Scaffolding student learning: A micro-analysis of teacher–student interaction

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A B S T R A C T

Teacher scaffolding and more specifically, support that is adapted to or contingent upon a student’s understanding, is considered effective in promoting student learning. Increasing control upon a student’s failures, decreasing control upon a student’s successes and keeping the degree of control the same in the case of partial student understanding are considered contingent support which provides an appropriate level of challenge. However, these theoretical premises have not yet been tested in classroom situations. The main goal of this study was to investigate different patterns of contingency and to explore how contingency affects student learning. Twenty-two pre-vocational teachers’ lessons were analysed regarding contingency and student learning, using micro-analysis. The results show that: (1) if the initial student understanding is poor, contingent support results in increased student understanding, and (2) teachers seldom underestimated students’ understanding but often overestimated students’ understanding. Contingent support can be effective and future research should focus on facilitating teachers in learning how to correctly diagnose students’ understanding.

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1. Introduction

Similar to a construction scaffold – which is built up adaptively to a building and taken away when not needed anymore – scaffolding support is adapted to students’ understanding and removed when redundant. Scaffolding is considered effective because it provides students with the right amount of challenge (Hammond & Gibbons, 2005). The scaffolding theory describes the scaffolding process in terms of adaptation of the level of control that is exercised by a tutor to students’ understanding (Wood, Wood, & Middleton, 1978). That is, giving more control upon students’ failures and giving less control upon students’ successes indicate an adequate estimation of students’ understanding. This provides students with the appropriate level of challenge (Mulvaney, McCartney, Bub, & Marshall, 2006) which is expected to result in student learning. The tutoring is contingent upon the student’s understanding as expressed in his or her responses.

In contrast, giving more control upon students’ successes may indicate an underestimation of the students’ understanding. This provides students with little challenge and is not expected to result in student learning. Giving less control upon students’ failures may indicate an overestimation of the students’ understanding. This provides students with too much challenge which is not expected to result in student learning either. If the teacher’s control is not adapted to the student’s level, the instruction is non-contingent: there is no scaffolding.

However, these theoretical premises about the relationship between regulating control and student learning have, to our knowledge, not yet been empirically tested in classroom situations such as small-group work. Chiu (2004) for example explored the effects of teacher interventions on students’ time on task and their progress in solving assignments, while working in groups. However, although he compared the effects of various teacher interventions, he did not analyse whether the interventions were...
contingent. In the present study we investigated teachers’ contingent instruction, that is, their adaptations of control upon students’ understanding. Furthermore, we investigated the students’ learning that was exhibited within the teacher–student interaction. The goal of the current study is to investigate different patterns of contingency and to explore how contingency affects student learning.

1.1. Scaffolding

The term scaffolding was coined in 1976 by Wood, Bruner, & Ross, 1976. It is closely related to Vygotsky’s socio-cultural theory and especially to his concept of the Zone of Proximal Development (ZPD) (1978). Vygotsky was not only interested in what students could do on their own (their actual level), but also in what students could do with the help of a more knowledgeable partner (their potential level). The distance between the actual and potential level is called the ZPD. Vygotsky (1978) argued that good support is that which is ahead of the learners’ actual development. Scaffolding support does not focus on what a student can already do but focuses on what a student cannot do yet on his/her own. However, if the support lies outside the ZPD, the degree of challenge is either too little or too high and the support can no longer be called scaffolding. Scaffolding thus seeks to provide the appropriate amount of challenge for students in order to learn.

In the last decades, the term scaffolding has often been used as a synonym for any kind of support (Mercer & Littleton, 2007; Stone, 1998). However, we see scaffolding as support that: (1) is contingent, (3) fades over time, and (3) is aimed at transferring the responsibility to the student (Van de Pol, Volman, & Beishuizen, 2010). Contingency represents the adaptive nature of scaffolding support. In other words, scaffolding support is support that is adapted to or contingent upon students’ understanding. Furthermore, the support is not provided on a permanent basis; it fades over time. Finally, the ultimate goal of scaffolding is to enable the student to perform a task alone and to transfer the responsibility for a task to the student. Contingency can be seen as the most central characteristic of scaffolding as non-contingent fading and non-contingent transfer of responsibility can never be called scaffolding.

1.2. Contingency

In their research, Wood and his colleagues concentrated on the central aspect of scaffolding, that is, contingency (e.g., Wood et al., 1978). They developed the contingent shift principle that consisted of two rules: increase control when students fail and decrease control when students succeed. A high degree of control is for example to provide an answer or an explanation whereas a low degree of control is for example to ask an open question. The absolute degree of control does not determine whether scaffolding takes place; it is about the adaptation of the degree of control to a student’s understanding that determines scaffolding. Increasing the degree of control and thus providing steering support can be scaffolding, but only if this is done when a student fails. Table 1 shows how the scaffolding theory views the relationship between contingency, challenge and student learning.

A non-contingent increase of control indicates a teacher’s underestimation of a student’s understanding; the teacher provides too little challenge. Too little challenge results in no further learning because the support given is too easy and may prevent students from processing other, more elaborate information (Wittwer, Nückles, & Renkl, 2010). A non-contingent decrease of control indicates a teacher’s overestimation of a student’s understanding; the teacher provides too much challenge. The help (e.g., explanations) given is too complex and may cause comprehension breakdowns (Wittwer et al., 2010).

In contrast, all patterns of contingent support indicate a correct estimation of a student’s understanding and also provide the right amount of challenge. In both cases, student learning can be expected; the teacher helps the student to perform the task successfully.

Helping students while applying contingent shifts in control appears to be effective in one-to-one situations with regard to e.g., self-regulated learning (Mattanah, Pratt, Cowan, & Cowan, 2005; Pino-Pasternak, Whitebread, & Tolmie, 2010; Stright, Neitzel, Sears, & Hoke-Sinex, 2001), block-building and puzzle construction tasks (Pratt, Green, MacVicar, & Bountrogianni, 1992; Pratt & Savoy-Levine, 1998; Wood & Middleton, 1975) and long-division math homework (Pino-Pasternak et al., 2010; Pratt et al., 1992). However, these studies have all been performed in tutoring or parent–child situations, not in classroom situations. In addition, most studies adopted a macro-perspective, that is, they related the contingency of support to students’ performances on tasks. In contrast, in the current study we explored the direct effect of contingent support by adopting a micro-perspective.

Table 1

<table>
<thead>
<tr>
<th>Contingency Patterns</th>
<th>Increase of control (Control +)</th>
<th>Decrease of control (Control -)</th>
<th>Same control (Control =)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Non-contingent support</td>
<td>Students’ initial understanding is: Teacher ... students’ understanding Degree of challenge: Learning:</td>
<td>good underestimate too little challenge no learning</td>
<td>poor/partial overestimates too much challenge no learning</td>
</tr>
<tr>
<td>Contingent support</td>
<td>Teacher ... students’ understanding Degree of challenge: Learning:</td>
<td>poor/partial correctly estimates appropriate learning</td>
<td>good correctly estimates appropriate learning</td>
</tr>
</tbody>
</table>

1.3. The present study

In the present study, we investigated teacher–student interactions in the context of small-group work of secondary social studies teachers. Doing this, we compared the interactions of teachers who participated in a scaffolding intervention programme with the interactions of teachers who did not participate in such a programme. Contingency of support was related to students’ shift in understanding, as shown within teacher–student interaction. The main research questions were:

1. What patterns of contingency can be discerned in teacher–student interaction, both in the trained and in the untrained condition?
   a. With regard to contingency and non-contingency
   b. With regard to specific patterns of contingency: increasing control (contingency-control +), decreasing control (contingency-control −) or keeping the level of control the same (contingency-control =), depending on the student’s initial level of understanding.

2. Is contingency associated to increased students’ understanding within teacher–student interaction?

With regard to research question 1a, we investigated patterns of contingency and non-contingency in general. For this question, we had different hypotheses for the two conditions. For the untrained condition, we built on results from parent–child research (Pino-Pasternak et al., 2010) and whole-class teaching (Nathan & Kim, 2009), that showed that about 50% of the interaction were contingent. We thus hypothesised that the teachers in the untrained condition would be contingent in about 50% of the cases. For the trained condition, we built on results from tutoring studies (Pratt & Savoy-Levine, 1998; Wood et al., 1978), which showed that trained tutors managed to act contingently in about 70% of the cases. We thus hypothesised that the trained teachers would be contingent in about 70% of the cases.

With regard to research question 1b, we hypothesised that from the non-contingent patterns, non-contingent decrease of control would occur to the greatest extent. In this case, the teacher decreases control upon poor student understanding and therewith overestimates a student’s understanding. Previous classroom studies – using more general measures – have found that teachers generally have difficulties in estimating students’ achievement levels while typically overestimating students’ actual performance (e.g., Begeny, Kroute, Brown, & Mann, 2011; Feinberg & Shapiro, 2009). Similar results are found in tutoring studies (e.g., Wittwer et al., 2010).

Research question 2 focuses on the relationship between contingency and students’ shifts in understanding. Here, we did not distinguish between the trained and untrained condition. We were mainly interested in exploring the effects of the actual contingency of the support, not the differences between conditions. With regard to the second research question, we expected a positive association between contingency and increasing student understanding.

2. Methods

2.1. Participants

For this study, we used lesson recordings from 22 social studies teachers (year 8, age students 12–14). Ten teachers participated in a professional development programme (PDP) on scaffolding whereas 12 teachers did not. The teachers were randomly assigned to the conditions. All teachers taught at the pre-vocational level, mostly at innovative schools. In these innovative schools, group-work is an important activity, so this was the setting for the current study.

2.2. Materials

2.2.1. The lesson

All teachers taught the same five-lesson project about the EU. In this project, the students worked on several open-ended assignments in small groups. As these lessons were also an opportunity for teachers in the trained condition to practice their scaffolding skills (as part of the PDP), we chose to analyse the interactions of the last lesson, as their scaffolding skills would be developed more at that point. In this last lesson, the students worked on a ‘Which Word Out’ assignment (Leat, 1998). In this assignment, the students were asked to choose three related concepts from the project’s list of concepts, leave one out and give two reasons why this concept could be left out.

2.2.2. Professional development

In the PDP, the teachers worked on their scaffolding skills using the model of contingent teaching (Van de Pol, Volman, & Beishuizen, 2012, based on Ruiz-Primo & Furtak, 2007). This model consists of four steps: (1) using diagnostic strategies to establish the students’ understanding, (2) checking the diagnosis with the student, (3) using intervention strategies (helping students), and (4) checking students’ learning after providing help. The PDP started with one theoretical session. Thereafter, each teacher had four practicing lessons including video-reflections with the first author afterwards. The PDP proved effective; the teachers who participated in the PDP increased their degree of contingency more than teachers who did not participate (Van de Pol, Volman, & Oort et al., in press). For more information on the PDP, see Van de Pol, Volman, & Beishuizen (2012).
2.2.3. Data

All interactions the teachers had with students on the subject-matter were selected. An interaction started when a teacher approached a group and lasted until the teacher left the group. A total of 88 interactions (consisting of 3364 turns) was encountered with a mean of four interactions per teacher. Within the interactions, three-turn-sequences of a teacher turn (T1) – a student turn (S1) – and a teacher turn (T2) were selected to analyse contingency, as described in Section 2.2.4. We used 432 three-turn-sequences for the analyses.

2.2.4. Contingency

We established the degree of contingency using the contingent shift framework (Van de Pol, Volman, Elbers, & Beishuizen, 2012). The unit of analysis was a three-turn-sequence of a teacher turn (T1), a student turn (S1) and a teacher turn (T2). We used those three-turn-sequences in which at least one of the teacher turns was coded as an intervention strategy (step 3) (as opposed to a diagnostic strategy, checking the diagnosis or checking students’ learning cf. Van de Pol, Volman, & Beishuizen, 2012 for further explanation of these steps). We determined contingency in three steps, as described in the following. Coded examples can be found in Excerpts 1–5.

First, we determined the degree of control that a teacher exercised with the help. The codes ranged from zero (no control) to five (highest level of control, e.g., providing the answer).

**Excerpt 1**

Example of Contingent control — and Contingent-control+.

<table>
<thead>
<tr>
<th>Turn</th>
<th>Sequence part</th>
<th>Stepa</th>
<th>Control</th>
<th>SUb</th>
<th>Contingency</th>
<th>Shift in understanding</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Teacher: What came first, the European Coals and Steel Community (ECSC) or the European Union (EU)?</td>
<td>T1</td>
<td>Intervention strategy</td>
<td>Medium (3)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 Student: the ECSC</td>
<td>S1</td>
<td>for lines 1–3, T1 for lines 3–5</td>
<td></td>
<td>Good (2)</td>
<td>Contingent control −</td>
<td></td>
</tr>
<tr>
<td>3 Teacher: Alright, and what kind of collaboration was that, the ECSC?</td>
<td>T2 for lines 1–3, T1 for lines 3–5</td>
<td>Intervention strategy</td>
<td>Low (2)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4 Student: of coals</td>
<td>S2 for lines 1–3, S1 for lines 3–5</td>
<td>Partial (1)</td>
<td></td>
<td>S2 − S1 = −1; decrease of understanding</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5 Teacher: of coals and steel</td>
<td>T2</td>
<td>Intervention strategy</td>
<td>High (5)</td>
<td>Contingent control +</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| a Step of contingent teaching. |
| b Student understanding. |

**Excerpt 2**

Example of contingent control =.

<table>
<thead>
<tr>
<th>Turn</th>
<th>Sequence part</th>
<th>Stepa</th>
<th>Control</th>
<th>SUb</th>
<th>Contingency</th>
<th>Shift in understanding</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Teacher: Do you know what a parliament is?</td>
<td>T1</td>
<td>Intervention strategy</td>
<td>Low (2)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 Student: That is a group of people</td>
<td>S1</td>
<td></td>
<td></td>
<td>Partial (1)</td>
<td>Contingent control =</td>
<td></td>
</tr>
<tr>
<td>3 Teacher: Yes, that is correct, but what does this group of people do?</td>
<td>T2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4 Student: they check the European Commission</td>
<td>S2</td>
<td></td>
<td>Good (2)</td>
<td></td>
<td>S2 − S1 = 1; increase of understanding</td>
<td></td>
</tr>
</tbody>
</table>

| a Step of contingent teaching. |
| b Student understanding. |

**Excerpt 3**

Example of Non-contingent control —.

<table>
<thead>
<tr>
<th>Turn</th>
<th>Sequence part</th>
<th>Stepa</th>
<th>Control</th>
<th>SUb</th>
<th>Contingency</th>
<th>Shift in understanding</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Teacher: Was the European Economic Community (EEC) a dictatorship?</td>
<td>T1</td>
<td>Intervention strategy</td>
<td>Medium (3)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 Student: I think so</td>
<td>S1</td>
<td></td>
<td></td>
<td>Poor (0)</td>
<td>Non-contingent control −</td>
<td></td>
</tr>
<tr>
<td>3 Teacher: I don’t think so. What is a dictatorship?</td>
<td>T2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4 Student: That one governs alone</td>
<td>S2</td>
<td></td>
<td>Partial (1)</td>
<td></td>
<td>S2 − S1 = 1; increase in understanding</td>
<td></td>
</tr>
</tbody>
</table>

| a Step of contingent teaching. |
| b Student understanding. |

Second, we coded all student turns that were part of a three-turn-sequence (=S1) and that directly followed a three-turn sequence (=S2) with regard to the degree of understanding. We assigned a zero for poor understanding, a one for partial understanding, and a two for good understanding. If no understanding could be determined, no code was given. The interrater-reliability was considered at least satisfactory (Kappa ≥ .70) for all codes (Van de Pol, Volman, & Elbers et al., 2012).

Third, we applied the contingency rules to all three-turn-sequences. We considered a three-turn-sequence contingent if the teacher increased control upon poor or partial student understanding (contingent control+) or if the teacher decreased control upon good student understanding (contingent control−). We considered keeping the degree of control the same contingent after partial student understanding (contingent control=) (for more information: Van de Pol, Volman, & Elbers et al., 2012).

2.2.5. Shifts in understanding

We computed the shifts in understanding by deducing the initial student understanding score within the three-turn-sequence (S1) from the understanding score of the turn that directly followed the three-turn-sequence (S2); see Excerpts 1–5 for examples. We did not use the overall range (from −2 to 2) in the analysis because a score of zero has different meanings, which hampers the interpretation. A score of zero can indicate that a student went from poor initial understanding (S1=0) to poor subsequent understanding (S2=0), from partial initial understanding (S1=1) to partial subsequent understanding (S2=1) or from good initial understanding (S1=2) to good subsequent understanding (S2=2). Instead, we performed each separately three selections of the dataset. First, we selected those cases in which the student initially (within the three-turn-sequence) had poor understanding (S1=0). In this case, we distinguished between no shift in understanding (S2−S1=0) or an increase of understanding (S2−S1=1 or 2). Second, we selected those cases in which the student initially had partial understanding (S1=1). In this case, we distinguished between a decrease or no shift in understanding (S2−S1=−1 or 0) or an increase of understanding (S2−S1=1). Third, only those cases in which the student initially had good understanding (S1=2) were selected. In this case, we distinguished between a decrease of understanding (S2−S1=−2 or −1) or no shift in understanding (S2−S1=0), which is in our coding system the highest score possible in the case of good initial understanding.

3. Results

3.1. Examples of contingent patterns

Before addressing our research questions and hypotheses, we first illustrate each contingent pattern using Excerpts 1 and 2.

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2 Note that we only used turns (S1 and S2) of the same student. If another student responded, no shift in understanding was calculated.
3.1.1. Contingent control

In the first three-turn-sequence of Excerpt 1 (lines 1–3), the teacher starts with a question with a medium level of control (level 3). We considered the level of control to be medium because it is a multiple choice question in which no new subject-matter or content is added. Upon the correct answer of the student, the teacher decreases the level of control to a low control level (level 2). The question the teacher asks in line 3 provides the student with more challenge than the previous question. The question is more open and invites the student to think and explain.

3.1.2. Contingent control+

In the second three-turn-sequence of Excerpt 1 (lines 3–5), the student gives an answer that is partially correct. The ECSC is about coals, but also about steel. The teacher’s reaction in line 5 is of increased control compared to the teacher’s question in line 3. The teacher complements the student’s answer which creates less challenge for the student. Note that keeping the degree of control the same would also have been contingent.

3.1.3. Contingent control=

In the three-turn sequence of Excerpt 2, an example of contingent control= is presented (lines 1–3). The teacher starts with a question of a relatively low control level (level 2), namely, what a parliament is. The answer of the student (line 2) is not wrong, but not complete either. The teacher contingently keeps the degree of control the same upon this partially correct answer by asking a follow-up question in line 3 of the same level of control (level 2).

3.2. Examples of non-contingent patterns

In Excerpts 3–5, we give an example of each non-contingent pattern.

3.2.1. Non-contingent control

In the conversation preceding Excerpt 3, the teacher had found out that the students selected the series of EEC, ECSC and EU. They had left out the EEC because, according to them, the EEC used to be a dictatorship whereas the ECSC and the EU were not. In line 1 of Excerpt 3, the teacher asks whether the EEC was a dictatorship and the student indicates that he thinks that that was the case. This is not true so the answer is considered false (line 2). However, the teacher decreases the level of control in line 3 by asking what a dictatorship is. Decreasing the level of control upon poor student understanding is considered non-contingent.

3.2.2. Non-contingent control+

In Excerpt 4, an example of non-contingent control+ is represented. The students chose the series of prosperity, competition and freedom. In the conversation that preceded this excerpt, the teacher and the student discussed the quality of the series and the teacher suggested that freedom might not fit so well. In line 1 of Excerpt 4, she asks the students what concept has a better connection. The degree of control exercised in this question is medium as there are a limited number of concepts available. The

### Table 2

Frequencies and Percentages of Different Contingency Patterns per Condition.

<table>
<thead>
<tr>
<th></th>
<th>Control+</th>
<th>Control=</th>
<th>Control−</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Untrained condition</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Non-contingent</td>
<td>12 (40%)</td>
<td>7 (23.3%)</td>
<td>11 (36.7%)</td>
<td>30 (38%)b</td>
</tr>
<tr>
<td>Contingent</td>
<td>33 (67.3%)</td>
<td>14 (28.6%)</td>
<td>2 (4.1%)</td>
<td>49 (62%)b</td>
</tr>
<tr>
<td>Total</td>
<td>45 (57%)</td>
<td>21 (26.6%)</td>
<td>13 (16.5%)</td>
<td>79 (100%)</td>
</tr>
<tr>
<td><strong>Trained condition</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Non-contingent</td>
<td>4 (6.7%)</td>
<td>22 (36.7%)</td>
<td>34 (56.7%)</td>
<td>60 (17%)b</td>
</tr>
<tr>
<td>Contingent</td>
<td>163 (55.6%)</td>
<td>57 (19.5%)</td>
<td>73 (24.5%)</td>
<td>293 (83%)b</td>
</tr>
<tr>
<td>Total</td>
<td>167 (47.3%)</td>
<td>79 (22.4%)</td>
<td>107 (30.3%)</td>
<td>353 (100%)</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>16 (17.8%)</td>
<td>29 (32.2%)</td>
<td>45 (50%)</td>
<td>90 (21%)b</td>
</tr>
<tr>
<td>Non-contingent</td>
<td>196 (57.3%)</td>
<td>71 (20.8%)</td>
<td>75 (21.9%)</td>
<td>342 (79%)b</td>
</tr>
<tr>
<td>Contingent</td>
<td>212 (49.1%)</td>
<td>100 (23.1%)</td>
<td>120 (27.8%)</td>
<td>432 (100%)</td>
</tr>
</tbody>
</table>

a row percentage.
b percentage of total.

### Table 3

Frequencies and Percentages of Student Subsequent Understanding per Contingency Pattern.

<table>
<thead>
<tr>
<th>Subsequent student understanding (S2)</th>
<th>Poor</th>
<th>Partial</th>
<th>Good</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control=</td>
<td>25 (24%)</td>
<td>29 (27.9%)</td>
<td>50 (48.1%)</td>
<td>104</td>
</tr>
<tr>
<td>Control−</td>
<td>18 (22.8%)</td>
<td>29 (36.7%)</td>
<td>32 (40.5%)</td>
<td>79</td>
</tr>
<tr>
<td>Control+</td>
<td>44 (27.3%)</td>
<td>48 (29.8%)</td>
<td>69 (42.9%)</td>
<td>161</td>
</tr>
<tr>
<td>Total</td>
<td>87 (25.3%)</td>
<td>106 (30.8%)</td>
<td>151 (43.9%)</td>
<td>344</td>
</tr>
</tbody>
</table>

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3.2.3. Non-contingent control

In Excerpt 5, the student gives a correct answer to the question posed in line 1. However, the teacher keeps the same degree of control (medium) upon this good answer which is considered non-contingent. Decreasing the level of control here would have been contingent.

3.3. Frequency of contingency patterns

To answer our first research question, we investigated the frequencies of the different patterns of contingency (Table 2).

With regard to the contingency and non-contingency in teacher–student interactions (question 1a), our hypotheses were not confirmed. The three-turn-sequences in the untrained condition were considered contingent in 62% of the cases (Table 2). This was significantly higher than 50% (t(78) = 2.2, p = .03, d = .09). The three-turn-sequences in the scaffolding condition were considered contingent in 83% of the cases. This was significantly higher than 70% (t(352) = 6.5, p = .00, d = .23).

With regard to specific contingency-patterns (question 1b), we found that overall, non-contingency was mostly characterised by control=(50%) and control− (32.2%) as expected, whereas contingency was mostly characterised by control+ (57.3%). These patterns appeared to be significantly different (χ²(2) = 46.9, p = .00). The effect size was considered medium: φ = .36.

When comparing the patterns within the two conditions, these appeared to be relatively similar. In the trained condition, contingency was characterised mostly by control+ (55.6%) and non-contingency by control = (56.7%). In the untrained condition, contingency was also mostly characterised by control+ (67.3%) but non-contingency mostly by control + as well (40%).

Overestimation of students’ understanding was more common than underestimation. Overestimation happened either when the teacher decreased the level of control in response to poor or partial understanding (non-contingent control -) or when the teacher keeps the degree of control the same upon students’ poor understanding (some occasions of non-contingent control =). Adding these two occasions of overestimation (not visible in Table 2) shows that the teachers overestimated their students’ understanding in 62% of the cases.

3.4. Effect of contingency on student learning

To answer our second research question we investigated contingency in relation to student learning. We hypothesised that contingency would be positively associated to student learning. Before testing this hypothesis, we checked whether the contingency pattern itself was not associated with students’ subsequent understanding (Table 3).

We found no significant association between the contingency pattern and subsequent student understanding (χ²(4) = 2.42, p = .66). In other words, no specific pattern of contingency seemed to result in a specific type of subsequent student understanding.

Subsequently, we investigated the association between contingency and subsequent student understanding (Table 4). There was a significant association between contingency and subsequent student understanding (χ²(2) = 15.3, p = .00). Based on the odds ratio, it appeared that if a three-turn-sequence was considered contingent, the odds at having partial or good subsequent understanding were respectively 4 times and 2 times higher than if the three-turn-sequence was considered non-contingent. The effect size was considered small/medium: φ = .21.

Table 4
Frequencies and Percentages of Student Subsequent Understanding for Contingent and Non-contingent Three-turn-sequences.

<table>
<thead>
<tr>
<th>Subsequent student understanding (S2)</th>
<th>Poor</th>
<th>Partial</th>
<th>Good</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Non-contingent</td>
<td>31 (40.8%)</td>
<td>13 (17.1%)</td>
<td>32 (42.1%)</td>
<td>76</td>
</tr>
<tr>
<td>Contingent</td>
<td>56 (20.9%)</td>
<td>93 (34.7%)</td>
<td>119 (44.4%)</td>
<td>268</td>
</tr>
<tr>
<td>Total</td>
<td>87 (25.3%)</td>
<td>106 (30.8%)</td>
<td>151 (43.9%)</td>
<td>344</td>
</tr>
</tbody>
</table>

Table 5
Frequencies and Percentages of Learning Scores for Contingent and Non-contingent Three-turn-sequences in the Case of Poor Initial Understanding.

<table>
<thead>
<tr>
<th>Shifts in understanding for poor initial understanding (S1 = 0)</th>
<th>No shift in understanding (S2 = 0)</th>
<th>Increase of understanding (S2 = 1 or 2)</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Non-contingent</td>
<td>11 (68.8%)</td>
<td>5 (31.2%)</td>
<td>16</td>
</tr>
<tr>
<td>Contingent</td>
<td>9 (34.6%)</td>
<td>17 (65.4%)</td>
<td>26</td>
</tr>
<tr>
<td>Total</td>
<td>20 (47.6%)</td>
<td>22 (52.4%)</td>
<td>42</td>
</tr>
</tbody>
</table>
with the learning score, no significant effect of control+ on learning score is found. Therefore, it is probably the control (whether contingent or non-contingent) necessarily resulted in good understanding. Even if we repeated this analysis.

However, we checked the main effect of the contingency patterns on student understanding and we did not find that increasing hints and information that is provided by the student in his/her response which is then considered correct by the teacher.

even provision of the answer. It might then be the case that, when control is increased, the student for example just repeats the increase of control upon poor initial understanding that affects student learning. Decreasing control upon poor initial understanding is already poor and the support the student receives might be too open and non-directive.

The degree of challenge might then be too large: the number of students that a teacher needs to adapt his or her support to.

Second, with regard to the contingency per condition, we found higher percentages compared to previous research. Non-trained teachers acted contingently in about 60% of the cases. This finding is higher than contingency levels found for example in whole-class teaching (Nathan & Kim, 2009) in which the teacher was not trained as well. The fact that the untrained teachers in this study scored higher than in the whole-class study of Nathan and Kim (2009), might be explained by the fact that gauging students’ understanding and adapting control is easier in a small-group setting compared to whole-class teaching as there are less students that a teacher needs to adapt his or her support to.

The degree of contingency found in the trained condition was found to be higher than the 70% we expected. Previous research (Pratt & Savoy-Levine, 1998; Wood et al., 1978) showed that trained tutors achieved 70% contingency in their interactions whereas the trained teachers in our sample achieved more than 80% contingency. This difference for the trained teachers might appear to be associated with a different patterns of shifts in understanding (χ² (1) = 4.6, p = .02 | one-sided). If a three-turn-sequence was considered contingent, the odds at an increase of understanding (from S1 = poor to S2 = partial or S2 = good) compared to no shift (from S1 = poor to S2 = poor) were 4.2 times higher than if the three-turn-sequence was considered non-contingent. The effect size was considered medium: φ = .33.

Subsequently, we conducted the analysis for all cases in which the student’s initial understanding was partial (Table 6). The Fisher exact test showed that the contingent and non-contingent sequences were not associated with a different pattern of shifts in understanding (p = .25 | one-sided).

Finally, we conducted the analysis for all cases in which the student’s initial understanding was good (Table 7). The Fisher exact test showed that the contingent and non-contingent sequences were not associated with a different pattern of shifts in understanding (p = .31 | one-sided).

### 4. Discussion

The main goal of the current study was to investigate different patterns of contingency and to explore how contingency relates to student learning. The current study resulted in four important findings.

First, we found that contingency was positively associated to student learning, however, only in the case when the student’s initial understanding was poor. In this case, the chance at learning was about four times higher when the teacher acted contingently than when the teacher acted non-contingently. When the initial understanding is poor, being contingent means to increase the level of control. If control is increased, the student experiences more direction, more explicit hints and sometimes even provision of the answer. It might then be the case that, when control is increased, the student for example just repeats the hints and information that is provided by the student in his/her response which is then considered correct by the teacher. However, we checked the main effect of the contingency pattern on student understanding and we did not find that increasing control (whether contingent or non-contingent) necessarily resulted in good understanding. Even if we repeated this analysis with the learning score, no significant effect of control+ on learning score is found. Therefore, it is probably the contingency of the increase of control upon poor initial understanding that affects students learning. Decreasing control upon poor initial understanding (which is non-contingent) did not result in learning. The degree of challenge might then be too large: the understanding is already poor and the support the student receives might be too open and non-directive.

The degree of contingency found in the trained condition was found to be higher than the 70% we expected. Previous research (Pratt & Savoy-Levine, 1998; Wood et al., 1978) showed that trained tutors achieved 70% contingency in their interactions whereas the trained teachers in our sample achieved more than 80% contingency. This difference for the trained teachers might

### Table 6

**Frequencies and Percentages of Learning Scores for Contingent and Non-contingent Three-turn-sequences in the Case of Partial Initial Understanding.**

<table>
<thead>
<tr>
<th>Shifts in understanding for partial initial understanding (S1 = 1)</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Decrease in understanding/no shift (S2 = 0 or 1)</td>
<td>Increase in understanding (S2 = 2)</td>
<td>Total</td>
<td></td>
</tr>
<tr>
<td>Non-contingent</td>
<td>5 (83.3%)</td>
<td>1 (16.7%)</td>
<td>6</td>
</tr>
<tr>
<td>Contingent</td>
<td>74 (60.2%)</td>
<td>49 (39.8%)</td>
<td>123</td>
</tr>
<tr>
<td>Total</td>
<td>79 (61.2%)</td>
<td>50 (38.8%)</td>
<td>129</td>
</tr>
</tbody>
</table>

### Table 7

**Frequencies and Percentages of Learning Scores for Contingent and Non-contingent Three-turn-sequences in the Case of Partial Good Understanding.**

<table>
<thead>
<tr>
<th>Shifts in understanding for good initial understanding (S1 = 2)</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Decrease in understanding (S2 = 0 or 1)</td>
<td>No shift (S2 = 2)</td>
<td>Total</td>
<td></td>
</tr>
<tr>
<td>Non-contingent</td>
<td>8 (40%)</td>
<td>12 (60%)</td>
<td>20</td>
</tr>
<tr>
<td>Contingent</td>
<td>14 (51.9%)</td>
<td>13 (48.1%)</td>
<td>27</td>
</tr>
<tr>
<td>Total</td>
<td>22 (46.8%)</td>
<td>25 (53.2%)</td>
<td>47</td>
</tr>
</tbody>
</table>

To be sure that this effect was not influenced by the student's initial understanding (S1), we finally conducted analyses for three situations in which the students' initial understanding was respectively poor, partial or good.

First, we conducted the analysis for all cases in which the student's initial understanding was poor (Table 5). Contingency appeared to be associated with a different patterns of shifts in understanding (χ² (1) = 4.6, p = .02 | one-sided). If a three-turn-sequence was considered contingent, the odds at an increase of understanding (from S1 = poor to S2 = partial or S2 = good) compared to no shift (from S1 = poor to S2 = poor) were 4.2 times higher than if the three-turn-sequence was considered non-contingent. The effect size was considered medium: φ = .33.

Subsequently, we conducted the analysis for all cases in which the student’s initial understanding was partial (Table 6). The Fisher exact test showed that the contingent and non-contingent sequences were not associated with a different pattern of shifts in understanding (p = .25 | one-sided).

Finally, we conducted the analysis for all cases in which the student’s initial understanding was good (Table 7). The Fisher exact test showed that the contingent and non-contingent sequences were not associated with a different pattern of shifts in understanding (p = .31 | one-sided).

3 The Fisher exact test was used here because the expected count was less than 5 for some cells.
be related to the fact that the intervention in our study was much more elaborate than the training the tutors in the other studies received. In the current study, the intervention consisted of a theoretical session and five sessions in which the teachers practiced their scaffolding skills and reflected afterwards using video material of the lessons.

Third, with regard to the specific patterns of contingency, we found that teachers (both trained and non-trained) acted non-contingently upon students’ initial understanding mainly by keeping the level of control the same upon poor/good initial understanding or by decreasing the degree of control upon students’ poor/partial understanding. When teachers (of both conditions) acted contingently, this was mainly done by increasing the level of control appropriately upon poor or partial understanding. Keeping the degree of control the same upon partial initial understanding (which is contingent) or decreasing control upon good understanding was (which is contingent) did not occur to a great extent. It might be the case that for example releasing control is more difficult for teachers than increasing control. Teachers feel more uncertain because students’ responses are for example less predictable when releasing control (Weimer, 2002). However, more research is needed to explore this issue further.

Fourth, the teachers more often overestimated the students’ understanding than underestimated their understanding. This is in line with outcomes of classroom and tutoring studies. In general, teachers and tutors appear to have difficulties with estimating students’ understanding, and most commonly, the students’ understanding is overestimated (e.g., Begeny et al., 2011; Wittwer et al., 2010). However, the measures in these studies were more general compared to the measures in our study. So apparently, both on a macro-level and on a micro-level, teachers tend to overestimate students’ understanding. This might be explained by the fact that teachers or tutors tend to use their own – more developed – knowledge as a reference point. This is called egocentric bias (Epley, Keysar, van Boven, & Gilovich, 2004). Yet, the parent–child study of Pino-Pasternak et al. (2010) reports a different finding. In their study, the frequency of non-contingent control+ was much higher than the frequency of non-contingent control−. The parents thus often underestimated the understanding of their child, providing more help than required which resulted in little challenge. Possibly, the egocentric bias does not apply to parents; parents are not necessarily experts in the area in which they are helping their child.

4.1. Future research

In the current study, we investigated the frequency of patterns of contingency and the association between contingency in general and student learning. A next step for future research would be to further scrutinise the effects of each of the contingency patterns (control+ , control− , and control=) on students’ learning, e.g., by using multilevel modelling. Although we had a big dataset of over 400 three-turn-sequences, we could not conduct this analysis because when breaking down contingent and non-contingent support each into three parts (control+ , control− , and control=) we had not enough cases per cell left. Scaffolding theory only theorises about the effects of contingent and non-contingent support in general, not about the specific contingent and non-contingent patterns. Wittwer and Renkl (2008) introduced some ideas about why non-contingent patterns may be ineffective (in tutoring situations): support that is both too easy (non-contingent control+) and too difficult (non-contingent control−) results in poor student understanding. Support that is too easy might prevent the learner from processing other, more elaborate information whereas support that is too difficult might cause comprehension breakdowns (Wittwer & Renkl, 2008). However, future research should investigate these claims. In addition, little is known about the effects of keeping the degree of control the same, either contingently or non-contingently or about mechanisms underlying any of the contingent patterns.

Furthermore, the amount of control levels that is skipped might also affect the effectiveness of contingent support. It could be possible that decreasing the level of control suddenly from the highest level (e.g., providing an explanation or answer) to the lowest level (walking away or asking an open question) does not result in good student understanding whereas a more subtle and smaller decrease does result in good student understanding. Wood et al. (1978) compared contingent support (all three patterns) to a ‘swing’ condition in which the level of control was either high or low. The children in the swing condition were less efficient and less active than children in the contingent condition. Children in the swing condition did not learn how to approach a task and what steps to take; “we found the children in this group quite bewildered when eventually left to their own devices” (Wood et al., 1978, p. 145). However, this was a tutoring study with a structured (block-building) task. More research should investigate what effect the size of the leaps has on the effectiveness of contingent support.

In addition, we assumed that giving more control upon good understanding or giving less control upon poor understanding (both non-contingent) means that the teacher respectively underestimated or overestimated the students’ understanding. However, future research could take teachers’ beliefs into account. It could be the case that some teachers believe that a general teaching style of high control and directing students or a general teaching style of low control and letting students discover things themselves is effective. This might also shed light on our finding that some teachers keep the degree of control the same non-contingently (i.e., upon poor of good understanding). Based on their beliefs, these teachers might deliberately choose to keep the level of control low (even if this is non-contingent), that means, as the result of a deliberate choice, not because student understanding is not assessed correctly. The teachers might for example not have wanted to stop the students’ line of thinking. These beliefs might thus have caused these non-contingent patterns of support rather than a misinterpretation of the students’ understanding.

Finally, we investigated direct student learning. However, some learning might need more time (cf. Howe, McWilliam, & Cross, 2005). Some learning – of for example very complex concepts – might only manifest itself in a series of turns or at a point in time that is much further apart from the three-turn-sequences we used. Future research should therefore also investigate the long-term effects of scaffolding on students’ learning; both with regard to similar tasks and with regard to transfer tasks or more abstract learning (Howe, in press). Moreover, it is known that the quality of peer interaction influences students’ learning and might even mediate the effect of scaffolding on students’ learning (Howe, in press). In this study, we only analysed teacher–student interaction in the context...
of peer interaction: we did not analyse the quality of peer interaction when the teacher was not present and neither did we investigate the role of present peers in the teacher–student interactions. Future research that investigates the more indirect effects of scaffolding in the context of small-group learning should take into account the quality of peer interactions. For the direct effects, however, as measured in this study, the quality of peer interaction might not matter as we only assessed the students’ understanding directly following the teachers’ intervention.

4.2. Conclusion

Based on the results of this study, contingency appeared to promote student learning, primarily when the initial understanding of the student was poor. The appropriate degree of control and therewith the appropriate degree of challenge facilitated learning. Finding ways of keeping the degree of challenge appropriate in the case of good initial student understanding is a challenge for future research. For now, we can conclude that acting contingently when the student has poor understanding appears effective. Learning more about the direct effects of scaffolding on student learning can inform further teacher professional development.

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References


