A review of astronomy in the school curriculum of OECD Countries

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Acknowledgements

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Thanks to the Collaboration!

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Goals & Motivation

• A rich picture of the current state of affairs of science education with emphasis on astronomy.

• Knowing what is happening currently across the world, will allow researchers engaged in policy and practice and politicians to plan for and implement future directions in astronomy education with informed knowledge.
China and South Africa
Curricula Studied

- A total of 53 national curricula from 37 countries were reviewed.
- **UK** is different for England, Wales, Northern Ireland and Scotland.
- Whilst for the case of the **USA**, we focused on the states of Texas, Kansas and California.
- In addition, **Canada** has different curricula for each of its provinces.
- Although, **Germany** and **Switzerland** too had different curricula for each province/canton, our analysis did not focus on each individual province/canton.
Curriculum, Pedagogy and Evaluation

- Bernstein (1975), claims that all schools around the world share three message systems: curriculum, pedagogy and assessment. "Formal education knowledge can be considered to be realized through three message systems: curriculum, pedagogy, and evaluation. Curriculum defines what counts as a valid knowledge, pedagogy defines what counts as a valid transmission of knowledge, and evaluation defines what counts as a valid realization of this knowledge..."
Curriculum, Objectives and Slavery.

- Bobbit’s explanation was that curriculum provides educators with a set of procedures/experiences enabling students to attain certain objectives, this notion has in ways been the foundation of curricula across countries.

- Curriculum has become innately fused into education systems, and teachers at times have become “slaves” to the curriculum.
Frequency of Astronomy

• Astronomy as an elective was quite rare with only, 9 out of the 53 curricula (17%), offering it as a subject within the general curriculum. Predictably, these electives provided in-depth and explicit guidance within the curriculum documents.

• Our analysis showed that 44 out of the 53 curricula (83%), included astronomy-related topics in grade 6, while 40 included astronomy in grade 1. In grades 2 and 7, this number drops to 28 out of 53 (52.8%).
Frequency of Astronomy

• Out of the 53 curricula, 14 of them (26.4%), had astronomy-related topics explicitly mentioned in all grades from 1 to 12.

• The least occurrence was having astronomy-related topics in only two grades, this made up 3.8% of the total curriculla.
• Visualisation of all 368 words, size of bubbles represent the number of occurrences of each word across the 53 curricula.
• Visualisation of all 368 words within each of the 16 categories. Size of bubbles represent the number of occurrences of each word across the 53 curricula.
• Primary School
• Middle School
• High School
Indigenous astronomy

- Indigenous astronomy although not prevalent across curricula has occurrences in 3 out of the 37 countries – Canada, New Zealand, and Norway. However, the Australian Curriculum has stated three cross-curriculum priorities have to be addressed by schools in their curriculum:
  - Aboriginal and Torres Strait Islander histories and cultures
  - Asia and Australia’s engagement with Asia
  - Sustainability

- Whilst the above three do not explicitly fall under astronomy, they do provide teachers with the opportunity to incorporate Cultural Astronomy into various subject areas, not limited to science.
The IB Diploma Program (DP) Physics course (International Baccalaureate Organization IBO, 2017) is a general syllabus aimed at University admission.

Astronomy concepts are covered to varying degrees throughout the compulsory IB core components shows a general overview of the components, both Standard and Higher Level, where astronomy is integral to the information being delivered in the unit.

Astronomical concepts are spread over the entire course, and in many instances, garner improved student interest and interaction. In addition, the IB Physics course also offers Astrophysics as an option for the two year course. The option covers stellar quantities, stellar characteristics, stellar evolution and cosmology.

Extended Essays
An example of hitting the curricula
History

• Our Solar Siblings began officially, after ethics approval, in October 2014. [www.oursolarsiblings.com](http://www.oursolarsiblings.com) based on work started in 2010.

• Primary focus is on being a curriculum and support resource for in-service teachers to teach astronomy at Years 9/10. Although it also has been significantly elsewhere.
Las Cumbres Observatory

- Main Partner. A growing network of over 20 large research telescopes in 8 locations around the world accessible remotely.

- Official Education Partner since 2014

- They concentrate on provision of telescope time and a quality user interface.

- We facilitate the plausible active connection of this resource for education use.
Goals

• Increase students’ understanding and appreciation for the Universe around them, what it looks like, what its history is and where they are in it as far as we can currently ascertain;

• Increase students’ appreciation for the true methodology and approach of science in contrast to the general, currently poor, students’ perceptions of school science.

• Increase the probability of students choosing science other than as a potential personal interest, as a topic for higher level study or as a potential future career path or, at the very least, help them discover that they may be interested in science;

• Involve the nontrivial use of real astronomical data from a real research grade telescope;

• Enable students, or a smaller subset that so desire, to take their research to a natural scientific conclusion in the form of a scientific publication.
Approaches

• Facilitate and develop everyday in-class teachers to use robotic telescopes to teach astronomy towards the end of compulsory science schooling. (Year 10 in Australia)

• Direct mentoring of high school students undertaking independent research projects within a variety of contexts, both inside and outside the formal school curriculum.

• Active and open development of scaffolds, mentoring and support for other projects using robotic telescopes in the classroom all around the world.
Year 10 Australian Curriculum

• The universe contains features including galaxies, stars and solar systems, and the Big Bang theory can be used to explain the origin of the universe (ACSSU188)

• Three weeks.
Science as a human endeavour

• Scientific understanding, including models and theories, is contestable and is refined over time through a process of review by the scientific community (ACSH191)

• Advances in scientific understanding often rely on technological advances and are often linked to scientific discoveries (ACSH192)
Science as a human endeavour

• People use scientific knowledge to evaluate whether they accept claims, explanations or predictions, and advances in science can affect people’s lives, including generating new career opportunities (ACSHE194)

• Values and needs of contemporary society can influence the focus of scientific research (ACSHE230)
Science Inquiry Skills

• Formulate questions or hypotheses that can be investigated scientifically (ACSIS198)
• Plan, select and use appropriate investigation types, including field work and laboratory experimentation, to collect reliable data; assess risk and address ethical issues associated with these methods (ACSIS199)
• Select and use appropriate equipment, including digital technologies, to collect and record data systematically and accurately (ACSIS200)
• Analyse patterns and trends in data, including describing relationships between variables and identifying inconsistencies (ACSIS203)
• Use knowledge of scientific concepts to draw conclusions that are consistent with evidence (ACSIS204)
• Evaluate conclusions, including identifying sources of uncertainty and possible alternative explanations, and describe specific ways to improve the quality of the data (ACSIS205)
• Critically analyse the validity of information in primary and secondary sources, and evaluate the approaches used to solve problems (ACSIS206)
• Communicate scientific ideas and information for a particular purpose, including constructing evidence-based arguments and using appropriate scientific language, conventions and representations (ACSIS208)
Most students will go through planning on observation sessions, familiarisation with objects in the sky and their properties, make colour images from original fits images and simple supernovae LC photometry to get $H_0$. (90% : Yr 9-10)
• Some will go deeper in class into star cluster photometry and stellar evolution. (10%: Extended 9/10, 11/12, IB, IRP)
• (≈0%: Some individuals or groups will want to do their own original research.)
The Standard Model.

• Allocate teams or individuals to work on a longer “Science as a Human Endeavour” presentation to research an allocated person/group and event in science history for sociocultural context as well as how science works.
• What are telescopes? Why does their size matter? Why are some images from telescopes blurry and others not?
• What are some of the major “pretty” objects out there in the universe?
• Where are these “pretty” objects in the night sky and why?
• Using images collected from LCO, how do we construct a colour image? What is an image, how is it constructed and what is ‘colour’?
• How do the size, shape and colour of galaxies differ?
• How do we measure the distance to a galaxy? Measuring the distance to M101 using simple photometry of a single supernova (sn2011fe).
• How do we measure the expansion of the universe? Measuring the distance to multiple galaxies using supernovae to create a Hubble Plot and estimate the age of the universe.
• Hold the presentation class about the various people/groups and major events followed by a reflection on science as a human endeavour.
Goals

• Increase students’ understanding and appreciation for the Universe around them, what it looks like, what its history is and where they are in it as far as we can currently ascertain;

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<thead>
<tr>
<th></th>
<th>Mean</th>
<th>St Deviation</th>
<th>N</th>
<th>Percentage Gain</th>
<th>Effect Size (Cohen’s D)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Equivalent Pre</td>
<td>45%</td>
<td>17%</td>
<td>31</td>
<td>31%</td>
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<tr>
<td>Equivalent Post</td>
<td>62%</td>
<td>17%</td>
<td>31</td>
<td>1.01</td>
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<tr>
<td>Non-Equivalent Pre</td>
<td>35%</td>
<td>16%</td>
<td>31</td>
<td>9%</td>
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</tr>
<tr>
<td>Non-Equivalent Post</td>
<td>41%</td>
<td>12%</td>
<td>31</td>
<td>0.44</td>
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The **Percentage Gain** for each Pre/Post pair is the Actual Gain (Post-Pre) divided by the largest possible gain achievable (100%-Pre). A gain of 100% means that everybody in the class correctly answered all of the questions they got incorrect on the pre-test and got all of the pre-test questions correct again. This is obviously impossible! As this Gain is actually an internal property of the survey itself, we are still collecting information on typical values in different contexts so cannot provide a strong guidance as to what is a ‘good’ gain as is yet. However, in similarly constructed surveys, “Traditional” chalk’n’talk classrooms tend to achieve about a 10% gain whilst inquiry-based/flipped/etc. classrooms can range from 25% to 40% and beyond.

The **Effect Size (Cohen’s D)** is a more general estimate of how dramatic the change is. A broad introduction is available [here](http://rpsychologist.com/d3/cohend/). It compares the difference in the means from the pre to post to their standard deviations. Roughly speaking 0.2 is a small, 0.5 is a medium, 0.8 is a large and 1.3 is a huge effect size.
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<th>Pre-measure</th>
<th>Post-measure</th>
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<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>SD</td>
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<tr>
<td>Learning science in school</td>
<td>3.38 0.82</td>
<td></td>
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<tr>
<td>Self-concept in science</td>
<td>3.41 0.70</td>
<td></td>
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<tr>
<td>Practical work in science</td>
<td>4.05 0.64</td>
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<tr>
<td>Science outside of school</td>
<td>2.75 0.93</td>
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<tr>
<td>Future participation in science</td>
<td>2.57 0.85</td>
<td></td>
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<tr>
<td>Importance of science</td>
<td>3.58 0.67</td>
<td></td>
</tr>
<tr>
<td>General attitude towards school</td>
<td>3.40 0.76</td>
<td></td>
</tr>
<tr>
<td>Combined interest in science</td>
<td>2.92 0.76</td>
<td></td>
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Astronomy and Science Student Attitudes (ASSA): A short review and validation of a new instrument.

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Lena Danaia, Charles Sturt University, New South Wales, Australia
Jasmina Lazendic-Galloway, Monash University, Clayton, Australia

Contact info: Sophie Bartlett, sophie-bartlett@outlook.com
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ANECTOTAL EVIDENCE ISN'T VALID. YES IT IS! I ONCE USED AN ANECDOTE AS EVIDENCE, AND LATER IT TURNED OUT I WAS RIGHT!
### How desirable would each of the following careers be to you?

<table>
<thead>
<tr>
<th>Career</th>
<th>Very Undesirable</th>
<th>Undesirable</th>
<th>Neutral</th>
<th>Desirable</th>
<th>Very Desirable</th>
</tr>
</thead>
<tbody>
<tr>
<td>Medical professional (e.g. doctor, dentist, vet)</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Health professional (e.g. nursing, pharmacy)</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Biologist</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Earth/Environmental scientist</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
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<tr>
<td>Astronomer</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
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<tr>
<td>Chemist</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
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<tr>
<td>Physicist</td>
<td>1</td>
<td>2</td>
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<tr>
<td>Engineer</td>
<td>1</td>
<td>2</td>
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<tr>
<td>Computer Scientist</td>
<td>1</td>
<td>2</td>
<td>3</td>
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<tr>
<td>Other Scientist</td>
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<td>2</td>
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<tr>
<td>Mathematician</td>
<td>1</td>
<td>2</td>
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<tr>
<td>Science Teacher</td>
<td>1</td>
<td>2</td>
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PHOTOMETRIC AND PROPER MOTION STUDY OF NEGLECTED OPEN CLUSTER NGC 2215


The Astronomical Journal

ABSTRACT

Optical UBVRI photometric measurements using the Faulkes Telescope North were taken in early 2011 and combined with 2MASS JHK, and WISE infrared photometry as well as UCAC4 proper motion data in order to estimate the main parameters of the galactic open cluster NGC 2215 of which large uncertainty exists in the current literature. Fitting a King model we estimate a core radius of $1.12 \pm 0.02$ pc (0.24 $\pm 0.01$ pc) and a limiting radius of $4.4 \pm 0.7$ (0.94 $\pm 0.11$ pc) for the cluster. The results of isochrone fits indicates an age of $\log(t) = 8.85 \pm 0.10$ with a distance of $d = 790 \pm 90$ pc, a metallicity of \([Fe/H] = -0.40 \pm 0.10\) dex and a reddening of $E(B-V) = 0.20 \pm 0.04$. A proportion of the work in this study was undertaken by Australian and Canadian upper secondary school students involved in the Space to Grow astronomy education project, and is the first scientific publication to have utilized our star cluster photometry curriculum materials.

Subject headings: Methods: observational — open clusters and associations: general — open clusters and associations: individual (NGC 2215) — Techniques: photometric

RR Lyrae Stars in the Globular Cluster NGC 6101


Department of Physics & Astronomy, Macquarie University, NSW 2109, Australia

Macquarie University Research Centre in Astronomy, Astrophysics & Astrophotonics, Macquarie University, NSW 2109, Australia

Oakhill College, Castle Hill, NSW 2154, Australia

Departamento de Astronomía y Astrofísica, Pontificia Universidad Católica de Chile, Chile

Charles Sturt University, Bathurst, NSW 2795, Australia

Corresponding author. Email: mtfitz@mpc.edu.au

Abstract: $V$- and $I$-band observations were taken over 9 months to study the RR Lyrae population of NGC 6101. We identify one new variable, which is either a potential short period object or an eclipsing binary and recover all previously identified RR Lyrae. One new RR Lyrae is reclassified as an RRc type, while two period estimates have been significantly confirmed that NGC 6101 is Oosterhoff type II with a high ratio of $n(c)/(n(a+b+c)) = 0.833$ with a ver
• astroedu.iau.org

• Coherent set of activities
iSTAR International Studies of Astronomy Education Research Database

• istardb.org

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Fitzgerald, Michael T. and McKinnon, David H. and Danaia, Lena J. and Deehan, James (2016) A Large-Scale Inquiry-Based Astronomy Intervention Project: Impact on Students’ Content Knowledge Performance and Views of their High School Science Classroom. Research in Science Education, 45 (6). pp. 901-916. ISSN 1573-1898


Fletcher, Jack K. (1977) An Experimental Comparison Of The Effectiveness Of A Traditional Type Planetarium Program And A Participatory Type Planetarium Program. Doctoral thesis, University of Virginia.


Inquiry-Based Educational Design for Large-Scale High School Telescopes


Abstract

In this paper, we outline the theory behind the educational design used to implement a large-scale educational project. This design was created in response to the realization of ineffective educational models. The new design follows an iterative improvement model where the materials and general feedback received from students are used to improve the design. The improvement cycle concentrates on avoiding overly positive self-evaluations and community factors while focusing on implementing changes that clearly support and the potential for success in the classroom, and the possibilities of the project. The project is designed to be implemented using real telescopes and is aimed at high school students.
## Thanks to the Collaboration!

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