How did that happen? Mixed-method Evaluation of Astronomy Resources

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Astronomy is a well-known effective point of engagement, sparking students' curiosity and desire to learn. However, astronomy has a lot to offer; pretty pictures, a mind-blowing vastness, big telescopes, and application of much of the more mundane classroom science. As a result, it can be difficult to disentangle what specifically causes students' engagement. That is, what does an astronomy resource need in order to be effective and what other components are surplus to requirement? This presentation focuses on a PhD study involving 226 secondary school students that set out to answer this question. Focusing on both methodology and results, this presentation will explore how mixed-method evaluation can offer valuable information for developing and delivering effective astronomy resources. By using quantitative methods to identify what happens, and qualitative methods to identify why this happens and under what circumstances. Although mixed methods evaluation demands greater time and manpower, it can provide hugely valuable results that are not exclusive to a single resource, but that provide transferable findings that can be of use to future development and wider educationalists.

Talk link: https://youtu.be/VK_XnMB6wec

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Astronomy is a well-known effective point of engagement, sparking students' curiosity and desire to learn (Salimpour et al., 2021; Osborne and Collins, 2001). However, astronomy has a lot to offer; pretty pictures, a mind-blowing vastness, big telescopes, and application of much of the more mundane classroom science. As a result, it can be difficult to disentangle what specifically causes students' engagement and positive learning experience when engaging with such materials. That is, what does an astronomy resource need in order to be effective and what other components are surplus to requirement?

A mixed method approach to evaluating such resources offers a valuable opportunity to capture this information. Its opportunities and strengths are argued here in the context of a PhD study involving ten case studies of secondary school classrooms that set out to identify how teacher-implemented astronomy resources can promote student learning experiences.

In a broad sense, evaluation is typically quantitative or qualitative. Quantitative approaches are used to explain a particular phenomenon through numerical data collection. They are deductive, objective and outcome-oriented. Qualitative approaches are inductive, subjective and process-oriented (Streefkerk, 2021). Each approach has its own advantages and disadvantages (see Streefkerk, 2021 for further detail). However, by combining the two methods we are able to surmount many of the individual limitations and utilise the individual advantages. As a result,

the evaluator can gain a more holistic understanding of the phenomena at study. Where the quantitative data can provide an understanding of *what* happened, the qualitative data can give a more comprehensive understanding of *why* it happened (Johnson and Onwuegbuzie, 2004; Ivankova et al., 2006; Denscombe, 2008; Greene, 2008). This is particularly useful in formative evaluation, where you are looking to develop or improve resources or where you yielded negative responses. Evidence of poor or even negative impact in quantitative data is disheartening, but not understanding why such a result was yielded due to a methodological limitation can also leave you with little understanding of what caused such a result and what steps can be taken to improve results in the future. Although mixed methods evaluation demands greater time and manpower, it can provide hugely valuable results that are not exclusive to a single resource, but that provide transferable findings that can be of use to future development and wider educationalists.

Creswell and Plano-Clark (2011) also discuss the sequencing of mixed methods. They explain that depending on what method you implement first, your evaluation can be either explanatory or exploratory. Exploratory methods begin with qualitative methods and then generalisations are sought through a follow-up quantitative method. This is helpful if you are looking to make generalisations, perhaps if your resource was effective among a small student cohort, you would want to identify if it is effective among larger or additional cohorts.

Alternatively, explanatory methods first apply a quantitative phase in order to understand the general picture, and is followed by a qualitative phase in order to explore the patterns from the quantitative data and why such findings were yielded. An explanatory approach is helpful when you want to understand the processes and mechanisms behind the quantitative results, perhaps to inform future astronomy resource development.

In the case of this PhD study, a sequential explanatory design was followed as the researcher wanted to understand specifically what happened but also what processes and experiences led to those outcomes so that findings could be transferred to future and wider educational resource development. The quantitative method involved a closed-questionnaire consisting of Likert-scale items. The questionnaire was implemented on two occasions: before students had engaged with the astronomy resources, to reflect on these five areas in relation to their day-to-day science lessons, and after students had engaged with the resources, to reflect on their experiences when using the astronomy resources. The use of a parallel questionnaire pre- and post-engagement meant that direct comparisons could be drawn and also offered a tool that could be used with future resources.

For the qualitative arm, classroom observations, student focus groups and teacher interviews were implemented with a smaller subset of the audience. Classroom observations were carried out before astronomy resource implementation (during a 'normal' science lesson) and while students were using the astronomy resources. Focus groups and interviews were implemented after implementation of the activities. In line with the sequential explanatory design, the focus group and interview question schedules were informed and guided by preliminary results from the questionnaires and observations. This allowed the researcher to explore why such events took place and why students were or were not engaged.

This process of mixed method evaluation revealed five key elements that promoted positive learning experiences among students. Although these were identified in the context of particular

astronomy resources, these elements are considered applicable to any activity or resource. Each of the five elements is now described, with accompanying relevant quote excerpts from students. 1. Processes of **investigation and exploration** that encourage students to follow the scientific process of gaining new knowledge: *"It was interactive, using real data. This makes it feel more relevant"*. 2. **Experiences of autonomy** gives students a sense of ownership over their learning: *"I liked the freedom of finding things out on our own"*. 3. **Novel, unexpected experiences** offer a 'wow' factor and provide an element of surprise: *"What? So that is the age of the Universe? I feel like Einstein!"*. 4. Providing students with opportunities to **cooperate and collaborate** with their peers helps provide a sense of relatedness (Gagne and Deci, 2005) *"It is easier to work off each other, like some people might have stronger points in that subject so they can teach other people stuff"*. 5. Embedding **effective differentiation** into resources to foster students' confidence and provide them with a challenging but achievable task: *"So I can do science"*.

However, despite the opportunities for autonomy and a student-centred classroom, the role of the teacher was still crucial in influencing students' experiences. Observations of each classroom revealed that despite using the same resource, implementation differed in each setting. Where teachers had a great awareness of individual learning needs among students, they were able to adapt the resources and embed appropriate differentiation. Additionally, great preparation from the teacher and familiarity with the resource led to more positive learning experiences among the students.

The results of this study provided valuable insight for educators and resource developers. The five key elements that were seen to promote positive learning experiences can stand as a foundation when developing a resource. Resource developers should recognise that resources will be implemented slightly differently in every classroom and thus should consider the teacher's role and their support needs. Resources should be adaptable and apply various scaffolds that can be added or removed in order to differentiate appropriately.

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