientific article.  
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32 360 Because what we, in my group did, was that we were to look at, there are aquatic  
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34 361 woodlice of different colours, they are grey, brown, green, and then we had a  
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36 362 hypothesis that it depends on where they grow, where they live. Depending on if they  
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38 363 live off the green seaweed they become green, and if they live on the brown seaweed,  
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40 364 they become brown. It was the only time that we formulated a hypothesis, and so to  
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42 365 say tested if that was the case. But that is probably the only time I have done anything  
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44 366 like that.  
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47 367 (*University B*)  
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50 368 This example was recalled by Lalla as the interviewer continued to probe the role played by  
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52 369 the notion of a hypothesis in their education. We can see that Lalla is talking about a  
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54 370 hypothesis in the form of a tentative explanation; however, it should be noted that this did not  
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56 371 seem to be a more reflective or systematic use of this term, as will become clearer in the next  
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3 372 section. As she says, this constitutes an unusual or unique example, in that it was the only  
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5 373 time they were supposed to formulate their own hypothesis and design corresponding  
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7 374 investigations to test it.  
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9 375  
10  
11 376 *Science education courses for teachers*  
12  
13 377 The absence of emphasis on and discussion of hypotheses in laboratory tasks in pure science  
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15 378 courses is contrasted by science education courses for teachers. Below, Jonas explicitly states  
16  
17 379 that he only recalls talk of hypotheses in this type of course. In the following examples, it can  
18  
19 380 be deduced from the larger context of the interview conversations that the students are  
20  
21 381 referring to the same kind of courses.  
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25  
26 382 21. Interviewer: So in your laboratory tasks, this stuff about reasoning around a  
27  
28 383 hypothesis doesn't seem to have been a big thing.  
29  
30 384 22. Jonas: I guess it's really only existed during the didactics [science education courses  
31  
32 385 for teachers] lab tasks.  
33  
34 386 (*University A*)  
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36 387 The science education courses for teachers seem to have two features that are particularly  
37  
38 388 relevant for the present discussion. The first is the so-called 'parallel process' already  
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40 389 mentioned. The second is that talk about hypotheses was often mixed with talk about theories  
41  
42 390 of learning. In the next quote, we see how a student reasoned about the purpose for using  
43  
44 391 hypotheses in schools as a pedagogical tool:  
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49 392 23. Interviewer: So have you talked a lot about hypotheses and what function they have?  
50  
51 393 24. Carola: Yes, and that is something we use during our practicum as well and that we  
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53 394 are to use later in the teacher profession in which when you do lab work with the  
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55 395 students, it is often the method you use. That the students should get to try but also  
56  
57 396 perhaps have some, yes, a conception, what will happen and then you find out and it is

like a way for the students, for them to discover what is, what science consists of.

What is it really? And you want to, yes, in a way you want to encourage the students

to learn more, and so on, and not serve everything on a plate. Or what do you guys

feel?

*(University C, Group 1)*

To Carola, a hypothesis seems to be associated with a pedagogical method. The

pedagogical function of the hypothesis in the teaching method she is describing is to

elicit the students' preconceptions, a notion usually connected to conceptual change

theories of learning (Park, 2006). Here we note that "method" is also a potential pivot

term related to 'hypothesis'. In the context of science education this term is often

ambiguous as can be seen in the definition of the inquiry emphasis conflation. Below is

a further illustration of referring to hypotheses as a pedagogical tool:

25. Miriam: The hypotheses were very important in the air lab.

26. Interviewer: Ok, in what way, what did it mean?

27. Miriam: Well, it was important in some way that we had a conception before we did

the actual eh experiment how... a conception about what could happen, and then we

were supposed to confirm or deny if it was true by performing the experiment.

28. Lisa: But Maria, surely it was a part of these lab tasks, wasn't it that students'

conceptions was that in this case, that it contains nothing, it is empty [...]?

29. Miriam: Yes, that's right because precisely this about dropping your own hypothesis,

that it is like wrong, so it is pretty difficult to do because you prefer that your everyday

conceptions perhaps are the ones that are true, so to speak, it is difficult to drop it

because then you lose in a way a part of your sense of reality in some way. And then

it's important to understand the new context how it works, how the theory perhaps

really is. So this was actually a part of the thing with this really.

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(University A)

It seems as if it is only in this context of a pedagogical approach to teaching the products of science that the notion of a hypothesis is common and has a clearly justified role for these students. Miriam’s last comment also demonstrates the personal nature of a hypothesis when used as a pedagogical tool, when she refers to ‘dropping your own hypothesis’ (turn 29), a point that will be discussed later.

*Reproducing the Customs of School Science*

Discussion about hypotheses does not seem to be very common in most pure science courses at the university level, and in particular, not in connection with laboratory work. The exception is science education courses for teachers, as noted, although in these, talk about hypotheses also seems to be taken for granted and not reflected upon critically. In the following quote by Albert, it is not completely clear if he is referring to a pure science course or to both kinds of courses. Nevertheless, the quote illustrates his perceived gap between the customs at the university and those in school; it also corroborates the earlier findings that the hypothesis is a guess about an outcome in the school custom (Gyllenpalm et al., 2009).

30. Albert: I can refer back to my practicum school once again speaking about hypothesis. In part, I agree about what has been said because when I hear the word hypothesis, I think about my [practicum] school when they write lab reports and regardless if you talk about year seven or year nine, they always get to start by writing their own hypothesis. How they think, what they believe... They read through the actual lab task and find out about what we are going to do a lab about. And the lab question is, what result they are to find out. Then they always get to write down what they believe is going to happen. And hypothesis in that sense, I can’t recall from the university

[courses], that now you are going to do this laboratory task and you are going to find out about this and this, and what do you think will happen?

(University B)

Albert describes the recurring habit of ‘always beginning with writing a hypothesis’ as a guess about an outcome, and he contrasts this with the courses he has taken at the university of which he ‘can’t recall’ anything similar. Later in the same interview, Lina refers back to Albert’s statement:

31. Interviewer: So hypothesis as “what you think will happen”, do you think that it is a good definition of what a hypothesis is?

32. Lina: Perhaps not scientifically like, but I can follow Albert’s track that it is like that I interpret the word sort of. That is also how I have asked students to formulate hypotheses before you have done laboratory tasks. And then like, well, what is a hypothesis? And then I’ve probably explained it sort of with the words that it’s like what you believe is going to happen, what colour you think it will be or what you believe, like that.

(University B)

Lina’s statement shows a certain questioning of the meaning of a hypothesis that can be connected to the interviewer encouraging the students to think about hypotheses in a scientific context. However, what she describes is how she normally has used the word during her practicum. These examples provide a snapshot of how the existing customs in school science continues to be reproduced.

*Questioning the Use of a Hypothesis as a Guess about an Outcome*

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3 469 On some occasions, the conversations led to the students questioning the role of a hypotheses  
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5 470 in scientific research compared to the more familiar school science and their own teacher  
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7 471 education.  
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10 472 33. Mattias: Yes, but if you now think that in real research where they really come up with  
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12 473 new things, do they really have hypotheses there in the same way we have them now?  
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14 474 That they sit down and think for an hour first, hmm...what's going to happen?  
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16 475 ( a few lines further down)  
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19 476 34. Tomas: [...] I mean we never start with that, with the idea, instead we start with the  
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21 477 complete experiment. And that can never science, I mean research could never start  
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23 478 with an experiment and then try to find out why you have this experiment, it seems a  
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25 479 bit twisted.  
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27 480 (*University D*)  
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31 481 Mattias raises a doubt as the interviewer asks if they all agree with the just stated definition of  
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33 482 a hypothesis as a guess about an outcome. A few lines further down, Tomas develops this  
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35 483 thread of reasoning by stating that it is a paradox to be given a method in the form of a recipe  
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37 484 to follow in a laboratory task and then being asked to guess what will happen. A similar  
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39 485 argument was provided by Johan in another interview in which he questioned the use of the  
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41 486 notion of a hypothesis and linked this to thoughts about studying causality.  
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45 487 35. Johan: If you look at, if you think about, eh, I don't know if it says, I think it says that  
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47 488 we are to write a hypothesis, and when you think about it, it's not really a hypothesis  
48  
49 489 in the same sense that it is when you write or do something more scientific, but it's  
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51 490 more that we do an assessment, what we believe is going to happen. It's not directly...  
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53 491 36. Interviewer: What would be more scientific?  
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57 492 37. Johan: I feel like you perhaps should, more like draw up a, a theory for what you  
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59 493 believe could, eh, effect. I believe this is going to happen because, and that because of

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3 494 this, we want to do this experiment. But here we have been assigned to do this  
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5 495 experiment and guess what we think is going to happen. So it is a bit more like  
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8 496 guessing...

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10 497 *(University C, Group 2)*  
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12 498 Johan's reasoning made Alexandra, who was in the same group, uncertain. She seemed to  
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14 499 have been certain that a hypothesis simply meant a guess about an outcome. This lead to a  
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16 500 meaning exchange between Johan and Alexandra in which Johan developed his argument  
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18 501 about the role of hypotheses in a similar way to that of Tomas above. What both Johan and  
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20 502 Tomas are observing is that there is a strange kind of reversed epistemology when it comes to  
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22 503 the prevailing use of a hypothesis as a guess about an outcome. What this means is that the  
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24 504 students are presented with a situation or experimental procedure (a scientific method) and  
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26 505 then asked about what they believe will happen. At the same time, everyone involved knows  
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28 506 that there is a single answer that is already known that is accepted as the correct one, i.e. there  
29  
30 507 is a didactical contract (Brousseau, 1997). Later in the same interview we note that, although  
31  
32 508 the familiar custom is challenged, they continue to show a kind of loyalty to the customs of  
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34 509 school science.

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36 510 38. Alexandra: Ok, but it doesn't feel like you very often in that case, that you formulate  
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38 511 any hypothesis when you work, I mean like we have done.

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40 512 39. Johan: No, not with them.

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42 513 40. Staffan: And that the students, no that's true, in school so...

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44 514 41. Alexandra: But you still call it a hypothesis.

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46 515 42. Staffan: Yes, well, I guess it is this form so that it's like and in that way, you prepare  
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48 516 yourself for the way it will be like perhaps in high school.

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50 517 43. Johan: Yes.  
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44. Interviewer: Is this something that you have discussed with your teachers or earlier in connection to laboratory tasks?

45. Several: No.

46. Staffan: In any case, very little, but not that I can remember.

47. Alexandra: No.

(University C, Group 2)

Alexandra is given an eye-opener and brings to light the existing contrast between the meaning of a hypothesis in school science compared to scientific research. Simultaneously, it seems as if the school custom exerts a strong pressure on the students, and that they tend to reproduce this custom as Staffan's statement in turn 42 indicates.

*Hypothesis Fear*

In the existing school custom in which a hypothesis usually means a guess about an outcome, there is also a certain emphasis on the 'you' part of this statement, i.e. what you (the student) personally believe. What this suggests is that 'you' are identified with 'your hypothesis' as if 'you are your hypothesis'. This is in line with the teachers' pedagogical use of the concept as a tool for making students aware of their own preconceptions or misconceptions (Gyllenpalm et al., 2009). Disregarding for a moment that this use of the notion gives a distorted image of the nature of scientific inquiry, there is also reason to suspect that the identity between 'you and your hypothesis' is the root of the hypothesis fear that both teachers and teacher students have reported observing in school children (Gyllenpalm et al., 2010). Lina's statement from turn 32 is continued, and it demonstrates this point, which is also corroborated by the rest of the group.

48. Lina: But, eh, at least the students I have had have had a really difficult time to formulate, they have been very uncertain when they try to formulate hypotheses, thinking that it's a bit scary like when they don't really know if it really is correct...

49. Olle: Students I've had have seen it more like a competition that "I have to be right". Because it has often happened then that they have written it down afterwards, if they are very competitive. "Yes, I don't write it yet, but look to see what happens first and then write it with a big exclamation mark, that yes, I made the correct guess, I was right!"

50. Lina: Yes (laughter)

51. Albert: I also recognize this, that there is a kind of uncertainty, that they are afraid of writing something incorrect. I have tried to explain to them that you can never lose credit based on the hypothesis.

(University B)

A strong emphasis on teaching students the correct explanations (Roberts, 1982) and the fact that because of this, the main purpose of performing laboratory tasks is to reach the correct conclusion (Andrée, 2007) most likely contribute to this hypothesis fear. The hypothesis becomes a tool for psychological manipulation and blackmailing and the stress caused is likely to contribute to students developing a negative attitude towards science as a school subject. Blackmailing occurs if students feel a need to play along with the 'guess the answer' game, because they want to please the teacher or achieve a certain grade even though they are uncomfortable. Simultaneously, there seems to be a reaction in some schools against the prevailing custom of using a hypothesis as a guess about an outcome because of the conflict it easily provokes.

52. Klara: We have never really discussed hypotheses either like in any context the way I see it, because when I was doing my practicum, it's like a lot of teachers are totally

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3 566 against using hypotheses. So I feel very ambivalent and we have never had any  
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5 567 discussion about this.  
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8 568 53. Melanie: Are they against it?  
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10 569 54. Klara: It can get very, in some classes, it can get very confusing when they write  
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12 570 hypotheses, as the teachers see it. Because then they make up really strange things and  
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14 571 then they can even imagine that “we wrote it in our hypothesis so it must be true” so it  
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16 572 can get a bit weird like that.  
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19 573 (*University D*)  
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22 574 Like many others, Klara notes that the subject of hypotheses is not a theme that has been  
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24 575 discussed during laboratory work or at any other time. The counter reaction to the stress  
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26 576 caused by the reversed epistemology apparently expressed by some teachers is  
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28 577 understandable. However, the reaction is misdirected, since it is based on taking the existing  
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30 578 custom as a given and then simply rejecting it as wrong. This is like throwing out the baby  
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32 579 with the bathwater. The teachers are then ‘completely against using hypotheses’ perhaps  
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34 580 without realizing that what they call a hypothesis may be something quite different from what  
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36 581 it normally means in scientific research.  
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43 583 Discussion  
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46 584 *Summary of Results*  
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48 585 The research objective of this article was to describe how teacher students use the potential  
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50 586 pivot term ‘hypothesis’ and how this use relates to a number of cultural institutions that can  
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52 587 be said to constitute science teacher education. We found that the students habitually used  
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54 588 ‘hypothesis’ as equivalent to a guess about an outcome, in line with the customs of school  
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56 589 science (Gyllenpalm et al., 2009). Although some students began to question this during the  
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59 590 course of the interviews, there was also evidence of the tendency to remain loyal to the  
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3 591 custom of school science. The use and function of hypotheses at university courses, as  
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6 592 described by the students, inspired us to distinguish between pure science courses and science  
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8 593 education courses for teachers. In the pure science courses, little or no emphasis is placed on  
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10 594 hypotheses or hypothesis testing as a part of laboratory tasks. Only in some rare cases when  
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12 595 students get to do more comprehensive inquiry projects did the concept of a hypothesis  
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15 596 appear, but this seems to be a one-time event for most students. This is a finding in line with  
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17 597 previous research on science teacher education in Sweden (Lager-Nyqvist, 2003). Thus, it  
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19 598 seems as if the students are expected to invent or discover the logic and subtleties of  
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21 599 formulating hypotheses and hypothesis testing on their own during the course of completing  
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23 600 one single more comprehensive inquiry project. It is a big leap for most students to make, and  
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25 601 as research shows, they are unlikely to learn much more about the nature of scientific inquiry  
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27 602 just from participating in this type of project without explicitly reflecting upon it from a  
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29 603 philosophy of science perspective (Lederman, 1999; Windschitl, 2003).

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31  
32 604 In contrast to the pure science courses, talk about hypothesis seems frequent in science  
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34 605 education courses for teachers, and it is often associated with a pedagogical methodology and  
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36 606 theorising about the nature of how individuals learn scientific concepts. Although  
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38 607 hypotheses were a common part of these courses, it was not a topic that had been discussed  
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40 608 often. In fact, there was nothing to suggest that it had been discussed in terms of scientific  
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42 609 research methodology. Finally, we also noted that the students confirmed our earlier finding  
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44 610 that school students may feel anxiety over formulating their own hypotheses as guesses about  
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46 611 an outcome; a phenomenon we have labelled 'hypothesis fear' (Gyllenpalm et al., 2010). Not  
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48 612 all themes were discussed in depth at each interview, although most themes were at least  
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50 613 touched on in all groups. Summarising the results, it is a surprisingly homogenous choir  
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53 614 formed by students from all over the country.  
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The uses of the term ‘hypothesis’ in the different contexts, or cultural institutions, described and analysed here are summarised in Table 1 below. These cultural institutions can be conceptualised as being connected in chain of partly overlapping cultures in the order given by the numbers in Table 1. Our results illustrate, by focusing on the pivot term “hypothesis”, a specific way in which the continuity of this chain between the cultures of scientific research on and school science is broken. This break is problematic since an important objective of school science is to introduce learners to the culture, practices and language-games of scientific research (Rogoff, 1990; Wickman, 2006). However, describing concrete and specific aspects of this break, as we have tried to, also suggests ways of overcoming these problems. Furthermore, three questions are raised by the results presented here. First, what is the origin of these radically different uses of ‘hypothesis’ in contexts where they might be expected to coincide? Second, how are the different customs that differentiate these cultures reproduced in respect to the use of ‘hypothesis’? And, third, what are the consequences of this state of affairs for teaching and curriculum development? Our answers to these questions are speculative and draw on the educational research literature, as well as on our results and theoretical framework.

[Insert Table 1 here]

*Constructivism as a Possible Origin of the Inquiry Emphasis Conflation*

There is reason to believe that failing to distinguish between a hypothesis and a prediction in school science is connected with the influences of constructivist theories of learning. Constructivist theories of learning can be traced to Piaget’s theory of individual development of cognitive schemata through a process of accommodation resulting from a loss of mental equilibrium (Piaget, 1964/2003). Piaget’s theory and the early elaborations of it to suit the field of science education research tend to mix theories of how individuals learn on a short time scale, and theories of how science as a collective enterprise advances over the

course of hundreds of years (Carey, 1999; Driver & Easley, 1978; Posner, Strike, Hewson, & Gertzog, 1982). Park (2006, p. 488) recently summarised teaching based on constructivism as being composed of four stages: 'recognition of prior idea, cognitive conflict, resolution of conflict, and recognition of the modified idea.' Somewhere along the way, the notion of hypothesis seems to have been hijacked as a tool for eliciting students' prior ideas and setting the stage for a cognitive conflict to occur. In this process, the hypothesis was confused with a prediction, and since the objective has not traditionally been to teach students about NOI, this collapsed distinction did not appear to have any negative consequences. However, if an understanding of NOI is important, this conflation becomes problematic. Furthermore, we note that due to the existing, but tacit, didactical contract (Brousseau, 1997) that characterises school science, this pedagogical use of the hypothesis seems to lead to the reported hypothesis fear suffered by students. The didactical contract generally states that what is important to learn are the correct explanations and producing the correct results in a laboratory task. As these explanations and results are known, there is no incentive for students to take a guess that turns out to be wrong because of the risk of appearing stupid. This risk and the prospect of wasted intellectual effort combined with a desire to please the teacher can be hypothesised to produce the anxiety reported amongst students.

It is possible that there are other origins of this conflation. One is that scientists themselves, and college textbooks, may not always use these terms in a consequent manner (Lawson, 2007). However, our results are in line with other critiques of constructivism that address its epistemological and ontological basis (Kruckenberg, 2006; Säljö, 2000), and the pedagogical practices derived from it (Caravita & Halldén, 1994; Furtak, 2006). Also, the idea that students misconception always obstruct learning and that teachers therefore need to focus primarily on conceptual change has recently been criticised (Hamza & Wickman, 2007).

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*Reproducing the Inquiry Emphasis Conflation*

Pure science courses generally omit discussions about hypotheses and the nature of scientific inquiry (NOI). Laboratory tasks in these types of courses are usually closed, fully structured and used to motivate, exemplify and teach the established theories and explanations of science (Hult, 2000). However, it is not merely what is said and done that is important in education, but also what is not said, what Östman (1998) called ‘companion meanings’. Thus, the pure science courses indirectly teach that talk about hypotheses in relation to research methodology and NOI is not important enough to merit systematic teaching and assessment. The fact that there is a general silence about NOI in general and the use of hypotheses in particular in pure science courses could be an effective buffer between the education cultures and the culture of scientific research, thus breaking the continuity of the chain. The link between scientific research and the rest of the educational system is broken by the silence about these issues; consequently, the pure science courses contribute to maintaining the status quo.

The science education courses for teachers seem to import the school customs right into the university. Here laboratory work is used both to illustrate science topics and teaching methods simultaneously (the so-called ‘parallel processes’), thus contributing more directly to reproducing the inquiry emphasis conflation. In these courses, talk of hypotheses is common, but also taken for granted and not reflected upon explicitly. It is also used as a pedagogical tool rather than as a concept for research methodology. The hypothesis is connected to theories of learning and methods for teaching, but not to discussions about and learning about NOI. Thus, methods of teaching are not separated from methods of scientific inquiry, and the inquiry emphasis conflation is perpetuated. In both the pure science courses and the science education courses for teachers, we note that what we find here is probably not intended by the



teachers leading these courses. It may be that they are aware of the distinctions we make here; however, the point is that this is not what we find when talking to the teacher students. Hence, if these issues have been raised, they have not had much impact.

Lortie (1975) has pointed out that teachers tend to teach the way they were taught, since an average student has 'spent 13000 hours in direct contact with classroom teachers by the time he [sic] graduates from high school' (p. 61), implying a powerful socialisation. As described in the theoretical framework, cultural institutions are upheld by and simultaneously shape individuals habits (Dewey 1930; Cohen 2007; Hodgson 2007; Maréchal 2010). Here we have presented evidence demonstrating how the custom of using the term 'hypothesis' indeed seems to be reproduced in school science with little or no influence from the customs of scientific research passing through the filter of teacher education.

### *Implications for Teaching and Curriculum Development*

Customs and other stable social structures are necessary for the growth and continuity of cultural institutions. Understanding the characteristic customs of the cultural institutions relevant for science education is a prerequisite for successful development and reform projects (Dewey, 1930; Keys & Bryan, 2001; Rowell & Ebberts, 2004; Windschitl, Thompson, & Braaten, 2008b). Otherwise, projects may be hindered by participants acting according to contradictory yet unexamined customs and habits related to key issues (Fredrichsen, Munford, & Orgill, 2006; Trumbull et al., 2005). Due to the status of 'hypothesis' as a potential pivot term, new curricular material that focus on hypothesis testing as a dimension of learning about scientific inquiry may be interpreted within the school custom of using hypotheses as a pedagogical tool. The concept of 'pivot term' may thus be used to draw attention to this and other potential sources of confusion and miscommunication.



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3 714 In conclusion, this study both corroborates our earlier finding that there is a custom in  
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5 715 science education to conflate methods of teaching with methods of scientific inquiry  
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8 716 (Gyllenpalm et al., 2009, 2010), and, furthermore, describes how this conflation is related to  
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10 717 the different uses of the pivot term “hypothesis” in different cultural institutions relevant for  
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12 718 teacher education. The consequences of this conflation may be the reported hypothesis fear as  
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15 719 well as an increased difficulty in reaching the intended goals of scientific literacy because  
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17 720 NOI as a learning goal becomes difficult to distinguish and emphasise. Teacher educators  
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19 721 need to be aware of how the existing customs relate to the goal of learning about scientific  
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21 722 inquiry associated with scientific literacy. In pure science courses, we suggest that more effort  
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24 723 be devoted to teaching about NOI and, in particular, the logic of hypothesis testing. In science  
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26 724 education courses for teachers, work needs to be done to distinguish explicitly between  
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29 725 theories of how individuals learn and descriptions of how knowledge production occurs in  
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31 726 science at large. We also suggest that the personalized form of address should be abandoned  
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34 727 when asking students for predictions and a hypothesis. Rather, there should be a critical  
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36 728 examination of all possible explanations (hypotheses) and how they relate to the empirical  
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38 729 evidence (predictions and actual outcomes).  
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43 731 References

44  
45 732 Anderson, R. D. (2007). Inquiry as an Organizing Theme for Science Curricula. In S. K.  
46  
47 733 Abell & N. G. Lederman (Eds.), *Handbook of research on science education* (pp. 807-  
48  
49 734 830). London: Routledge.  
50  
51  
52 735 Andrée, M. (2007). *Den levda läroplanen. En studie av naturorienterande*  
53  
54 736 *undervisningspraktiker i grundskolan*. Stockholm: Stockholm Institute of Education.  
55  
56  
57 737 Baxter, L. M., & Kurtz, M. J. (2001). When a hypothesis is not an educated guess. *Science*  
58  
59 738 *and Children*, 38, 18-20.  
60

- 739 Beveridge, W. I. B. (1961). *The art of scientific investigation* (Rev. ed.). London: Mercury.
- 740 Bloor, M., Frankland, J., Thomas, M., & Robson, K. (2001). *Focus Groups in Social*
- 741 *Research*. London: SAGE.
- 742 Brousseau, G. (1997). *Theory of Didactical Situations in Mathematics*. Dordrecht: Kluwer
- 743 Academic Publishers.
- 744 Bybee, R. (2000). Teaching science as inquiry. In J. Minstrell, & Emily H. van Zee (Eds.),
- 745 *Inquiring into Inquiry Learning and Teaching in Science*. Washington, DC: AAAS.
- 746 Caravita, S., & Halldén, O. (1994). Re-framing the problem of conceptual change. *Learning*
- 747 *and Instruction*, 4, 89-111.
- 748 Carey, S. (1999). Sources of Conceptual Change. In E. K. Scholnick (Ed.), *Conceptual*
- 749 *development: Piaget's legacy* (pp. 293-326). Mahwah, N.J.: Lawrence Erlbaum.
- 750 Chalmers, A. F. (1999). *What is this thing called science?* (3rd ed.). Buckingham: Open
- 751 University Press.
- 752 Cherryholmes, C. H. (1999). *Reading Pragmatism*. New York: Teachers College Press.
- 753 Cohen, M. D. (2007). Reading Dewey: Reflection on the Study of Routine. *Organization*
- 754 *Studies*, 28(5), 773-786.
- 755 DeBoer, G. E. (1991). *A history of ideas in science education: Implications for practice*.
- 756 New York: Teachers College Press.
- 757 Dewey, J. (1910). *How we think*. London: Heath & Co.
- 758 Dewey, J. (1916/2004). *Democracy and education*. Mineola, N.Y.: Dover Publications.
- 759 Dewey, J. (1930). *Human nature and conduct: An introduction to social psychology*. New
- 760 York: Modern Library.
- 761 Driver, R., & Easley, J. (1978). Pupils and Paradigms: A Review of Literature Related to
- 762 Concept Development in Adolescent Science Students. *Studies in Science Education*,
- 763 5, 61-84.

- 764 Fredrichsen, P. M., Munford, D., & Orgill, M. (2006). Brokering at the Boundary: A  
 765 Prospective Science Teacher Engages Students in Inquiry. *Science Education*, 90,  
 766 522-543.
- 767 Furtak, E. M. (2006). The problem with answers: An exploration of guided scientific inquiry  
 768 teaching. *Science Education*, 90(3), 453-467.
- 769 Gyllenpalm, J., Wickman, P.-O., & Holmgren, S.-O. (2010). Secondary science teachers'  
 770 selective traditions and examples of inquiry-oriented approaches. *Nordina*, 6(1).
- 771 Gyllenpalm, J., Wickman, P.-O., & Holmgren, S.-O. (2010). Teachers' Language on Scientific  
 772 Inquiry: Methods of teaching or methods of inquiry? *International Journal of Science*  
 773 *Education*, 32(9), 1151-1172
- 774 Hamza, K., & Wickman, P.-O. (2007). Describing and Analyzing Learning in Action: An  
 775 Empirical Study of the Importance of Misconceptions in Learning Science *Science*  
 776 *Education*, 92, 141-164.
- 777 Hansson, S. O. (2006). Falsificationism Falsified. *Foundations of Science*, 11, 275-286.
- 778 Hodgson, G. (2006). What Are Institutions? *Journal of Economic Issues*, XL(1).
- 779 Hodgson, G. (2007). Institutions and Individuals: Interaction and Evolution. *Organization*  
 780 *Studies*, 28(1), 95-116.
- 781 Hult, H. (2000). *Laborationen - myt och verklighet: en kunskapsöversikt över laborationer*  
 782 *inom teknisk och naturvetenskaplig utbildning*. CUP:s Rapportserie Nr 6. Linköping:  
 783 Centrum för universitetspedagogik.
- 784 Hurtado, S., Carera, N. L., Lin, M. H., Arellano, L., & Espinosa, L. L. (2009). Diversifying  
 785 Science: Underrepresented Student Experiences in Structured Research Programs  
 786 *Research in Higher Education*, 50, 189-214.
- 787 James, W. (1907/1995). *Pragmatism*. Mineola: Dover Publications.

- Keys, C. W., & Bryan, L. A. (2001). Co-Constructing Inquiry-Based Science with Teachers: Essential Research for Lasting Reform. *Journal of Research in Science Teaching*, 38, 631-645.
- Kruckenbergh, R. (2006). A Deweyan Perspective on Science Education: Constructivism, Experience, and Why We Learn Science. *Science & Education*, 15, 1-30.
- Lager-Nyqvist, L. (2003). *Att göra det man kan: en longitudinell studie av hur sju lärarstudenter utvecklar sin undervisning och formar sin lärarroll i naturvetenskap*. Göteborg: Acta Universitatis Gothoburgensis.
- Lawson, A. E., Oertman, M., & Jensen, J. (2007). Connecting science and mathematics: The nature of scientific and statistical hypothesis testing. *International Journal of Science and Mathematics Education*, 6, 405-416.
- Lederman, N. (2004). Syntax of nature of science within inquiry and science instruction. In N. Lederman (Ed.), *Scientific Inquiry and the Nature of Science* (pp. 301-317). London: Kluwer Academic Publishers.
- Lederman, N., G. (1999). Teachers' understanding of the nature of science and classroom practice: Factors that facilitate or impede the relationship. *Journal of Research in Science Teaching*, 36, 916-929.
- Lortie, D. C. (1975). *Schoolteacher: A sociological study*. Chicago: University of Chicago Press.
- Maréchal, K. (2010). Not irrational but habitual: The importance of 'behavioural lock-in' in energy consumption. *Ecological Economics*, 69, 1104-1114.
- McComas, W. F. (1998). The principal elements of the nature of science: dispelling the myths. In W. F. McComas (Ed.), *The Nature of Science in Science Education Rationales and Strategies* (pp. 53-70). Dordrecht, The Netherlands: Kluwer Academic Press.

- 813 Metz, K. (2004). The Knowledge Building Enterprises in Science and Elementary Science  
814 Classrooms. In N. Lederman (Ed.), *Scientific Inquiry and the Nature of Science* (pp.  
815 105-130). London: Kluwer Academic Publishers.
- 816 Östman, L. (1998). How companion meanings are expressed by science education discourse.  
817 In D. A. Roberts & L. Östman (Eds.), *Problems of Meaning in Science Curriculum*  
818 (pp. 54-77). New York: Teacher College Press.
- 819 Park, J. (2006). Modelling Analysis of Students' Processes of Generating Scientific  
820 Explanatory Hypothesis. *International Journal of Science Education*, 28, 469-489.
- 821 Piaget, J. (1964/2003). Cognitive Development in Children: Piaget, Development and  
822 Learning. *Journal of Research in Science Teaching*, 40, 8-18 .
- 823 Posner, J. G., Strike, A. K., Hewson, W. P., & Gertzog, A. W. (1982). Accommodation of a  
824 Scientific Concept: Toward a Theory of Conceptual Change. *Science Education*, 66,  
825 211-227.
- 826 Roberts, D. A. (1982). Developing the concept of curricular emphases in science education.  
827 *Science Education*, 14, 10-25.
- 828 Roberts, D. A. (2007). Scientific Literacy/Science Literacy. In S. K. Abell & N. G. Lederman  
829 (Eds.), *Handbook of research on science education* (pp. 729-780). London: Lawrence  
830 Erlbaum Associates Inc.
- 831 Rocard, M. (2007). *Science education now: A renewed pedagogy for the future of Europe*.  
832 Luxembourg: Office for Official Publications of the European Communities.
- 833 Rowell, P., & Ebberts, M. (2004). Shaping school science: Competing discourses in an  
834 inquiry-based elementary program. *International Journal of Science Education*, 26,  
835 915-934.
- 836 Rogoff, B. (1990). *Apprenticeship in thinking: cognitive development in social context*.  
837 Oxford: Oxford University Press.

- 838 Rorty, R. (1979). *Philosophy and the mirror of nature*. Princeton: Princeton University Press.
- 839 Rudolph, J., L. (2002). Portraying Epistemology: School Science in Historical Context.
- 840 *Science Education*, 87, 64-79.
- 841 Säljö, R. (2005). *Lärande och kulturella redskap : om lärprocesser och det kollektiva minnet*.
- 842 Stockholm: Norstedts akademiska förlag.
- 843 Schwab, J. J. (1962). *The Teaching of Science as Enquiry*. Cambridge: Harvard University
- 844 Press.
- 845 Schwartz, R. S., Lederman, N. G., & Crawford, B. A. (2004). Developing views of nature of
- 846 science in an authentic context: An explicit approach to bridging the gap between
- 847 nature of science and scientific inquiry. *Science Education*, 88, 610-645.
- 848 Wertsch, J. V. (1998). *Mind as action*. Oxford: Oxford University Press.
- 849 Wickman, P.-O. (2004). The practical epistemologies of the classroom: A study of laboratory
- 850 work. *Science Education*, 88(3), 325-344.
- 851 Wickman, P.-O. (2006). *Aesthetic experience in science education: Learning and meaning-*
- 852 *making as situated talk and action*. Mahwah, N.J.: Lawrence Erlbaum Associates.
- 853 Wickman, P.-O., & Östman, L. (2002). Learning as discourse change: A sociocultural
- 854 mechanism. *Science Education*, 86(5), 601-623.
- 855 Windschitl, M. (2003). Inquiry projects in science teacher education: What can investigative
- 856 experiences reveal about teacher thinking and eventual classroom practice? *Science*
- 857 *Education*, 87, 112-143.
- 858 Windschitl, M. (2004). Folk Theories of 'Inquiry': How Preservice Teachers Reproduce the
- 859 Discourse and Practices of an Atheoretical Scientific Method. *Journal of Research in*
- 860 *Science Teaching*, 41(5), 481-512.

1  
2  
3 861 Windschitl, M., Thompson, J., & Braaten, M. (2008a). Beyond the Scientific Method: Model-  
4  
5 862 Based Inquiry as a New Paradigm of Preference for School science Investigations.  
6  
7 863 *Science Education*, 92, 941-967.  
8  
9  
10 864 Windschitl, M., Thompson, J., & Braaten, M. (2008b). How Novice Science Teachers  
11  
12 865 Appropriate Epistemic Discourses Around Model-Based Inquiry for Use in  
13  
14 866 Classrooms. *Cognition and Instruction*, 26, 310-378.  
15  
16  
17 867 Wilson, E. B., Jr. (1990). *An introduction to scientific research*. New York: Dover  
18  
19 868 Publications.  
20  
21  
22 869 Wittgenstein, L. (1968). *Philosophical investigations*. (3rd ed.). Oxford: Blackwell.  
23  
24  
25 870 Volante, L., & Earl, L. (2002). Teacher Candidates' Perceptions of Conceptual Orientations in  
26  
27 871 Their Preservice Program. *Canadian Journal of Education*, 27(4), 419-438.  
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32 873 Appendix A  
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34 874 *Interview Template*  
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36 875 1. Can you describe the example you have chosen? (Context? Prerequisite knowledge? Time  
37  
38 876 frames? Research question? How was the question answered? Group or individual? Aids?  
39  
40 877 Assessment? Presentation of results? Comparisons of results?)  
41  
42  
43 878 2. How did you understand the purpose of this as part of your own teacher education?  
44  
45  
46 879 3. Particular words/notions to try to focus on:  
47  
48 880 - Question, guess, hypothesis  
49  
50 881 - Method, observation, experiment, scientific, systematic, objective  
51  
52 882 - Prior knowledge, theory, model  
53  
54 883 - Logical reasoning, critical thinking, proof, cause, prediction  
55  
56 884 - Presentation, report, examine, compare with the results of others  
57  
58  
59 885 4. Other questions that may be relevant to ask:  
60



- 886 - Did you get to formulate your own research question?
- 887 - Plan and conduct investigations on your own to answer your own research question?
- 888 - Is there a difference between a laboratory task and an experiment?
- 889 - Did you plan and conduct a controlled experiment on your own?
- 890 - What is a controlled experiment?
- 891 - Did you formulate your own hypotheses and predictions?
- 892 - Is there a difference between the concepts of hypothesis and prediction?
- 893 - Has any teacher discussed these concepts in your education?

894

## 895 Appendix B

### 896 *Focusing Exercise*

897 The purpose of laboratory tasks or inquiry projects in my education has often been to:

- 898 1. Learn about the science behind technical and natural phenomenon in our everyday life.
- 899 2. Learn about the nature of science: what is characteristic of science.
- 900 3. Learn scientific subject matter as a preparation for taking more advanced courses
- 901 4. Motivate or exemplify scientific theories and models of explanation.
- 902 5. Learn about the historical development of science as a part of our culture.
- 903 6. Learn about the role of science in society, technology and decision-making.
- 904 7. Learn to handle processes and methods used in scientific research.

905

## 906 Appendix C

907 Theme 1: Natural scientific methods and theories

908 Theme 2: Pedagogical methods and theories

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