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**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.

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3 1 The Uses of the Term Hypothesis and the Inquiry Emphasis Conflation in Science Teacher
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5 2 Education
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10 4 Abstract
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12 5 This paper examines the use and role of the term 'hypothesis' in science teacher education as
13 6 described by teacher students. Data was collected through focus group interviews conducted
14 7 at seven occasions with 32 students from six well known Swedish universities. The theoretical
15 8 framework is a sociocultural and pragmatist perspective on language and learning,
16 9 introducing the notion of pivot terms to operationalise language use as a habit and mediated
17 10 action. We describe three different customs of using the term 'hypothesis' within four cultural
18 11 institutions that can be said to constitute science teacher education in Sweden. Students were
19 12 found to habitually use the term hypothesis as meaning a guess about an outcome. This is
20 13 contrasted to the function of this term in scientific research as a tentative explanation. We also
21 14 found differences in how this term was used between the pure science courses given by the
22 15 science departments of universities and science education courses taken only by teacher
23 16 students. Findings also included further support for school students hypothesis fear reported
24 17 in an earlier study. It is discussed how these findings can obstruct learning and teaching about
25 18 the nature of scientific inquiry. Constructivist theories of learning are suggested as a possible
26 19 origin of these problems. The findings are also related to curricular reform and development.
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50 21 Introduction
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52 22 In the current debate on curriculum development in science education, two notions stand out:
53 23 scientific literacy and inquiry. Scientific literacy has been discussed in depth by Roberts
54 24 (2007) who distinguishes between what he calls Visions I and II of curriculum aims in science
55 25 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
9
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
14
15 31 inquiry in science education (Anderson, 2007; DeBoer, 1991). In part this may be due to the
16
17 32 fact that the term inquiry is used to refer both to a pedagogical strategy for teaching science,
18
19 33 and as a content for students to learn (Bybee, 2000). The educational goals associated with
20
21 34 inquiry as a content have been described by Lederman (2004) as learning to do inquiry and
22
23 35 learning about inquiry. It is learning about inquiry that is arguably the more important goal for
24
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
30
31 38 important dimension can be for learners to understand the basics of hypothesis testing through
32
33 39 the use of controlled experiments. The method of controlled experiments is central in many
34
35 40 natural sciences, but it is not the equivalent of 'the scientific method' (Beveridge, 1961), and
36
37 41 many scholars agree that this notion seriously misrepresents science (Rudolph, 2002;
38
39 42 Windschitl, 2004). In fact, learning about the method of the controlled experiment may be an
40
41 43 important step in understanding that this is one particular type of method used in science. In
42
43 44 the present study we focus on the use and role of hypotheses in science and science education
44
45 45 as an important sub-dimension of learning about scientific inquiry.
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50 46 We have in a previous study described teachers' selective traditions in relation to
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52 47 scientific inquiry in secondary schools (Gyllenpalm, Wickman, & Holmgren, 2010). Our
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54 48 results indicated that teaching activities that teachers describe as being inquiry-oriented are
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56 49 not explicitly connected with a targeted knowledge in terms of learning about inquiry. This is
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58 50 problematic, as it has been shown that an understanding of the nature of scientific inquiry is
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3 51 not gained merely by participating in inquiry activities, but that these issues must be
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5 52 addressed and reflected upon explicitly (Lederman, 1999; Schwartz, Lederman, & Crawford,
6
7 53 2004; Windschitl, Thompson, & Braaten, 2008a). In analysing the tradition of laboratory
8
9 54 work in Swedish secondary schools, we found that teachers seemed to conflate methods of
10
11 55 teaching (i.e. inquiry as a pedagogical approach) and methods of scientific inquiry (i.e. the
12
13 56 targeted knowledge when learning about inquiry) (Gyllenpalm, Wickman, & Holmgren,
14
15 57 2009). This included failing to distinguish between the concepts of hypothesis and prediction
16
17 58 and using hypotheses as pedagogical tools for teaching the results of science thus further
18
19 59 obscuring learning about scientific inquiry. In this article, we call this conflation of means
20
21 60 (methods of teaching) and ends (methods of scientific inquiry) in science teaching for the
22
23 61 inquiry emphasis conflation. The purpose of the study reported on in this article was to
24
25 62 investigate if the results from our previous study would be corroborated by interviews with
26
27 63 another group of informants (i.e. teacher students instead of experienced teachers). In addition
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29 64 this different group of informants also allowed us to examining the role teacher education in
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31 65 Sweden might have in reproducing the inquiry emphasis conflation.
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41 Theoretical Framework

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43 68 In this study we take a sociocultural and pragmatist perspective on language and learning. The
44
45 69 focus of sociocultural theory is to explicate the relationship between social, historical and
46
47 70 cultural contexts on the one hand, and individual action on the other (Wertsch, 1998). In the
48
49 71 analysis presented here the particular cultural contexts are those of school, university
50
51 72 education and scientific research, which we will refer to as cultural institutions (Rogoff, 1990;
52
53 73 Säljö, 2005). Cultural institutions are relatively stable systems of human relations,
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55 74 communicative patterns, physical artefacts, activities, routines and other types of social
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57 75 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
4
5 77 dimensions as well as more informal systems of practice (Rogoff, 1990). Institutions are in
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7
8 78 this way systems of established and embedded social rules that structure social interactions,
9
10 79 although the rules are not always explicit and compelling in a definite way (Hodgson, 2006).
11
12 80 The modifier 'cultural' refer to that these institutions also embody cultural values and
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15 81 purposes (Rogoff, 1990), and have been shaped by their particular historical and contingent
16
17 82 developmental path (Wertsch, 1998).

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19
20 83 The relationship between cultural institutions and individuals' actions within these can
21
22 84 be approached by analysing mediated action and habits. Mediated action refers to an agent
23
24 85 acting by means of, or mediated by, cultural artefacts (Wertsch, 1998), with the most
25
26 86 ubiquitous cultural artefact being language (Säljö, 2005). Mediational means both provide
27
28 87 affordances and constrains (Wertsch, 1998) for how we communicate, act and think. Our uses
29
30 88 of language, including particular distinctions and divisions, is to a large extent habitual
31
32 89 (Wickman, 2006). By habits we mean predispositions and tendencies for certain kinds of
33
34 90 actions in certain situations (Dewey, 1930), and not strictly repetitive behaviour in a
35
36 91 biological sense (Cohen, 2007). Institutions are upheld by the habits of individuals,
37
38 92 simultaneously as institutions and the mediational means they provide, shape individuals
39
40 93 habits (Dewey, 1930; Hodgson, 2007; Maréchal, 2010). We call these collectively shared
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42 94 habits, that characterise cultural institutions, customs (Dewey, 1930; Cohen, 2007). Being
43
44 95 socially transmitted, habits require the attention and will of the agent while learning them, but
45
46 96 once established they tend to function without explicit reflection. Nevertheless, habits can be
47
48 97 made the object of explicit deliberation, which is a first step in changing habits, and the
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50 98 transformation of habits for coping with new situations can be conceptualised as learning
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52 99 (Rorty, 1979; Wickman, 2006).

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3 101 *Cultural Institutions and Science Teacher Education*
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5 102 Four different cultural institutions have emerged as relevant in describing and analysing the
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8 103 results presented here: scientific research, pure science courses, science education courses for
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10 104 teachers and school science. These cultural institutions are interrelated but they can be briefly
11
12 105 described individually as follows. Scientific research refers to basic or applied research at a
13
14 106 university or the equivalent with the aim of increased or better knowledge of natural processes
15
16 107 and phenomena. Pure science courses refer to courses given by a science department at a
17
18 108 university, often led by an active researcher, and with no particular orientation towards
19
20 109 teacher education. This type of course tends to focus quite exclusively on introducing students
21
22 110 to a well-established body of scientific knowledge. Science education courses for teachers, on
23
24 111 the other hand, are given by the teacher education department or the equivalent, and are often
25
26 112 led by teachers with a lot of experience from teaching science in schools. This type of course
27
28 113 often has the dual purpose of teaching students science and simultaneously teaching them
29
30 114 how to teach science in schools (sometimes called ‘parallel processes’), although the
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32 115 emphasis between these two purposes may vary. School science is here science as a school
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34 116 subject in secondary and upper secondary schools.
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43 118 *Language use and the meaning of words*
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45 119 A pragmatist perspective on language means that instead of seeing language as an outer
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47 120 expression or representation of an inner mental state, as is usually the case in cognitive
48
49 121 perspectives, the meaning of words or any utterances are to be found in their use and
50
51 122 consequences (James 1907/1995; Wickman, 2006; Wickman & Östman, 2002). This means
52
53 123 that words do not have an essential or universal meaning but must be understood as part of an
54
55 124 activity, context, or what Wittgenstein called a ‘language-game’ (Wickman, 2006). To
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57 125 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
4
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
9
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).
14
15 131 This means that to learn a language-game is not simply to know the use of certain words but
16
17 132 also means the acquisition of habits of using these words as part of an activity (Wickman,
18
19 133 2004). In order to reflect upon the customs (i.e. shared habits) of the major cultural institution
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21
22 134 relevant to science teacher education, it is therefore relevant to study and make explicit the
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24
25 135 particular uses of language that are associated with them.

26
27 136 We define a pivot term as a single word or term that can be used to highlight how two
28
29 137 or more different cultural institutions and their associated language-games overlap or
30
31 138 intersect. It can metaphorically be described as a term on which one can balance two such
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34 139 systems - a common point around which they can be said to revolve. A pivot term thus relates
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36 140 to some central aspect of two or more activities, or language-games, with distinctively
37
38 141 different purposes, resulting in the word having radically different meanings and connotations
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41 142 in these activities. If the customs of using a particular term differs significantly between two
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44 143 cultural institutions it may be described as a pivot term. The same pivot term may thus
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46 144 mediate quite different action in different activities. Pivot terms are special compared to other
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48 145 words, only because they can be positioned to provide a point of leverage for analytically
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51 146 separating two or more activities. This is not an essential or universal quality of a certain class
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53 147 of words, but a description of a role or function that a term may play when comparing its
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55 148 customary use in relation to the different purposes of different cultural institutions. Analysing
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58 149 the use of potential pivot terms is thus a way to operationalise how specific words can play a
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60 150 central role in mediating action.

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6 152 *The Use of 'Hypothesis' in Scientific Research*
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8 153 The possible pivot term analyzed in this paper is 'hypothesis' and its use in the cultures that
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10 154 meet in science teacher education. In the results section we present empirical data on its use in
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12 155 the cultures that teacher students are directly involved in. However, to examine how these
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15 156 uses are related to the aim of teaching teacher students about inquiry as it is carried out in
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17 157 scientific research, a comparison needs to be made with its use in scientific research.

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22 159 The word 'hypothesis' is commonly used in science to refer to a tentative explanation related
23
24 160 to some observed phenomena (Chalmers, 1999). A hypothesis is not a single prediction
25
26 161 (McComas, 1998) but a suggestion about how the data is connected (Wilson, 1990). Often, it
27
28 162 is a proposition about a correlation or causal mechanism. What follows are three examples of
29
30 163 hypotheses from recent scientific research. All examples are taken from articles published in
31
32 164 *Nature* in the year 2000 (Hansson, 2006).

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36 165 1. Neurotransmitter receptors of type D5 differ from those of type D1 in having special
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38 166 functional interactions with $GABG_A$ receptors.
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41 167 2. Certain gravel depositions in Hawaiian coastal slopes were created in a single event by giant
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43 168 tsunamis.
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46 169 3. Super conductivity will arise in C_{60} at high temperatures if it is hole-doped.

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49 170 These hypotheses all have in common that they in different ways state tentative explanations,
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51 171 with reference to causal or functional relationships, of natural phenomena. Example one
52
53 172 proposes as "functional interaction", example two how a geological feature was "created" (i.e.
54
55 173 caused) and example three proposes "hole-doping" as a factor that might cause the
56
57 174 phenomenon of "super conductivity" under certain conditions. Furthermore, they all refer to
58
59 175 theoretical concepts (e.g. superconductivity, neurotransmitter, gravel deposit) that have

1
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3 176 meaning only in relation to a more comprehensive theory and research programme of some
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5
6 177 kind. Example three may superficially be mistaken for a prediction. If one only considers
7
8 178 grammatical form, this may be true, in a sense, but the key here is the second part, 'if it is
9
10 179 hole-doped'. This refers to a cause or explanation of the predicted superconductivity in this
11
12 180 particular case. For this explanation to make sense, the hypothesis must be connected to a
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14
15 181 more comprehensive model relating the particulars of C_{60} within the even more
16
17
18 182 comprehensive theory of solid state physics. This implies that a hypothesis cannot stand
19
20 183 alone, and that the theory or research objective to which it is related is needed to separate a
21
22 184 scientific hypothesis from a groundless guess about an outcome or arbitrary fortune-telling
23
24
25 185 (McComas, 1998).

26
27 186 It can be questioned whether hypotheses play an important role in all forms of scientific
28
29 187 research (Hansson, 2006). However, it is definitely widely used in the way described here in
30
31 188 science studies, which is the field of scholarship in which the nature of scientific inquiry
32
33 189 (NOI) is systematically studied and described.

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37 38 39 191 *Research Question*

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41 192 The objective of this article is to examine the uses of the potential pivot term 'hypothesis' and
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43 193 analyse the possible consequences of these for science teacher education. In particular the
44
45 194 research questions are:

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48 195 1. How do science teacher students use the word 'hypothesis' and describe its function when
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50 196 discussing examples of laboratory tasks in their own university education?
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53 197 2. In what ways are the customary ways of using the word 'hypothesis' different in the
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55 198 cultural institutions that constitute science teacher education in Sweden?
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3 199 The first research question is addressed by presenting and analysing transcripts from the focus
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5 200 group interviews, while the second question is addressed analytically based on the findings
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8 201 related to question one.
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11 203 Method

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15 204 In order to obtain information about the characteristic customs of teacher education in a
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17 205 manner that was not too artificial, and simultaneously hear a large number of informants from
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19 206 a range of backgrounds, focus group interviews were chosen as the method of data collection.
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22 207 This approach was inspired by Volante and Earl (2002), who used focus groups to explore
23
24 208 teacher students understanding of the conceptual orientations of their own teacher education
25
26 209 programmes and practicum experiences, and also Hurtado, Carera, Lin, Arellano, and
27
28 210 Espinosa (2009), who used focus groups to study university students experiences with the
29
30 211 culture of science.
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33 212

34 213 *Sample Selection*

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36 214 Six well-known universities were chosen to obtain a broad representation of teacher education
37
38 215 programmes in Sweden. The target group was teacher students who specialised in natural
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40 216 science for secondary schools and who were approaching the end of their education. In all
41
42 217 seven focus group interviews were conducted with a total of 32 students and 3 to 6
43
44 218 participants in each group at the following universities: Gothenburg University, Malmö
45
46 219 University, Mälardalen University, Stockholm University, Umeå University and Uppsala
47
48 220 University
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51 221 *Focus Group Interviews*

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53 222 The focus group interviews were orchestrated to situate the conversations in a context similar
54
55 223 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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7
8 226 on average 1.5 hours and were conducted by the first author, according to the following
9
10 227 structure:

11
12 228 1. Introduction and presentations

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15 229 2. Focusing exercise: ranking the purposes of laboratory tasks

16
17 230 3. Students tell about their own examples of laboratory work

18
19
20 231 4. 'Pedagogical methods and theories' are compared with 'Natural scientific methods and
21
22 232 theories'

23
24 233 At the beginning of the interview, the researcher repeated the information that the students
25
26 234 had been given before the meeting and described the overall objective and how data was
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28
29 235 going to be used. During the interviews, an interview guide was used (Appendix A) to help
30
31 236 call attention to and focus on relevant themes of discussion.

32
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34 237 A focusing exercise is described by Bloor, Frankland, Thomas, and Robson (2001) as
35
36 238 'an attempt to concentrate the group's attention and interaction on a particular topic' (p.43). In
37
38 239 our case, this was done by asking the students to agree upon a ranking of seven statements
39
40
41 240 about the main purposes of laboratory work in their university education, as perceived by
42
43 241 them (Appendix B). The statements were inspired by Roberts's seven curriculum emphases in
44
45 242 science education (Roberts, 1982). During the exercise, the students were asked to explain
46
47 243 their reasoning as they worked on the task and to refer back to concrete examples from their
48
49
50 244 own education. The exercise took approximately 30 minutes to complete.

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52
53 245 After the focusing exercise, each of the examples provided by each student was
54
55 246 discussed. These mainly consisted of laboratory reports or instructions. The students were
56
57 247 asked individually to elaborate on the context in which the example was situated in their
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60 248 education, and to relate it to the list of purposes discussed during the focusing exercise. As a

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3 249 final topic for the interview, two sheets of papers were distributed with two different topics or
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5 250 themes (Appendix C) and the students were asked to discuss these in relation to the focusing
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8 251 exercise and their own examples.
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10 252 The objective of these preparations and tasks was to create conditions favourable for
11
12 253 engaging conversations, which we hoped would provide many natural opportunities to
13
14 254 elaborate on the meaning and use of inquiry related terms such as ‘hypothesis’. It was not our
15
16 255 intention to elicit the students’ views on the nature of the purpose of laboratory work or how
17
18 256 ‘pedagogical theories’ might differ from ‘natural scientific theories’. These themes were
19
20 257 instead used as heuristics to help create meaningful, content rich and focused conversations.
21
22 258 We feel that over all we succeeded with this and several students commented after the
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24 259 interviews that they had found the event both inspiring and educative.
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31 261 *Analysis of Data*

32 262 All focus group interviews were transcribed verbatim and then proofread to ensure a high
33
34 263 quality of the transcribed record. The transcripts were then coded in terms of the general
35
36 264 topics of the interviews as well as sections relating to the use of the term ‘hypothesis’. This
37
38 265 provided an overview of the material. In the next step, the transcripts were re-coded in more
39
40 266 detail, with a focus on the use and mentioning of the term ‘hypothesis’ using the Transana
41
42 267 software for qualitative data analysis. All episodes containing references to hypotheses were
43
44 268 printed and sorted in subcategories in order to find the common themes described in this
45
46 269 article. The most representing transcripts have been chosen to be presented and commented
47
48 270 upon in the Result section. The transcripts are translations from verbatim Swedish transcripts
49
50 271 to English. Great care has been taken to stay as close as possible to original sense of the
51
52 272 wording, but the transcripts in Swedish also contain many grammatically odd formulations as
53
54 273 transcribed talk often does.
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275 Results

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

280

281 *The Dominant Use of "Hypothesis" in Teacher Education*

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

292 1. Sara: Hypothesis? Hypothesis is what you believe is going to happen in the
293 experiment.

294 2. Klara: Yes.

295 3. Sara: That's what you're supposed to come up with before if it is a hypothesis...

296 (*University D*)

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3 297 Students using the word 'hypothesis' as a guess about an outcome were also asked if they had
4
5 298 noted the fact that this equates a hypothesis with a prediction. This was clearly not something
6
7
8 299 the students had considered, as exemplified in the following quote:

9
10 300 4. Interviewer: It sounds somewhat like a prediction as well.

11
12 301 5. Johan: Yes, well, yes perhaps you could better say that's what it is. It is nothing...

13
14
15 302 6. Interviewer: Is this something that you have distinguished between or talked about?

16
17 303 7. Several: No

18
19
20 304 8. Johan: You know it's not directly, it's not like we have formulated our own hypothesis
21
22 305 to be able to see if there is any difference, it's more like we have... I guess our, our
23
24 306 hypothesis was to be formulated, what do you think is going to happen with the one
25
26 307 that's in darkness and the one that is in light, and what does it depend on? So I guess
27
28 308 that's what we have written.

29
30
31 309 (*University C, Group 2*)

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34 310 The last comment by Johan refers to a take-home laboratory task in which the students
35
36 311 were to perform an experiment to test how two different treatments (one environment
37
38 312 with sunlight and one without) affected the growth of a plant. This was part of a science
39
40 313 education course for teachers. As exemplified here, the use of a hypothesis as a guess
41
42 314 about an outcome dominated the focus group conversations. There were no indications
43
44 315 of the students having noted that this use conflates a hypothesis with a prediction.

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49
50 317 *Absence of Hypotheses in Pure science courses*

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52
53 318 The custom of having students formulate their own hypotheses as guesses about the outcome
54
55 319 of a laboratory task in school science is in stark contrast to the customs of the pure science
56
57 320 courses. In these courses, talk about hypotheses is rare and it is normally not an important
58
59 321 concept in laboratory tasks.

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3 322 9. Interviewer: Well, now I don't think that there were any of these examples that you
4
5 323 mentioned that began with some hypothesis?
6

7
8 324 10. Jan: We haven't had a lab like that.
9

10 325 11. Petra: We haven't had a lab like that, no.
11

12 326 *(University E)*
13

14
15 327 Whereas it can easily be seen in the complete interview transcripts that the two above
16
17 328 quotes explicitly refer to pure science courses, it is inferred from the context in the next
18
19 329 two quotes. As this distinction was found to be important only after analysing the
20
21 330 interviews, it was not addressed explicitly during the interviews.
22
23

24 331 12. Klara: Yeah, but it's just that you rarely get to, I mean there are no hypotheses in that
25
26 332 way; instead you often get to do lab tasks in which you know what will happen if you
27
28 333 mess up, sort of. There is a correct result in some way. And that ... Yes ... then there
29
30 334 isn't really a hypothesis and then you don't work with hypotheses in that way.
31
32

33 335 *(University F)*
34

35
36 336 These quotes illustrate that in the pure science courses, there is little use for or even
37
38 337 mentioning of hypotheses. Previous research has also shown that in pure science courses,
39
40 338 laboratory tasks are usually highly structured and recipe like (Hult, 2000). The absence of
41
42 339 hypotheses in laboratory tasks in pure science courses is also accompanied by what seems to
43
44 340 be a rather low emphasis on discussion about the nature of science and the nature of scientific
45
46 341 inquiry in general. In the quote below, Klara is referring to item number seven in the focusing
47
48 342 exercise when she concludes that they have not discussed the nature of scientific inquiry:
49
50

51 343 13. Interviewer: The scientific method, what would that be?
52

53 344 14. Mattias: It's what they say...
54
55

56 345 15. Klara: It's what they always talk about, but no one wants to define.
57
58

59 346 16. Sara: Nobody wants to explain it, no.
60

1
2
3 347 17. Klara: And it's really important that we know.
4

5 348 (five turns further down)
6

7
8 349 18. Klara: And in that case, if number seven has to do with that, I definitely think that we
9
10 350 don't get into that when we do laboratory tasks and experiments at all.
11

12 351 19. Camilla: No
13

14
15 352 (*University D*)
16

17 353 Although hypotheses are rare in pure science courses, there were examples discussed during
18
19 354 the interviews that can be said to involve hypothesis testing more explicitly. Again, it is not
20
21 355 always clear if the distinction between pure science courses and science education courses for
22
23 356 teachers can be applied in all of these examples. In any case, they constituted rare and more
24
25 357 comprehensive tasks in which the students were given more freedom and responsibility to
26
27 358 conduct their own inquiry projects.
28
29
30

31 359 20. Lalla: The only lab task, or whatever you should call it, it was this scientific article.
32

33
34 360 Because what we, in my group did, was that we were to look at, there are aquatic
35
36 361 woodlice of different colours, they are grey, brown, green, and then we had a
37
38 362 hypothesis that it depends on where they grow, where they live. Depending on if they
39
40 363 live off the green seaweed they become green, and if they live on the brown seaweed,
41
42 364 they become brown. It was the only time that we formulated a hypothesis, and so to
43
44 365 say tested if that was the case. But that is probably the only time I have done anything
45
46 366 like that.
47
48
49

50 367 (*University B*)
51

52
53 368 This example was recalled by Lalla as the interviewer continued to probe the role played by
54
55 369 the notion of a hypothesis in their education. We can see that Lalla is talking about a
56
57 370 hypothesis in the form of a tentative explanation; however, it should be noted that this did not
58
59 371 seem to be a more reflective or systematic use of this term, as will become clearer in the next
60

1
2
3 372 section. As she says, this constitutes an unusual or unique example, in that it was the only
4
5 373 time they were supposed to formulate their own hypothesis and design corresponding
6
7
8 374 investigations to test it.
9

10 375

11
12 376 *Science education courses for teachers*

13
14
15 377 The absence of emphasis on and discussion of hypotheses in laboratory tasks in pure science
16
17 378 courses is contrasted by science education courses for teachers. Below, Jonas explicitly states
18
19 379 that he only recalls talk of hypotheses in this type of course. In the following examples, it can
20
21
22 380 be deduced from the larger context of the interview conversations that the students are
23
24
25 381 referring to the same kind of courses.

26
27 382 21. Interviewer: So in your laboratory tasks, this stuff about reasoning around a
28
29 383 hypothesis doesn't seem to have been a big thing.

30
31 384 22. Jonas: I guess it's really only existed during the didactics [science education courses
32
33 385 for teachers] lab tasks.

34
35
36 386 (*University A*)

37
38
39 387 The science education courses for teachers seem to have two features that are particularly
40
41 388 relevant for the present discussion. The first is the so-called 'parallel process' already
42
43 389 mentioned. The second is that talk about hypotheses was often mixed with talk about theories
44
45
46 390 of learning. In the next quote, we see how a student reasoned about the purpose for using
47
48 391 hypotheses in schools as a pedagogical tool:

49
50
51 392 23. Interviewer: So have you talked a lot about hypotheses and what function they have?

52
53 393 24. Carola: Yes, and that is something we use during our practicum as well and that we
54
55 394 are to use later in the teacher profession in which when you do lab work with the
56
57
58 395 students, it is often the method you use. That the students should get to try but also
59
60 396 perhaps have some, yes, a conception, what will happen and then you find out and it is

1
2
3 397 like a way for the students, for them to discover what is, what science consists of.

4
5 398 What is it really? And you want to, yes, in a way you want to encourage the students

6
7 399 to learn more, and so on, and not serve everything on a plate. Or what do you guys

8
9 400 feel?

10
11 401 *(University C, Group 1)*

12
13 402 To Carola, a hypothesis seems to be associated with a pedagogical method. The

14
15 403 pedagogical function of the hypothesis in the teaching method she is describing is to

16
17 404 elicit the students' preconceptions, a notion usually connected to conceptual change

18
19 405 theories of learning (Park, 2006). Here we note that "method" is also a potential pivot

20
21 406 term related to 'hypothesis'. In the context of science education this term is often

22
23 407 ambiguous as can be seen in the definition of the inquiry emphasis conflation. Below is

24
25 408 a further illustration of referring to hypotheses as a pedagogical tool:

26
27 409 25. Miriam: The hypotheses were very important in the air lab.

28
29 410 26. Interviewer: Ok, in what way, what did it mean?

30
31 411 27. Miriam: Well, it was important in some way that we had a conception before we did

32
33 412 the actual eh experiment how... a conception about what could happen, and then we

34
35 413 were supposed to confirm or deny if it was true by performing the experiment.

36
37 414 28. Lisa: But Maria, surely it was a part of these lab tasks, wasn't it that students'

38
39 415 conceptions was that in this case, that it contains nothing, it is empty [...]?

40
41 416 29. Miriam: Yes, that's right because precisely this about dropping your own hypothesis,

42
43 417 that it is like wrong, so it is pretty difficult to do because you prefer that your everyday

44
45 418 conceptions perhaps are the ones that are true, so to speak, it is difficult to drop it

46
47 419 because then you lose in a way a part of your sense of reality in some way. And then

48
49 420 it's important to understand the new context how it works, how the theory perhaps

50
51 421 really is. So this was actually a part of the thing with this really.

1
2
3 422 (University A)
4

5 423 It seems as if it is only in this context of a pedagogical approach to teaching the products of
6
7 424 science that the notion of a hypothesis is common and has a clearly justified role for these
8
9
10 425 students. Miriam's last comment also demonstrates the personal nature of a hypothesis when
11
12 426 used as a pedagogical tool, when she refers to 'dropping your own hypothesis' (turn 29), a
13
14
15 427 point that will be discussed later.
16

17 428

18
19
20 429 *Reproducing the Customs of School Science*
21

22 430 Discussion about hypotheses does not seem to be very common in most pure science courses
23
24 431 at the university level, and in particular, not in connection with laboratory work. The
25
26 432 exception is science education courses for teachers, as noted, although in these, talk about
27
28 433 hypotheses also seems to be taken for granted and not reflected upon critically. In the
29
30 434 following quote by Albert, it is not completely clear if he is referring to a pure science course
31
32 435 or to both kinds of courses. Nevertheless, the quote illustrates his perceived gap between the
33
34 436 customs at the university and those in school; it also corroborates the earlier findings that the
35
36 437 hypothesis is a guess about an outcome in the school custom (Gyllenpalm et al., 2009).
37
38
39

40
41 438 30. Albert: I can refer back to my practicum school once again speaking about hypothesis.
42

43 439 In part, I agree about what has been said because when I hear the word hypothesis, I
44
45 440 think about my [practicum] school when they write lab reports and regardless if you
46
47 441 talk about year seven or year nine, they always get to start by writing their own
48
49 442 hypothesis. How they think, what they believe... They read through the actual lab task
50
51 443 and find out about what we are going to do a lab about. And the lab question is, what
52
53 444 result they are to find out. Then they always get to write down what they believe is
54
55 445 going to happen. And hypothesis in that sense, I can't recall from the university
56
57
58
59
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1
2
3 446 [courses], that now you are going to do this laboratory task and you are going to find
4
5 447 out about this and this, and what do you think will happen?
6
7

8 448 *(University B)*
9

10 449 Albert describes the recurring habit of ‘always beginning with writing a hypothesis’ as a
11
12 450 guess about an outcome, and he contrasts this with the courses he has taken at the university
13
14 451 of which he ‘can’t recall’ anything similar. Later in the same interview, Lina refers back to
15
16 452 Albert’s statement:
17
18

19
20 453 31. Interviewer: So hypothesis as “what you think will happen”, do you think that it is a
21
22 454 good definition of what a hypothesis is?
23

24 455 32. Lina: Perhaps not scientifically like, but I can follow Albert’s track that it is like that I
25
26 456 interpret the word sort of. That is also how I have asked students to formulate
27
28 457 hypotheses before you have done laboratory tasks. And then like, well, what is a
29
30 458 hypothesis? And then I’ve probably explained it sort of with the words that it’s like
31
32 459 what you believe is going to happen, what colour you think it will be or what you
33
34 460 believe, like that.
35
36

37
38 461 *(University B)*
39

40
41 462 Lina’s statement shows a certain questioning of the meaning of a hypothesis that can be
42
43 463 connected to the interviewer encouraging the students to think about hypotheses in a scientific
44
45 464 context. However, what she describes is how she normally has used the word during her
46
47 465 practicum. These examples provide a snapshot of how the existing customs in school science
48
49 466 continues to be reproduced.
50
51

52 467

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54
55 468 *Questioning the Use of a Hypothesis as a Guess about an Outcome*
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1
2
3 469 On some occasions, the conversations led to the students questioning the role of a hypotheses
4
5 470 in scientific research compared to the more familiar school science and their own teacher
6
7
8 471 education.

9
10 472 33. Mattias: Yes, but if you now think that in real research where they really come up with
11
12 473 new things, do they really have hypotheses there in the same way we have them now?
13
14
15 474 That they sit down and think for an hour first, hmm...what's going to happen?

16
17 475 (a few lines further down)

18
19
20 476 34. Tomas: [...] I mean we never start with that, with the idea, instead we start with the
21
22 477 complete experiment. And that can never science, I mean research could never start
23
24 478 with an experiment and then try to find out why you have this experiment, it seems a
25
26
27 479 bit twisted.

28
29 480 (*University D*)

30
31 481 Mattias raises a doubt as the interviewer asks if they all agree with the just stated definition of
32
33 482 a hypothesis as a guess about an outcome. A few lines further down, Tomas develops this
34
35 483 thread of reasoning by stating that it is a paradox to be given a method in the form of a recipe
36
37 484 to follow in a laboratory task and then being asked to guess what will happen. A similar
38
39 485 argument was provided by Johan in another interview in which he questioned the use of the
40
41 486 notion of a hypothesis and linked this to thoughts about studying causality.

42
43
44
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
46
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
50
51 490 more that we do an assessment, what we believe is going to happen. It's not directly...

52
53
54
55 491 36. Interviewer: What would be more scientific?

56
57 492 37. Johan: I feel like you perhaps should, more like draw up a, a theory for what you
58
59 493 believe could, eh, effect. I believe this is going to happen because, and that because of

1
2
3 494 this, we want to do this experiment. But here we have been assigned to do this
4
5 495 experiment and guess what we think is going to happen. So it is a bit more like
6
7
8 496 guessing...

9
10 497 *(University C, Group 2)*
11

12 498 Johan's reasoning made Alexandra, who was in the same group, uncertain. She seemed to
13
14 499 have been certain that a hypothesis simply meant a guess about an outcome. This led to a
15
16 500 meaning exchange between Johan and Alexandra in which Johan developed his argument
17
18 501 about the role of hypotheses in a similar way to that of Tomas above. What both Johan and
19
20 502 Tomas are observing is that there is a strange kind of reversed epistemology when it comes to
21
22 503 the prevailing use of a hypothesis as a guess about an outcome. What this means is that the
23
24 504 students are presented with a situation or experimental procedure (a scientific method) and
25
26 505 then asked about what they believe will happen. At the same time, everyone involved knows
27
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
33
34 509 school science.

35
36 510 38. Alexandra: Ok, but it doesn't feel like you very often in that case, that you formulate
37
38 511 any hypothesis when you work, I mean like we have done.

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

41
42 513 40. Staffan: And that the students, no that's true, in school so...

43
44 514 41. Alexandra: But you still call it a hypothesis.

45
46 515 42. Staffan: Yes, well, I guess it is this form so that it's like and in that way, you prepare
47
48 516 yourself for the way it will be like perhaps in high school.

49
50 517 43. Johan: Yes.
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3 518 44. Interviewer: Is this something that you have discussed with your teachers or earlier in
4
5 519 connection to laboratory tasks?
6
7

8 520 45. Several: No.
9

10 521 46. Staffan: In any case, very little, but not that I can remember.
11

12 522 47. Alexandra: No.
13

14
15 523 (*University C, Group 2*)
16

17 524 Alexandra is given an eye-opener and brings to light the existing contrast between the
18
19 525 meaning of a hypothesis in school science compared to scientific research. Simultaneously, it
20
21 526 seems as if the school custom exerts a strong pressure on the students, and that they tend to
22
23 527 reproduce this custom as Staffan's statement in turn 42 indicates.
24
25
26

27 528
28
29 529 *Hypothesis Fear*
30

31 530 In the existing school custom in which a hypothesis usually means a guess about an outcome,
32
33 531 there is also a certain emphasis on the 'you' part of this statement, i.e. what you (the student)
34
35 532 personally believe. What this suggests is that 'you' are identified with 'your hypothesis' as if
36
37 533 'you are your hypothesis'. This is in line with the teachers' pedagogical use of the concept as
38
39 534 a tool for making students aware of their own preconceptions or misconceptions (Gyllenpalm
40
41 535 et al., 2009). Disregarding for a moment that this use of the notion gives a distorted image of
42
43 536 the nature of scientific inquiry, there is also reason to suspect that the identity between 'you
44
45 537 and your hypothesis' is the root of the hypothesis fear that both teachers and teacher students
46
47 538 have reported observing in school children (Gyllenpalm et al., 2010). Lina's statement from
48
49 539 turn 32 is continued, and it demonstrates this point, which is also corroborated by the rest of
50
51 540 the group.
52
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1
2
3 541 48. Lina: But, eh, at least the students I have had have had a really difficult time to
4
5 542 formulate, they have been very uncertain when they try to formulate hypotheses,
6
7 543 thinking that it's a bit scary like when they don't really know if it really is correct...

8
9
10 544 49. Olle: Students I've had have seen it more like a competition that "I have to be right".
11
12 545 Because it has often happened then that they have written it down afterwards, if they
13
14 546 are very competitive. "Yes, I don't write it yet, but look to see what happens first and
15
16 547 then write it with a big exclamation mark, that yes, I made the correct guess, I was
17
18 548 right!"

19
20 549 50. Lina: Yes (laughter)

21
22 550 51. Albert: I also recognize this, that there is a kind of uncertainty, that they are afraid of
23
24 551 writing something incorrect. I have tried to explain to them that you can never lose
25
26 552 credit based on the hypothesis.

27
28
29 553 (*University B*)

30
31
32 554 A strong emphasis on teaching students the correct explanations (Roberts, 1982) and the fact
33
34 555 that because of this, the main purpose of performing laboratory tasks is to reach the correct
35
36 556 conclusion (Andrée, 2007) most likely contribute to this hypothesis fear. The hypothesis
37
38 557 becomes a tool for psychological manipulation and blackmailing and the stress caused is
39
40 558 likely to contribute to students developing a negative attitude towards science as a school
41
42 559 subject. Blackmailing occurs if students feel a need to play along with the 'guess the answer'
43
44 560 game, because they want to please the teacher or achieve a certain grade even though they are
45
46 561 uncomfortable. Simultaneously, there seems to be a reaction in some schools against the
47
48 562 prevailing custom of using a hypothesis as a guess about an outcome because of the conflict it
49
50 563 easily provokes.

51
52
53 564 52. Klara: We have never really discussed hypotheses either like in any context the way I
54
55 565 see it, because when I was doing my practicum, it's like a lot of teachers are totally

1
2
3 566 against using hypotheses. So I feel very ambivalent and we have never had any
4
5
6 567 discussion about this.
7
8 568 53. Melanie: Are they against it?
9
10 569 54. Klara: It can get very, in some classes, it can get very confusing when they write
11
12 570 hypotheses, as the teachers see it. Because then they make up really strange things and
13
14
15 571 then they can even imagine that “we wrote it in our hypothesis so it must be true” so it
16
17 572 can get a bit weird like that.

18
19
20 573 (*University D*)

21
22 574 Like many others, Klara notes that the subject of hypotheses is not a theme that has been
23
24 575 discussed during laboratory work or at any other time. The counter reaction to the stress
25
26 576 caused by the reversed epistemology apparently expressed by some teachers is
27
28
29 577 understandable. However, the reaction is misdirected, since it is based on taking the existing
30
31 578 custom as a given and then simply rejecting it as wrong. This is like throwing out the baby
32
33 579 with the bathwater. The teachers are then ‘completely against using hypotheses’ perhaps
34
35
36 580 without realizing that what they call a hypothesis may be something quite different from what
37
38 581 it normally means in scientific research.

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41 582

42
43 583 Discussion

44
45 584 *Summary of Results*

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47
48 585 The research objective of this article was to describe how teacher students use the potential
49
50 586 pivot term ‘hypothesis’ and how this use relates to a number of cultural institutions that can
51
52 587 be said to constitute science teacher education. We found that the students habitually used
53
54 588 ‘hypothesis’ as equivalent to a guess about an outcome, in line with the customs of school
55
56 589 science (Gyllenpalm et al., 2009). Although some students began to question this during the
57
58 590 course of the interviews, there was also evidence of the tendency to remain loyal to the
59
60

1
2
3 591 custom of school science. The use and function of hypotheses at university courses, as
4
5
6 592 described by the students, inspired us to distinguish between pure science courses and science
7
8 593 education courses for teachers. In the pure science courses, little or no emphasis is placed on
9
10 594 hypotheses or hypothesis testing as a part of laboratory tasks. Only in some rare cases when
11
12 595 students get to do more comprehensive inquiry projects did the concept of a hypothesis
13
14
15 596 appear, but this seems to be a one-time event for most students. This is a finding in line with
16
17 597 previous research on science teacher education in Sweden (Lager-Nyqvist, 2003). Thus, it
18
19 598 seems as if the students are expected to invent or discover the logic and subtleties of
20
21
22 599 formulating hypotheses and hypothesis testing on their own during the course of completing
23
24 600 one single more comprehensive inquiry project. It is a big leap for most students to make, and
25
26
27 601 as research shows, they are unlikely to learn much more about the nature of scientific inquiry
28
29 602 just from participating in this type of project without explicitly reflecting upon it from a
30
31 603 philosophy of science perspective (Lederman, 1999; Windschitl, 2003).

32
33
34 604 In contrast to the pure science courses, talk about hypothesis seems frequent in science
35
36 605 education courses for teachers, and it is often associated with a pedagogical methodology and
37
38 606 theorising about the nature of how individuals learn scientific concepts. Although
39
40
41 607 hypotheses were a common part of these courses, it was not a topic that had been discussed
42
43 608 often. In fact, there was nothing to suggest that it had been discussed in terms of scientific
44
45 609 research methodology. Finally, we also noted that the students confirmed our earlier finding
46
47
48 610 that school students may feel anxiety over formulating their own hypotheses as guesses about
49
50
51 611 an outcome; a phenomenon we have labelled 'hypothesis fear' (Gyllenpalm et al., 2010). Not
52
53 612 all themes were discussed in depth at each interview, although most themes were at least
54
55 613 touched on in all groups. Summarising the results, it is a surprisingly homogenous choir
56
57
58 614 formed by students from all over the country.

1
2
3 615 The uses of the term 'hypothesis' in the different contexts, or cultural institutions,
4
5 616 described and analysed here are summarised in Table 1 below. These cultural institutions can
6
7
8 617 be conceptualised as being connected in chain of partly overlapping cultures in the order given
9
10 618 by the numbers in Table 1. Our results illustrate, by focusing on the pivot term "hypothesis",
11
12 619 a specific way in which the continuity of this chain between the cultures of scientific research
13
14
15 620 on and school science is broken. This break is problematic since an important objective of
16
17 621 school science is to introduce learners to the culture, practices and language-games of
18
19 622 scientific research (Rogoff, 1990; Wickman, 2006). However, describing concrete and
20
21 623 specific aspects of this break, as we have tried to, also suggests ways of overcoming these
22
23 624 problems. Furthermore, three questions are raised by the results presented here. First, what is
24
25 625 the origin of these radically different uses of 'hypothesis' in contexts where they might be
26
27 626 expected to coincide? Second, how are the different customs that differentiate these cultures
28
29 627 reproduced in respect to the use of 'hypothesis'? And, third, what are the consequences of this
30
31 628 state of affairs for teaching and curriculum development? Our answers to these questions are
32
33 629 speculative and draw on the educational research literature, as well as on our results and
34
35 630 theoretical framework.

36
37
38
39
40
41 631 [Insert Table 1 here]

42 43 632 *Constructivism as a Possible Origin of the Inquiry Emphasis Conflation*

44
45 633 There is reason to believe that failing to distinguish between a hypothesis and a
46
47 634 prediction in school science is connected with the influences of constructivist theories of
48
49 635 learning. Constructivist theories of learning can be traced to Piaget's theory of individual
50
51 636 development of cognitive schemata through a process of accommodation resulting from a loss
52
53 637 of mental equilibrium (Piaget, 1964/2003). Piaget's theory and the early elaborations of it to
54
55 638 suit the field of science education research tend to mix theories of how individuals learn on a
56
57 639 short time scale, and theories of how science as a collective enterprise advances over the

1
2
3 640 course of hundreds of years (Carey, 1999; Driver & Easley, 1978; Posner, Strike, Hewson, &
4
5 641 Gertzog, 1982). Park (2006, p. 488) recently summarised teaching based on constructivism as
6
7 642 being composed of four stages: 'recognition of prior idea, cognitive conflict, resolution of
8
9 643 conflict, and recognition of the modified idea.' Somewhere along the way, the notion of
10
11 644 hypothesis seems to have been hijacked as a tool for eliciting students' prior ideas and setting
12
13 645 the stage for a cognitive conflict to occur. In this process, the hypothesis was confused with a
14
15 646 prediction, and since the objective has not traditionally been to teach students about NOI, this
16
17 647 collapsed distinction did not appear to have any negative consequences. However, if an
18
19 648 understanding of NOI is important, this conflation becomes problematic. Furthermore, we
20
21 649 note that due to the existing, but tacit, didactical contract (Brousseau, 1997) that characterises
22
23 650 school science, this pedagogical use of the hypothesis seems to lead to the reported hypothesis
24
25 651 fear suffered by students. The didactical contract generally states that what is important to
26
27 652 learn are the correct explanations and producing the correct results in a laboratory task. As
28
29 653 these explanations and results are known, there is no incentive for students to take a guess that
30
31 654 turns out to be wrong because of the risk of appearing stupid. This risk and the prospect of
32
33 655 wasted intellectual effort combined with a desire to please the teacher can be hypothesised to
34
35 656 produce the anxiety reported amongst students.

36
37 657 It is possible that there are other origins of this conflation. One is that scientists
38
39 658 themselves, and college textbooks, may not always use these terms in a consequent manner
40
41 659 (Lawson, 2007). However, our results are in line with other critiques of constructivism that
42
43 660 address its epistemological and ontological basis (Kruckenberg, 2006; Säljö, 2000), and the
44
45 661 pedagogical practices derived from it (Caravita & Halldén, 1994; Furtak, 2006). Also, the
46
47 662 idea that students misconception always obstruct learning and that teachers therefore need to
48
49 663 focus primarily on conceptual change has recently been criticised (Hamza & Wickman,
50
51 664 2007).

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3 665
4
5
6 666 *Reproducing the Inquiry Emphasis Conflation*
7
8 667 Pure science courses generally omit discussions about hypotheses and the nature of
9
10 668 scientific inquiry (NOI). Laboratory tasks in these types of courses are usually closed, fully
11
12 669 structured and used to motivate, exemplify and teach the established theories and explanations
13
14
15 670 of science (Hult, 2000). However, it is not merely what is said and done that is important in
16
17 671 education, but also what is not said, what Östman (1998) called ‘companion meanings’. Thus,
18
19
20 672 the pure science courses indirectly teach that talk about hypotheses in relation to research
21
22 673 methodology and NOI is not important enough to merit systematic teaching and assessment.
23
24
25 674 The fact that there is a general silence about NOI in general and the use of hypotheses in
26
27 675 particular in pure science courses could be an effective buffer between the education cultures
28
29 676 and the culture of scientific research, thus breaking the continuity of the chain. The link
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31 677 between scientific research and the rest of the educational system is broken by the silence
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34 678 about these issues; consequently, the pure science courses contribute to maintaining the status
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36 679 quo.

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39 680 The science education courses for teachers seem to import the school customs right into
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41 681 the university. Here laboratory work is used both to illustrate science topics and teaching
42
43 682 methods simultaneously (the so-called ‘parallel processes’), thus contributing more directly to
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45 683 reproducing the inquiry emphasis conflation. In these courses, talk of hypotheses is common,
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47
48 684 but also taken for granted and not reflected upon explicitly. It is also used as a pedagogical
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50 685 tool rather than as a concept for research methodology. The hypothesis is connected to
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53 686 theories of learning and methods for teaching, but not to discussions about and learning about
54
55 687 NOI. Thus, methods of teaching are not separated from methods of scientific inquiry, and the
56
57 688 inquiry emphasis conflation is perpetuated. In both the pure science courses and the science
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59 689 education courses for teachers, we note that what we find here is probably not intended by the

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3 690 teachers leading these courses. It may be that they are aware of the distinctions we make here;
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5 691 however, the point is that this is not what we find when talking to the teacher students. Hence,
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8 692 if these issues have been raised, they have not had much impact.
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10 693 Lortie (1975) has pointed out that teachers tend to teach the way they were taught, since
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12 694 an average student has ‘spent 13000 hours in direct contact with classroom teachers by the
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14
15 695 time he [sic] graduates from high school’ (p. 61), implying a powerful socialisation. As
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17 696 described in the theoretical framework, cultural institutions are upheld by and simultaneously
18
19 697 shape individuals habits (Dewey 1930; Cohen 2007; Hodgson 2007; Maréchal 2010). Here
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21
22 698 we have presented evidence demonstrating how the custom of using the term ‘hypothesis’
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24 699 indeed seems to be reproduced in school science with little or no influence from the customs
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27 700 of scientific research passing through the filter of teacher education.
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30 31 702 *Implications for Teaching and Curriculum Development*

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34 703 Customs and other stable social structures are necessary for the growth and continuity
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36 704 of cultural institutions. Understanding the characteristic customs of the cultural institutions
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38 705 relevant for science education is a prerequisite for successful development and reform
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41 706 projects (Dewey, 1930; Keys & Bryan, 2001; Rowell & Ebbers, 2004; Windschitl,
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43 707 Thompson, & Braaten, 2008b). Otherwise, projects may be hindered by participants acting
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45 708 according to contradictory yet unexamined customs and habits related to key issues
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48 709 (Fredrichsen, Munford, & Orgill, 2006; Trumbull et al., 2005). Due to the status of
49
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51 710 ‘hypothesis’ as a potential pivot term, new curricular material that focus on hypothesis testing
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53 711 as a dimension of learning about scientific inquiry may be interpreted within the school
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55 712 custom of using hypotheses as a pedagogical tool. The concept of ‘pivot term’ may thus be
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58 713 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
11
12 718 teacher education. The consequences of this conflation may be the reported hypothesis fear as
13
14 719 well as an increased difficulty in reaching the intended goals of scientific literacy because
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16 720 NOI as a learning goal becomes difficult to distinguish and emphasise. Teacher educators
17
18 721 need to be aware of how the existing customs relate to the goal of learning about scientific
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20 722 inquiry associated with scientific literacy. In pure science courses, we suggest that more effort
21
22 723 be devoted to teaching about NOI and, in particular, the logic of hypothesis testing. In science
23
24 724 education courses for teachers, work needs to be done to distinguish explicitly between
25
26 725 theories of how individuals learn and descriptions of how knowledge production occurs in
27
28 726 science at large. We also suggest that the personalized form of address should be abandoned
29
30 727 when asking students for predictions and a hypothesis. Rather, there should be a critical
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32 728 examination of all possible explanations (hypotheses) and how they relate to the empirical
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34 729 evidence (predictions and actual outcomes).
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31 873 Appendix A
32
33 874 *Interview Template*
34
35 875 1. Can you describe the example you have chosen? (Context? Prerequisite knowledge? Time
36
37 876 frames? Research question? How was the question answered? Group or individual? Aids?
38
39 877 Assessment? Presentation of results? Comparisons of results?)
40
41
42 878 2. How did you understand the purpose of this as part of your own teacher education?
43
44
45 879 3. Particular words/notions to try to focus on:
46
47 880 - Question, guess, hypothesis
48
49 881 - Method, observation, experiment, scientific, systematic, objective
50
51 882 - Prior knowledge, theory, model
52
53 883 - Logical reasoning, critical thinking, proof, cause, prediction
54
55 884 - Presentation, report, examine, compare with the results of others
56
57
58 885 4. Other questions that may be relevant to ask:
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3 886 - Did you get to formulate your own research question?
4
5 887 - Plan and conduct investigations on your own to answer your own research question?
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8 888 - Is there a difference between a laboratory task and an experiment?
9
10 889 - Did you plan and conduct a controlled experiment on your own?
11
12 890 - What is a controlled experiment?
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14
15 891 - Did you formulate your own hypotheses and predictions?
16
17 892 - Is there a difference between the concepts of hypothesis and prediction?
18
19
20 893 - Has any teacher discussed these concepts in your education?
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22 894

23
24 895 Appendix B

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26
27 896 *Focusing Exercise*

28
29 897 The purpose of laboratory tasks or inquiry projects in my education has often been to:

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31 898 1. Learn about the science behind technical and natural phenomenon in our everyday life.

32
33 899 2. Learn about the nature of science: what is characteristic of science.

34
35 900 3. Learn scientific subject matter as a preparation for taking more advanced courses

36
37 901 4. Motivate or exemplify scientific theories and models of explanation.

38
39 902 5. Learn about the historical development of science as a part of our culture.

40
41 903 6. Learn about the role of science in society, technology and decision-making.

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43 904 7. Learn to handle processes and methods used in scientific research.

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50 906 Appendix C

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52 907 Theme 1: Natural scientific methods and theories

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54 908 Theme 2: Pedagogical methods and theories

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