

CAPTURING THE REAL WORLD IN THE CLASSROOM

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Pupil best learn mathematics and science by doing mathematics and science. Practical investigation work is part of this job. For this, pupils need to develop a broad range of skills that includes amongst others asking good questions, connecting a real world phenomenon with the world of mathematics and science, setting up an investigation or experiment, and collecting, representing, analysing, and interpreting information. In this paper we report on a classroom experiment in which pupils in pre-vocational secondary education develop and practise such skills by carrying out a small investigation task using digital video technology.

IMPRESSION OF PUPILS' WORK

Pupils in the third year of the theoretical learning pathway in pre-vocational education (age 14/15 yrs.) work in teams on recording a video clip about a subject of their own choice. They use things that they brought from home, direct their web cams, put the video software VirtualDub (www.virtualdub.org) in capture mode, and ... go ahead and shoot a video clip. Darts, paper airplanes, rope-skipping, bouncing balls, handstand, balloons, ... Many things happen in- and outside the classroom.

Hereafter comes the excitement and stress of watching the recorded video clip and making sense of it. A lot of questions are raised: what has come of the video clip? What are interesting points in the video clip to focus on? Are there angles or distances to measure, or timings of events to make that reveal an interesting aspect of the recorded motion? What do graphs that present information about various aspects of the motion look like? For this kind of small investigations we have used the computer learning environment Coach [Heck, 2002]. Pupils print the graphs that they have found, annotate their diagrams with a short explanation, and hand this paper in as end product of their work.



SETTINGS AND OBJECTIVES OF THE PROJECT

We gave an impression of the video measurement project that has been included in the examination programme of the VMBO-TL3 classes at the Bonhoeffer College in Castricum, the Netherlands. VMBO is an acronym for pre-vocational education. It was introduced in 1999 as education for practically inclined students following their primary education. It takes four years of study and sixty percent of secondary school students in the Netherlands participate in this type of education. Pupils passing the examination may go on to senior vocational education and prepare for a particular profession. Our study took place with pupils in the theoretical learning pathway (TL), which prepares them for middle management and for secondary vocational training, or for senior general secondary education. Because many schools struggle in the theoretical learning pathway with the motivation of pupils, with the pupils' orientation on the vocational sectors, with their preparation to senior vocational school, and with the downfall in figures of pupils moving to senior general education, the public demand for educational reform has grown enormously, the right to exist is disputed, and the cry for reintroduction of its predecessor, junior general secondary education, as a school type separated from pre-vocational education can be heard more frequently.

There exists undoubtedly some contradiction between 'vocational education' and 'theoretical learning pathway'. In general, we notice a tendency to keep a tight hand on pupils in the classroom as the only way to make pupils learn anything. Clarity and discipline in classroom activities are the key words. How appropriate such an approach may be in itself, it can also lead to a situation that practical investigative work by pupils, which is essential in science education, is offered in the same closed, fixed manner as theory. This is a pity because learning by doing and through lab work will have much more appeal for pupils than theory lessons and it will stimulate them to put more efforts in their learning.

We think it is well possible to entice VMBO-TL pupils with practical work to a more active, self-responsible, and self-controlled way of learning. But this will only work if enough time is reserved for practical work, say one-third of the instruction time. The new orientation of the Ministry of Education, Culture, and Science on secondary education, written down in [van der Hoeven, 2004], offers opportunities for schools to take up such an approach. However, it also presupposes that we have answers to questions such as "How open can a task be for TL3-pupils? With how much responsibility can they deal and when must a teacher bring structure to the activities in the classroom?". Such questions can only be answered through classroom experiments at schools. This classroom study is one of such experiments.

Eighty pupils in three classes in the theoretical learning pathway have done the video measurement project in the study year 2003/2004. The pupils did not have much experience with Coach: they had seen it before used by the teacher and they had occasionally carried out themselves measurements with sensors. A school network

with sufficient computers and a well-equipped science lab are available at school. At the time of the project, five web cams were available and a teaching assistant helped the pupils, if needed. The project work was done under the responsibility and guidance of the pupils' own physics teacher. There were three teachers with different backgrounds involved: one of the teachers, who is also the first author of this paper, was experienced in video measurement activities. Another teacher was familiar with computer supported lab work and demonstration experiments, but had not used video before. The third teacher had hardly experience with Coach and acted more as a fast-follower. The most experienced teacher started with project and the other teachers followed in their classes, taking advantage of the first findings. We will discuss the consequences for the pupils' activities and results in the classrooms.

The main objective of this project is to let pupils carry out a short investigation on a self-chosen motion, at their own educational level. They can show an exploring attitude and adequate practical skills. This concerns the preparation, implementation, and completion of the investigation, as well as effective collection, processing, and presentation of data that are obtained from self-made video clips.

Putting the video measurement project into the examination programme is a sign of a high level of ambition of the team of teachers within the theoretical pathway at the Bonhoeffer College. Other teachers may find it too ambitious. This is why the pupils' activities and their results have been monitored as well as possible, in order to find answers to the following questions: Are VMBO-TL3 pupils able to deal with the open task given to them and what performances are turned in? Has the recording of the video-clips by pupils themselves additional value, or should one use prepared video clips instead? Does the investment of time and energy still bring pupils some understanding of mathematics and science? How could the instructional setting be improved to advance the smooth running of things and to optimize the pupils' results?

DESIGN AND IMPLEMENTATION OF THE LESSONS

We describe the design of the pupils' project work, which was planned for five lesson hours of forty-five minutes, and we describe how the lessons actually went in the classroom of the most experienced teacher.

Lesson 1. Introduction to capturing and measuring video clips

At the start, the teacher explains what the lesson is about and what the goals of the project are. He gives a live demonstration of using the software VirtualDub to capture a video clip with a web cam. There are many technicalities and things to take into account, but the idea of the demonstration is to show that any pupil is able to do this as well; it is not only for whizkids. The second time, pupils make their own class notes. They are expected to rely on their own notes when it is their turn to capture a video clip; no manual is provided. Next, it is the turn of two pupils to capture a video

in front of the class. If all goes well, it gives the entire class the feeling that they will have success, too.

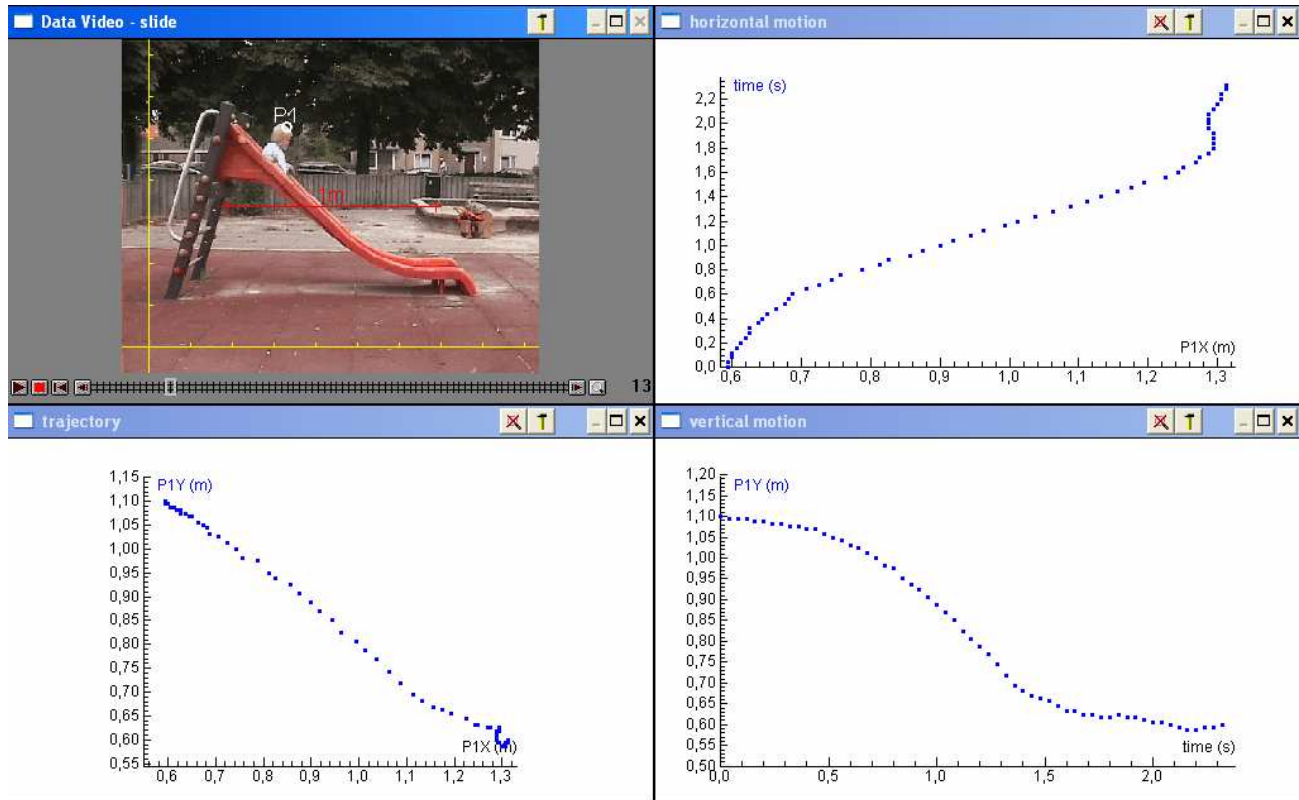


Figure 1. Sample video activity of a toddler on a slide in a playground.

This recording of video clips does not take more than half an hour. So there is still some time left to practise measuring on a video clip. After a short demonstration, the pupils can practise with video activities that have been prepared for this purpose (pupils only have to trace a point by mouse clicking; the measurement settings and diagrams are preset). It is important that the sample video activities are appealing. A great success (especially with the girls) was the activity of a toddler on a slide in the playground (see Figure 1 above). Video clips with a sweet toddler are more effective than video clips that are undoubtedly oriented towards physics, such as movies of falling balls, collision of balls, or air cushion motion of objects.

Lesson 2. How to make a useful video clip

Pupils are provided five video clips in which something has gone wrong with the capturing (see the example to the right). They must answer three questions:

1. What is wrong with the video clip?
2. How can you fix this with VirtualDub?
Also carry out the repair!
3. How could you prevent the mistakes?



In this lesson, we pay much time and attention to the fact that the plane of motion is best perpendicular to the camera direction. The pupils also must decide now what kind of video clip they want to capture and write down their plans of how to do this.

Lesson 3. Video measurement

In this lesson, the teacher demonstrates the pupils how to create a Coach video activity from scratch, how to embed the captured video clip, and how to carry out a measurement on the movie. Things that pass under review are the coordinate system and calibration, video compression, plane of motion and camera direction, display of collected data in diagrams, and so on. Actually, the teacher used in the classroom the video clip about a darts throw, which was recorded before by two pupils, as an inspiring example. This demonstration also serves another purpose: it gives the teacher once more the opportunity to explain pupils what is actually expected from them.

Lesson 4. Pupils capturing their video clips

In the fourth lesson, the pupils capture their video clips. They can get help from the teacher and/or his assistant if necessary, but they are expected to work as much as possible on their own, using their own class notes or getting help from fellow pupils.

Lesson 5. Pupils measuring on the self-made video clip and writing a short report

In the last lesson, pupils carry out a measurement on the self-made video clip, create relevant diagrams, annotate the graphs with relevant information, and finally write a short report. This report may be a screen shot of the Coach activity with some words of explanation and conclusions, as is shown in Figure 2 below.

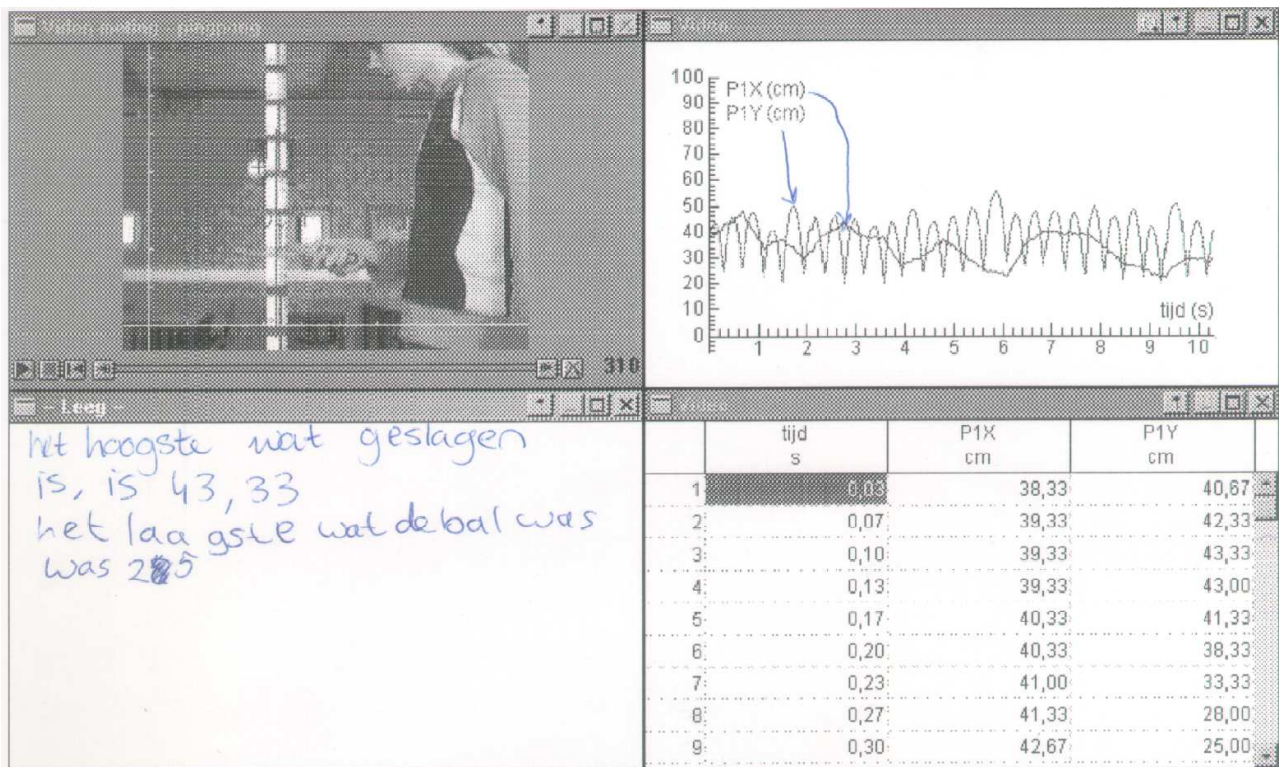


Figure 2. The full report of Irene and Nanda about table tennis

FINDINGS

Let us begin with the unforeseen technical problems that we encountered the first time. Although every team succeeded in making a useful video clip, capturing and embedding the video clip in a Coach activity was hindered by the following things:

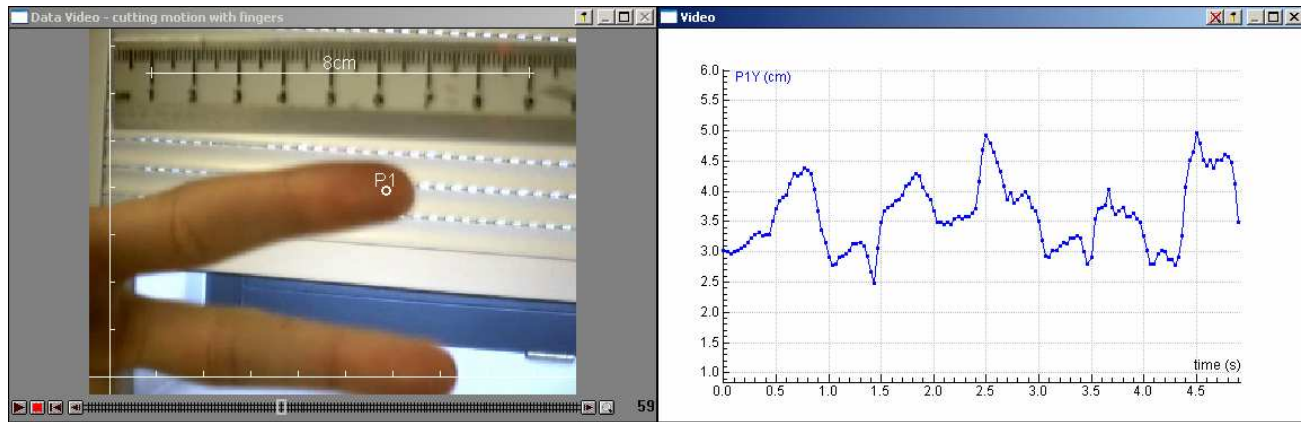
- o Because some pupils forgot to use video compression they flooded the computer network at school with files of 60 MB or larger, which essentially meant a collapse of the network. Without serious video compression, e.g., MPEG-4 Video Codec V2, the files were also too big for using diskettes as transport media.
- o The network installation of Coach at school prohibited that pupils could save video clips in a Coach project; these rights were only reserved for teachers. Transport of video clips from a laptop to the school computer via a memory stick could also be done only by the teacher or teaching assistant.

Each team spent about twenty minutes on capturing a video clip. Most of the time was required for finding one's way in the menu items of VirtualDub to specify correct settings of the software before capturing. Therefore, pupils paid less attention to setting up the experiment in an adequate way. Many of them wanted to capture immediately and hardly did a test run to see whether the quality could be improved. Also, they often forgot about a measuring stick in the movie clip for calibration purposes. If the teacher stressed in the foregoing lessons that the best camera direction is perpendicular to the plane of motion (in order to avoid perspective distortion), then the pupils did this well. However, when the teacher did not emphasize this, the pupils sometimes made less useful video clips. While capturing, pupils seemed to forget their research questions; they simply recorded the phenomenon that they had chosen, without consulting their notes. The lesson we learned from this is that we should request from the pupils a better planning of their work.

Our conclusions about capturing a video clip with VirtualDub by TL3-pupils is that, despite its success, it was a bit too time-consuming to do with the whole class at once. It involved too many technicalities that distracted the pupils from setting up their experiment in an appropriate way and it made them rely on teachers and assistants for help. In common practice, there is not so much staff available to support a lesson or lab session. For this reason, the video module of the Coach software has been redesigned to make the process of capturing and measuring a video clip easier. In the latest version it is possible to capture a video clip with a digital camera or web cam from within the Coach activity. The main advantage is that many camera settings can be specified beforehand by the author of the activity and that the recorded video clip is immediately available for data collection and processing.

The experience of the teacher with the learning environment and with video measurement, as well as the availability of laptop computers and the choice of location to capture the video clips, had a great impact on the scenes recorded. The least experienced teacher chose for a setting which he felt most comfortable with, viz., the

science lab and a limited choice of subjects to record: rolling balls (12 teams) and bouncing balls (3 teams). Marlotte and Kirsten were nevertheless more inspired and recorded a cutting motion with their fingers. Figure 3 show part of their report.



This graph is more readable. You see that the finger goes up and down, because we made a cutting movement. The movement is irregular, because the finger goes sometimes faster. The height is measured on the y-axis, the highest point is 5 cm. The time is measured in (s). The total time of the graph is 5 seconds. The initial point of the graph is (0, 3.0). The end point of the graph is (5, 3.5).

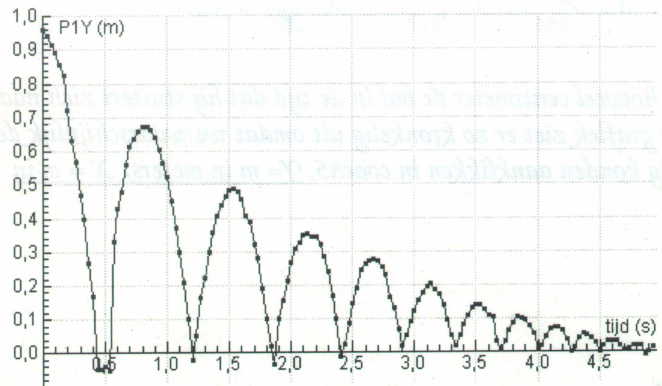
Figure 3. Cutting motion with fingers by Marlotte and Kirsten

In the class of the teacher who already had experience with Coach, but not with video measurement, work was also done within the science lab only. But pupils were stimulated to make a subject choice of their own. This led to a variety of video clips: rolling and bouncing balls, springs, a pendulum, jumping from standing position, hitting each other, hand waving, and the moving seconds hand of the clock in the science lab. The subjects in the class of the most experienced teacher, who also used two laptops in order to be able to capture a video clip at any location, were the most variable: flight of a paper airplane, rope-skipping, darts throwing, thrown-in of a soccer ball, table tennis ball, skipping, and handstand are nice examples. The creativity of the pupils was certainly switched on.

Pupils did their best to obtain accurate data in their video measurement, to explain the graphical representations, and to link up the graphs with the phenomenon in the real world that they recorded themselves. They used mathematics and physics beyond their expected level. Note in the fragment of the report shown in Figure 3 that the pupils read out coordinates of points without any mistake and paid attention to units of quantities. Marlotte and Kirsten sought an explanation for the irregular graph in terms of the real world motion. In Figure 4 below, which shows a fragment of the report of Rianne and Kim on a bouncing ball, you find a similar attempt to explain the form of the graph in physical terms.

We experienced that TL3-pupils were easily satisfied with one graphical representation of collected data, regardless of its suitability. To make sure that pupils use all

standard diagrams of motion, we set out a Coach activity with three diagrams as shown in Figure 1 in later lessons. We require from the pupils to report explicitly on all three graphs. Since we experienced that TL3-pupils had difficulty with understanding horizontal displacement on a vertical axis. This is the reason why time is plotted against horizontal position in the upper right window of Figure 1.



In this graph are arcs, these arcs arise because the ball is bouncing all the time. In the beginning the arcs are high because the ball has a high speed because it is released at a height of 1 meter. Hereafter the arcs get smaller because the ball reduces speed. This is a uniformly decelerated movement. $Y=m$ in meters, $X=$ time in seconds.

Figure 4. Part of the report of Rianne and Kim on a bouncing ball.

CONCLUSIONS

In summary, the authors and the teachers involved were quite pleased with the enthusiasm and performance of the pupils in their project work. The pupils were able to create interesting and useful video clips, to carry out meaningful measurements on the movie clips, and they could link the recorded motion with graphical representations and physics concepts in a better way than usually with pencil and paper.

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