IAA-PDC-23-0X-XX
USING KILLER ASTEROIDS TO ENGAGE CHILDREN IN ASTRONOMY AND SCIENCE

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Keywords: *Education, Outreach*

Extended Abstract

Astronomy and space are accepted as very effective points of engagement for students of all ages, inspiring curiosity and providing a stimulus to learn [1], and providing exciting context for developing skills.

Comet Chasers is a UK-based education and outreach project using the 'Wow' factor of space (and comets in particular) to engage children in activities related to STEM and the development of wider curriculum-related skills. In the last year the project has, with the aid of a Royal Astronomical Society grant, and other funding, used the excitement of the DART Mission to engage schools and the wider community. With the strapline of 'Help NASA save the planet from asteroid strikes' we have successfully reached new schools and audiences. We have worked with over 250 students from 50 different schools. Some of the engagement was intensive, working with them in class or online, delivering curriculum-related activities as well as setting up observations. For others it was more specifically related to learning about the DART Mission and setting up observations. We have also attended events and engaged the wider public (over 750 people) and the Welsh media, raising awareness of the Mission and its objectives.

The key element of the project has been the link with the LCOGT scientists working as part of the DART Mission, and other DART Mission scientists through the LOOK Project [2]. Through the Faulkes Telescope Project (FT) we have access to the same 1m LCOGT telescopes that were used to gather data for the Mission, and additionally the project has access to LCOGT's two 2m telescopes (in Hawaii and Australia) [3]. Under the guidance of those scientists, we have enabled schools and individuals at events to schedule over 920 scientifically-useful observations of the Didymos/Dimorphos system,

Activities
The school activities have included:

- learning about the issue – what are asteroids and comets? Including why we need to study and monitor them as they can be killers if they impact Earth (with the obligatory reference to dinosaurs and mass extinctions); learning about and handling meteorites and fossils; exploring impact craters through demonstrations and the Down2Earth interactive simulator;

- exploring how we make observations of asteroids and comets – learning about reflected light; how reflection changes with physical properties; what are light curves

and what can we learn from them; using hands-on demonstrations using 'The Rotato' (a simulator comprising a small rotating turntable, a torch, webcam and simple recording and plotting program) for generating real-time light curves of various objects (so called as it started with **rot**ating a pot**ato** as an asteroid analogue);

- learning about the DART Mission - the planetary defence aims and objectives, methodologies, spacecraft, organisations involved, metrics for success, and how these will be measured;

- simulating the orbital mechanics of the binary asteroid - using the 'Rotato' with models of Didymos and Dimorphos; and measuring the resultant dips in the light curve to calculate orbital times;

- making over 920 real science observations - using the research-grade telescopes from the Las Cumbres Observatory (LCO) Global Telescope (LCOGT) Network through the Faulkes Telescope Project. These observations are now part of the LCOGT data set and have been including in the analysis of ejecta (see Lister et al. at this meeting);

- analysing images – making animations of the asteroid's movement, comparing their own 'before' and 'after' images and seeing and measuring the new tail. (This generated a lot of excitement!);

- showing that even young children in small schools in rural or deprived areas can play a part in large important missions, helping to raise educational and career aspirations.

Additionally, we have engaged with a wider, more general audience, at various events, including the National Eisteddfod of Wales. The project has featured in a number of Welsh television programmes and in various articles.

Observations

Over 920 observations were made in the period between 2022-07-05 and 2023-03-05. Some observations were primarily for photometry, with shorter exposures and a fractional (0.5) ephemeris tracking rate. Others were to allow the debris tails to be monitored, with longer exposures tracked at the rate of the asteroid. The extra light gathering capability of the 2m telescopes was used to good effect for tail measurements, although the smaller field of view (9.1' x 9.1' for the 2m telescopes compared with 26' x 26' for the 1m telescopes) meant that the end of the tail may have extended beyond frame.

In all cases those who had scheduled the observations were very excited to see the results (particularly when these were made into animations).

Some examples of the observations are shown in Figures 1- 6.

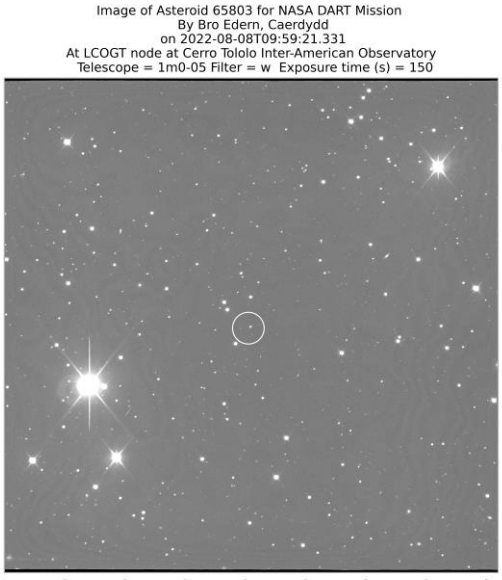

Figure 1 Observation of the Didymos system pre-impact. Image credit: Ysgol Gyfun Gymraeg Bro Edern, Caerdydd

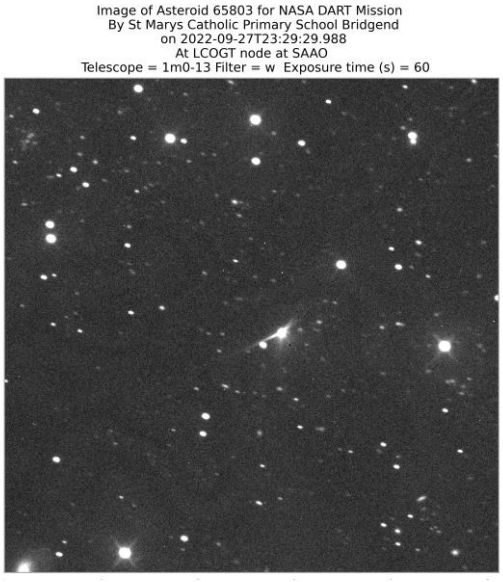

Figure 2 Observation of the Didymos system post-impact showing multiple ejecta tails. Image credit: St Mary's Catholic Primary School, Bridgend.

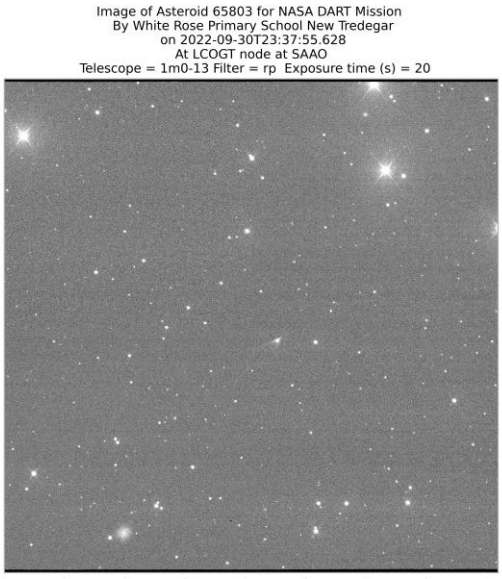

Figure 3 Observation of the Didymos system post-impact showing multiple ejecta tails, and the primary tail growing longer.
Image credit: White Rose Primary School, New Tredegar.

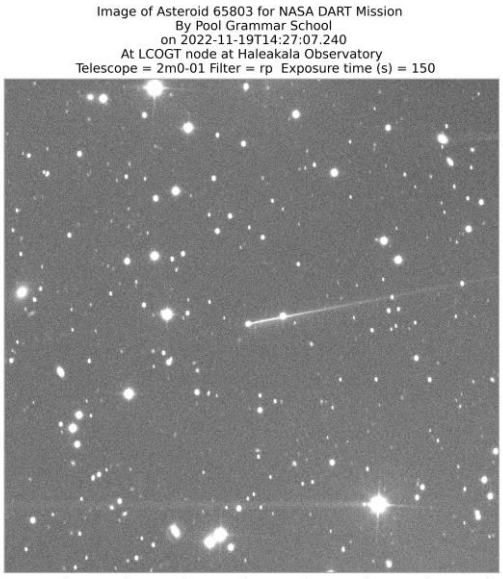

Figure 5 Observation of the Didymos system post-impact with the 2m Faulkes North telescope, showing the well developed single tail extending to at least the edge of the field of view. Image credit: Poole Grammar School (AK)

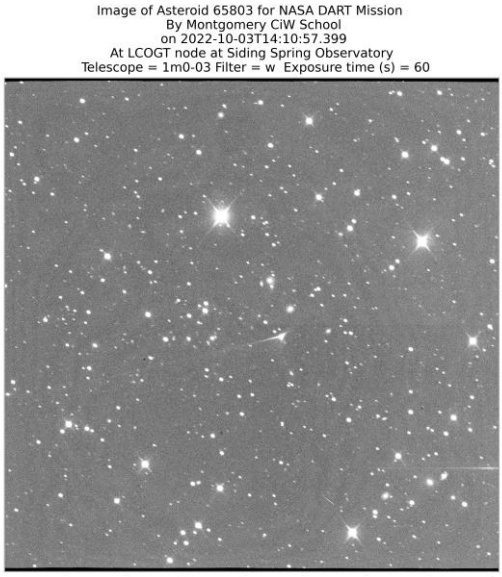

Figure 4 Observation of the Didymos system post-impact showing further tail development.
Image credit: Montgomery CiW School

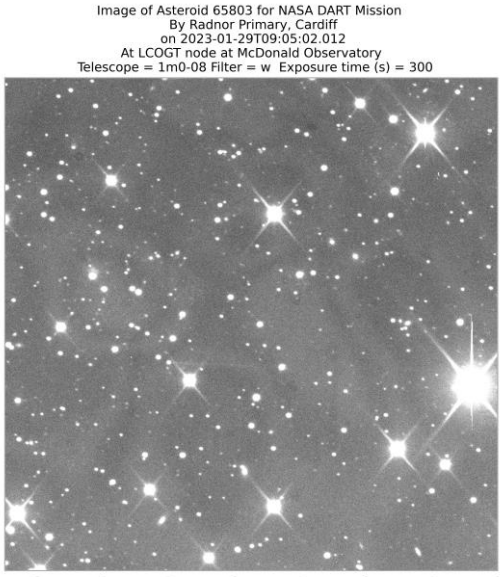

Figure 6 Observation of the Didymos system 4 months post-impact. With a long exposure of 300s and a wide bandwidth PanSTARRS w filter the tail is still visible.
Image credit: Radnor Primary, Cardiff

Curriculum-related learning and skills

The new Curriculum for Wales [4] was introduced in September 2021. It shifts the educational focus from content-based learning to skills-based learning. This gives teachers much greater freedom in their teaching but brings its own challenges with preparing new stimulating lessons. To assist with this we continue to develop resources for teachers, in consultation with

teachers, which use astronomy as the context for a series of enquiry-based learning and core skills development lessons. The DART Mission activities are an example of this. While the observations are important, the early engagement develops children's understanding of why we make observations, how, and what the data can tell us They develop skills such as scientific method, analysis, research, teamwork, and presentation.

Interaction with the DART Mission Scientists

Some of the school observations have been shared directly with the DART Mission Team through the official Slack channel. The schools have been thrilled to know that their observations are both welcomed and useful. The direct engagement with Mission scientists on Twitter has also been appreciated.

Children have submitted questions for the DART Mission team, which will hopefully be answered at this conference.

Final stages of the project

The observing phase of the project is now complete, as the asteroid system is too far away and too faint for the LCOGT telescopes. So far we have had children estimating the length of the tail. We are now collating and sifting the full data set and are developing resources to allow children to do simple astrometry and photometry.

The Mission results presented at the conference will also be distilled and reported back to schools.

We hope schools will then 'write up' their work in the form of a cometchasers.org webpage poster.

We will provide certificates for the children and their schools at the end of the year.

Feedback so far

We will undertake an evaluation when the project is completed. But we have already gathered some feedback from children, their teachers and Mission scientists. Some examples are:

Teachers:

- The class were delighted and it's nice to see children excited by things like real meteors that can be handled and for them all to see the images they have taken being used.
- This is raising the aspirations of our children – they see they can be part of something big and important.
- We've been impressed with the quality of the resources and the impact on our children.
- The children are loving it – they are so engaged.

Children:

- It has been so exciting being part of the Comet Chasers Project. We made observations from our classroom of an asteroid before it was hit by a spacecraft! (audio here)
- I love astronomy, its amazing! It's so cool setting up the telescopes.
- I don't believe we are doing this for DART.
- Woohoo look at that tail!
- When I saw the DART Mission on the news I told my family I was part of it!
- The pressure is on… this observation is for NASA!
- I want to learn more!!

DART researchers

- The data from schools is useful for studying the results of the spacecraft's impact, and particularly how the tail changed and evolved over time. This will help us understand the properties of the ejecta material.
- The addition of the observations from the 2m Faulkes North Telescope MuSCAT3 4 channel imager to the combined LCO dataset will allow further colour analysis to be undertaken.

Conclusion and further work

The project has demonstrated that offering schools, and others, the opportunity to learn about and contribute to a Space Mission generates excitement and engagement.

The links with researchers worldwide have made schools feel part of something big and important, and with their observations they see they can contribute.

For the DART Mission it has raised wider awareness of what the Mission's aims and objectives were, it's importance, what the Mission achieved, and how this helps provide information for future planning.

The resources developed, the in-class delivery of activities and ongoing support have all been well received. Excellent relationships have been established with schools, and collaboration will be ongoing.

The team is now working on more resources, looking to expand the age range covered and also develop more resources in Welsh.

Acknowledgements: Observations have been made by: St Mary's Catholic Primary Bridgend, White Rose Primary New Tredegar, Radnor Primary Cardiff, Montgomery Church in |Wales Primary, Ysgol Gyfun Gymraeg Bro Edern, Caerdydd, Rhiwbina Primary

Cardiff, Poole Grammar School, Abbey Grange Academy Leeds. Helen Usher, Cai Stoddard-Jones, Sion Emlyn, Sarah Roberts, Richard Morgan, Arushi Nath, Rytis Babianskas, and National Eisteddfod attendees.

Funding for the project has been provided by the Royal Astronomical Society, The Open University, Cardiff University, and the Faulkes Telescope Project (which is partly funded by the Dill Faulkes Educational Trust). We are grateful for the help and encouragement of members of the DART Mission Team.

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