Animating in Science Teaching and Learning

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Abstract. It has recently become possible to create a video of a short animation in a school science classroom using a digital or mobile phone camera, Plasticine and freely available software within one or two lessons. Teachers in different countries are seizing on the learning opportunities offered by having students animate a science process such as a sound wave or cell division etc. yet there has been little research into how and this engaging activity supports learning. This paper reports a project that explored animation creation with four classes of students (grades 4, 8, 11 and grade 12. It was found that making animations in school was enjoyed by nearly everyone and the students reported that, of the range of learning opportunities stimulated by making animations, talking in their groups during the task and seeing and discussing other groups' work were the most help to their understanding of the science concepts being animated.

Keywords. Animation · Science · Teaching · Learning

1 Introduction

Learning is complex, learning science particularly so. According to many science educators [1,2,3] this is due to its content which includes abstractions, difficult ideas, laws and theoretical entities that cannot be seen or handled. In fact much of science learning is concerned with understanding largely invisible processes that cannot be easily observed as they may be too small, too slow or on too large a scale [4]. Take, for example, an equation for a chemical reaction such as $2H_2+O_2 \rightarrow 2H_2O$, Krajcik [5] points out that students often fail to understand that this represents unseen processes such as atom rearrangement with bonds breaking then forming. In creating a stop-motion animation by using Plasticine to model the atoms in the original and in the different molecules that result, these changes are captured on camera and in creating an organised sequence to play back to others the previously unseen processes are emphasised. The multiple, linked representations of the process being animated combine to enhance understanding in the way suggested by Kozma [6] in his recommendations for the design of technological tools to support students' understanding in science. Kress et al. [7] have also pointed out the importance of using multiple modes of communication (voice, gesture, diagrams, text, photographs, video etc.) in science teaching as each has different potential to support teaching and learning. Indeed Hoban and Nielsen [8] show that all the different stages student teachers followed in creating an animation: researching the topic, storyboarding, creating models, taking photos and narrating the resulting video, were important to their learning the underpinning science. They concluded that each of these representations enables investigation of the same concept but in different ways creating a cumulative semiotic progression with meaning building from one representation to the next to promote learning.

However, it should be noted that earlier work has shown that animations used in teaching have not always been found to be effective in supporting learning. Ainsworth [9] notes that they can detract from, as well as, engender learning pointing out how translation between one representation and another can be variable thus reinforcing Sutherland et al.'s point [10] that the role played by the teacher when employing technology supported learning activities is critical. The importance of the teacher's role in producing animations is confirmed in a recent study [11] with 10th to 12th grade students, who found that not only does animation creation, if effectively scaffolded by the teacher, result in students gaining in conceptual understanding but also that students' creativity appeared to have been sparked by constructing the animations. Lastly, creating animations is certainly engaging, as has been seen with a range of age groups e.g. Hoban, Loughran and Neilsen [12] who note that both their graduate student teachers and the student teachers' primary school pupils found it to be an engaging and rewarding activity.

The research questions to be explored in this small scale study are therefore:

- Which activities during creating stop-motion animations in science lessons promote learning?
- Which activities during creating stop-motion animations in science lessons are most rewarding?
- How can learning activities involving stop-motion animations be effectively deployed in teaching science at different levels?

2 Method

2.1 Design

This research study, largely exploratory in nature, follows a mixed methods design [13]. It combines collection of quantitative data on student attitude to making animations and their perception of how the different activities supported their understanding of the science with more qualitative data sourced from teacher interview and non-participant observation during the science lessons themselves.

2.2 Participants

Participants were recruited from local teachers known to be interested in research opportunities. Four introduced animation creation as a means of teaching and learning, each to single class chosen at opportunity. These opportunities included the set topic presenting itself in the teachers' view as relevant for animation and lesson time being available. Therefore the participants comprised students from four classes (grade 4, grade 8, grade 11 and grade 12) from different schools as shown in Table I. All schools were sited in populous, urban locations and all classes were mixed gender. The teachers were all experienced with more than three years of teaching however, only the Grade 12 teacher had used animation in teaching science previously.

Table I. The different classes

Type of school	*Class*	*Lesson*	*N*
Local government maintained, primary	Grade 4 (age 8-9)	All morning excluding breaks	25
Central government maintained, secondary	Grade 8 (age 12-13)	A 60 minute lesson	26
Independent, secondary	Grade 11 (age 15-16)	Six 100 min double lessons over 6 weeks	25
As above	Grade 12 (age 16-17)	A 100 minute double lesson	9

2.3 Procedure

Each teacher chose to manage the lesson or sequence of lessons on animation slightly differently however, in every case it was presented to the pupils as a way of consolidating their learning on the current science topics. In three cases a single class period was set aside however there was much more time available to the Grade 11 teacher who had unexpectedly completed the Physics GCSE syllabus early. Models made by this class were much more detailed and several incorporated human characters such as 'Big Head Ned' who had issues with stability.

Table II. The different software tools used

Class	*Topic taught*	*Tools used*
Grade 4	Filtering and sieving	Powerpoint with one image per slide and digital cameras
Grade 8	Circulatory and respiratory systems	Choice of drawing (Serif Draw Plus or Pivot) or Powerpoint using own web cam or web based images
Grade 11	Physics revision	Windows Moviemaker and digital cameras
Grade 12	Transport across cell membranes	Flip video cameras

Following the lesson(s) described above, the researcher invited the pupils to complete the survey and the teachers were interviewed.

2.4 Data Collection and Analysis

Instruments included a questionnaire survey and a semi-structured teacher interview schedule. The survey asked students to rate the different experiences during creating animations on a seven point numeric rating scale (from 1 to 7) once for enjoyment and once for their support with understanding the science. This list of experiences comprised: researching the topic, storyboarding, making (modelling or drawing), taking photos or finding images, putting pictures/slides in order, adding titles, adding a commentary, adding sound effects or music, talking during the task, seeing the finished animation, seeing others' animations and discussing others' animations. The interview questions were more open, addressing the teachers' perceptions of the entire process and any concerns they had about teaching in this way. The quantitative data on students' attitudes and perceptions of learning were analysed using the mean as a measure of central tendency to show how highly the different learning activities were rated. The qualitative data from interviews were analyed thematically [14] whereby the teachers' comments were coded into different themes according to their content and salient and recurring themes were identified.

3 Results

Surveys were completed by all 26 Grade 4 students, 21 of 26 Grade 8 students, 12 of 22 Grade 11 students and all 9 Grade 12 students. Overall this gives a response rate of 82%. Table III below gives the different learning activities carried out by the pupils together with their mean rating scores (on a scale where 1 is not at all and 7 is very, very much) for enjoyment of the activity and the number of participants reporting on that activity. The number of participants varies as not all teachers enabled all aspects of making animations and not all students answered all questions.

Table III. Students' ratings showing the most popular learning activities

Learning activity	*Enjoyment Score (max 7)*	*N*
Seeing other's animations	6.04	59
Making, modelling and/or drawing	5.98	56
Seeing the finished animation	5.61	59
Adding sound fx or music	5.61	18
Talking during the task	5.46	52

Nearly all students were very positive about how much they enjoyed making animations as a teaching and learning method. Seeing the rest of the classes' animations was enjoyed the most receiving on average the highest possible rating, even more so than seeing your own. Other aspects that were much enjoyed were making, modelling and/or drawing, talking during the task, seeing the finished animation and adding sound effects or music.

Table IV below gives the different learning activities with their mean rating scores for how much the activity helped with understanding the science topic and the number of participants responding which varies for the same reasons as given for Table III.

Table IV. Students' ratings showing the most effective learning activities

Learning activity	*Helps Understanding Score (max 7)*	*N*
Discussing other's animations	5.54	26
Talking during task	5.44	50
Seeing other's animations	5.28	54
Making, modelling and/or drawing	5.09	54
Seeing the finished animation	5.07	55

Opportunities for discussing the underpinning science processes triggered by the need to make representations of them shown in the table above as 'talking during task' and 'discussing other groups' animations' were both reported to be very helpful to understanding. Opportunities for discussing others' work were both teacher led when the class animations were displayed at the end of the teaching sequence and student led as there was interest shown throughout in how classmates were getting on. These were closely followed by 'making, modelling and/or drawing' and seeing the final animations with 'seeing others' animations' being rated as slightly more helpful to understanding the science process involved.

It is noticeable that seeing the others' finished animations was also enjoyed even more than seeing your own group's. The activity that stands out as being scored very highly for both enjoyment and helping understanding was talking during the task, whilst making, modelling and/or drawing, though enjoyed just as much, was rated slightly less highly for supporting understanding than discussing the models during their creation.

Teachers too were largely positive about the experience though realistic about possible resource issues. The results of the teacher post-lesson interviews could be grouped into three thematic areas: the teachers' concerns, the teaching strategies they used and their recommendations for other teachers. Their concerns focused on the students' capability to use the animation tools: cameras, laptops and software and the amount of necessary preparation. To effectively deploy learning activities involving stop-motion animations in teaching science required planning the teaching unit well to ensure both sufficient time was available (for initial content delivery, for making and showing animations) and for preparation (checking the students had relevant skills, booking the hardware and checking the software was in place). As for teaching strategies, all four teachers noted how making animations led to opportunities for individual questioning, whether for assessing students' science knowledge and understanding or for evaluating and supporting, if necessary, their progress in creating the animation. This led to further reflections from three of the four teachers on making animations as a teaching strategy that highlights assessment for learning opportunities:

"You can do exercise like this to make them think about the shape, to help them understand the shape of the proteins, think about what they actually look like in 3D and actually tie structures to the functions more successfully."

"they were talking about red blood cells coming down the capillaries and picking up oxygen so they were putting the science together"

Other teaching strategies noted by the teachers included consolidation through multiple opportunities for learning.

4 Discussion and Conclusions

It was impressive that all students in all four lessons observed were successful in that all groups produced an animation in the time made available. The activity was also clearly enjoyed by teachers and nearly all students with no reported difficulties. In both cases where a student did not report enjoying the task the teacher reported there had been initial negativity about the constitution of their group.

Discussion during planning the animation, model creating, filming and playback (in the latter it was more likely to be teacher led) was reported in all cases to be a clear benefit to learning linked to the necessary focus on key science terms being used correctly. Creating the different representations engaged the vast majority of group members of all ages in this discussion as did the different learning opportunities of making, modelling and/or drawing, taking photos, ordering images, viewing one's own and the classes' finished animations. Like Hoban and Nielsen [8] most of the teachers viewed all stages as important to learning though, in this study, only some of the students really engaged with storyboarding which had been reported [8] as a key stage in the semiotic progression linked to learning through making animations.

A second clear benefit also reported by all four teachers was the way the task exposed students' understanding giving teachers the opportunity to see and promptly address any misconceptions. The models and/or images acted as a vehicle for discussion and teachers reported how having the different representations supported both their questioning to evaluate learning and students in showing their understanding of a science process.

The main issue that impacts on effective deployment of animation creation in teaching science was found to be the amount of necessary preparation that includes planning for both resource provision and ensuring students had appropriate skills and are grouped appropriately.

In summary it was found that making animations, which can now be done within an hour in a classroom equipped with digital cameras and laptops or iPads, enables learning opportunities that centre on social interactions between students and their teacher and between students themselves during the creation and evaluation of multiple representations of a science process.

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