4.3 Case study 3 (CS3 Denmark)

Concept focus	Construction of legorgs and measurement of "fitness" as a model for natural selection
Inquiry skills	Forming coherent arguments Working collaboratively (debating with peers, teamwork)
Scientific reasoning and literacy	Not assessed
Assessment methods	Classroom dialogue Teacher observation Worksheets Student-devised materials (report)
Student group	**Grade:** upper second level; three classes **Age:** 15-18 years **Group composition:** mixed ability and gender **Prior experience with inquiry:** Very experienced with inquiry

This case study details the findings from three separate implementations, with students aged 15-18 years. A key skill identified for assessment was *forming coherent arguments*, which was assessed through evaluation of student worksheets or reports. Assessment of *working collaboratively* was also achieved through teacher observation in the classroom and evaluation of video recordings of the lessons.

(i) How was the learning sequence adapted?

The learning sequence was carried out with the lesson plan as a manuscript for the students' work. At first the teacher split the class into groups of 4-5 students. In these groups the teacher presented the concept of the exercise with emphasis on keeping track of all the schemes that the students produced during their work. The students then started out with generation 1 and were told to call for help when getting to the gene pool tables. The groups were free to work at their own pace and were asked to organise themselves.

(ii) Which skills were to be assessed?

During this implementation, the teachers focused on two inquiry skills, namely *forming coherent arguments* and *working collaboratively*.

In order to assess *forming coherent arguments* the students were told to write a report after the exercise, with guidance through a set of questions posed by the teacher and given to the students as a hand-out. These questions were at first directed towards the exercise and the direct output from the exercise. The last questions though were of a more general character to lead the students' work with the exercise in to a more general thinking of evolution in biology. In order to answer the posed questions the students had to form their own arguments. These arguments were then collected and assessed by the teacher and afterwards in general discussed in class as different possibilities.

During the students' work, each group were recorded on video. Classroom observations and video recordings were therefore used as assessment material for *working collaboratively* (teamwork, debating with peers). Furthermore semi-structured interviews were conducted with 21 students. These interviews also offered valuable information on the assessment of these skills.

(iii) Criteria for judging assessment data

In *forming coherent arguments* and reflective thinking the main criteria for assessment was students' written work. In this work the teachers had time to try and go behind the thinking of the students. But also during the work the teachers had a coherent approach to assessing and guiding

students in the direction of both reflection and argumentation in that the teachers consistently posed questions back at the students instead of just giving the students the correct answer.

Teamwork was assessed as a group assessment instead of an individual assessment. The teachers' focus was to get the groups working in an organised way. If the groups succeeded in this on their own the teacher did not interrupt the group. But if groups were having trouble in organising themselves the teacher again approached the groups with reflective questions on how to get moving and what to do instead of taking over the organisation.

(iv) Evidence collected

Teacher opinion

The teachers who tried the exercise agreed on the value of having the students working in groups on a topic that would otherwise be presented in theory. In order to have the students to discuss within the groups, the teachers adopted a strategy of not answering questions directly. Instead the teachers posed questions back to the students, so that they themselves could come up with an answer. The teachers were very clear on giving direct help with technical questions and giving questions to reflect on if addressed with conceptual questions.

The teachers noticed the students' frustrations in order to get the exercise working but left it mostly to the students themselves to come up with a solution in working together. One teacher observed that the students possessed different skills, abilities and knowledge at the start of the exercise. Bringing together these different strengths, the students managed to get the exercise working in collaboration, and finally they ended up with comparing what they had done during the exercise and see how they came to different results.

Afterwards the teachers also noticed that the students in their group work actually overcame these challenges in had not only a gain in inquiry skills and competencies but also gained conceptual understanding of the concepts within natural selection. A teacher said:

> ***"So there is no doubt that there is some conceptual understanding as output, despite the frustrations they*** *[the students]* ***had in this Lego exercise. Of course there was a great deal of chaos during the exercise."***

Observer notes

As I observed the students in their work, I noticed several groups where the organisation of the group was carried out very fast. The students seemingly knew the strengths and weaknesses of their peers and organised the group work according to this. As observer it was most obvious to assess the students on their teamwork, since so much attention was paid to organising the group that there were only few discussions.

During student discussions it seemed that the students were willing to listen to others' arguments and carry on the discussion from there. After the exercise the video recordings were also analysed according to an engagement matrix. For the students analysed there is a tendency for them to get more and more involved in not only participating but also in organising the work of the group.

Sample student artefacts

Examples from the students' written work on reflective thinking include:

> ***"I would say that movement is a pretty good measure for the animals' fitness – it is easy to measure. And it is easily understandable that the animal that moves the best has a better survival. Not all organisms are perfectly adapted to their environments because a perfect adaption does not happen over a few days. It takes really many generations and thereby years to become adapted good to an environment. All organisms mutate all the time. There is both good and bad mutations and these also have influence on how well adapted you are."***

> ***"Natural selection can have two influences on a population depending on whether it is a large or a small population. The large population influence "survival of the fittest". This means that the best-adapted individuals forward their genes. This means that the genetic variation in the population is decided to which individuals that reproduce. In the small population the influence is almost the same as for the large population only with a twist of randomness that plays a bigger role. For example could there be only few animals that reproduce"***

From interviews with the students it was clear that even though the students were used to group work they found this exercise different. Only a few could express this as clearly as one of the girls did:

> ***And then it was more like an exercise where all were needed. Everyone should have understood it or else it would cluster up – meaning a totally waste of time. So it was important that we had helped all along. Sometimes you can also – from e.g. physics and chemistry – then there is often one who understood it and then you can – then the one can just explain it but here we really needed to be together in it because it was a bigger project and it took longer time. If you only had one who understood it then it would have been really crappy. So we like needed to get everyone along. And that I also think went well***

During the exercise there were also examples of students debating with peers. In one of the groups a boy found it hard to understand the sense in giving the length of movement as a number for the fitness of the animal. A discussion from the video recordings of the group was transcribed (Figure 1).

The following is part of a discussion in one of the groups doing the exercise. The group consists of 6 students (◆FF, ❖FM, ★RM, ✚LF, KM, & RF). Student KM and student RF do not take part in this discussion. At this point the group has worked on the exercise for about 45 minutes. The group has just finished measuring fitness on the first generation and is about to calculate the gene pool for the second generation when FM is starting to wonder:

◆FF: ***You don't get it FM***

★RM: ***You have to remember the sequence we have [...] although we have it written down***

◆FF: ***In case you forgot***

❖FM: ***What if we just take them*** *[Lego bricks]* ***and redo them so we have another sequence***

✚LF: ***As far as I understand then [...]***

❖FM: ***Then it would not give the same***

◆FF: ***No it does not make sense***

❖FM: ***It just doesn't***

◆FF: ***Don't you get the point. I don't get that you don't get the point***

✚LF: (is discussing with FF how right they are while demonstrating on a Legorg) ***[...] that they cannot see that they are good in this context but in another they do not work***

✚LF: ***FM, FM ... FM,FM, FM. It is because this exercise will show that because of the good feature in some of them ... if they appear in a different time or maybe in a different environment then they would not be that good. That is what this exercise will show.***

◆FF: ***You can see that can't you FM. Those are the good but if they were on the top they would not be that good. Then it would tumble [...] have another form***

★RM: ***But they are bad here. The other one moves well***

✚LF: ***Yes it is bad there but ...***

◆FF: ***But it is good that it is standing***

★RM: ***They have to move***

❖FM: ***In the next round we have to ...***

✚LF: ***This is exactly what the exercise is supposed to show***

❖FM: ***Please be quiet***

◆✚FF&LF: ***Ho Ho***

❖FM: ***In the next round we have to have as many bricks in relation to how far they moved. But if this one ... the other one moved 40.8 [mm] and this one moved 0 [mm]. Then we still get as many bricks from this one.***

✚LF: ***It is though supposed to show that the morphological features only works in certain combinations or else it does not matter.***

❖FM: ***It just still does not make any sense***

◆FF: ***Why doesn't it make sense?***

❖FM: ***It's because ...***

✚LF: ***What is it that you want it to show***

❖FM: ***When we take this one with 40.8 [mm] then it has ... then it gives the same bricks as the one that with 0 [mm]... in the bag.***

The discussion is interrupted by the teacher who needs results from the class and then explains the next step to happen. The discussion end for now and the group start to work with the step just explained by the teacher. Approximately 10 minutes after this interruption the discussion continues.

✚LF: ***Ah yes. Now it is starting to make sense. FM. FM. Now it is starting to make sense, because now we take the position where it was the best. We take it up here and then we chose from ...***

❖FM: ***But this still doesn't mean that we get ...***

✚LF: ***No, no of course not but we get it clarified after five generations***

❖FM: ***Yes in the end but this does not mean that ...***

RM gets up, shakes the shoulder of FM and leaves the group. The discussion ends.

Figure 1: Example of student dialogue (transcribed from video-recording of session)