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The messier objects as a tool in teaching astronomy

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ABSTRACT

The French astronomer Charles Messier (1730-1817) compiled a catalogue [1] of astronomical objects which reached 109 in number after additions by later astronomers were added. The catalogue contains galaxies, emission nebulae, a supernova remnant, a double star, globular clusters, open clusters, an asterism, a star cloud, and planetary nebulae. While the objective of Messier in compiling the catalogue was to guide comet hunters not to be confused by his objects which he thought looked like comets [2], the Messier Catalogue as it later became known became a standard guide to astronomers for a study of the sky's "greatest hits" or the best samples of objects which can be observed and studied. This paper explores the value of the Messier Catalogue in the teaching of Astronomy and Earth Science. The range of objects is wide and contains some of the best examples of their type. The teaching method I propose is the actual observations of the objects through a telescope, with the corresponding explanation. Some principles which will be covered through this process are stellar evolution from the birth and death of stars, galaxy types, formation of galaxies, galactic interactions, life in the Universe, cosmology, and our place in the Universe.

Keywords: Astronomy; Earth Science Education; Astronomical Observing; Messier Objects

1. INTRODUCTION

Amateur astronomers who begin to advance in the art of astronomical observing always aim to complete their observations of the Messier Objects, all 109 of them. In March of every year, astronomy societies and groups conduct the Messier Marathon where participants attempt to observe all the Messier Objects in just one night. This is not an impossible feat, as the more advanced observers who know the night sky like the back of their hands, repeatedly observe all of them marathon after marathon, and some do not even use star maps in doing so. Completing the observation of the Messier Objects is the unwritten but accepted criterion towards being an intermediate observer, a notch above beginner status.

The Messier Objects are embodied in a list prepared by Charles Messier, a French comet hunter, in 1771. Soon, the list became popular to observers because it contains excellent objects for study, and represents many of the night sky's "greatest hits". The types of objects include a supernova remnant, planetary nebulae, star forming nebulae, open clusters, globular clusters, spiral galaxies, lenticular galaxies, elliptical galaxies, and irregular galaxies.

Each object has a story to tell, as each has been studied by astronomers for their characteristics and nature and for the secrets they keep. These are often revealed by advanced astronomers to beginners during observations.

The Rizal Technological University has for eight years been offering Astronomy as an Elective for Bachelor of Science in Education students, and as a major course in Bachelor of Science in Education BSE Physical Science. It is the only school in the Philippines offering formal programs in Astronomy. As one of the very few Filipinos who are members of the International Astronomical Union, and as member of astronomical societies, I had many opportunities in conducting field lectures to RTU students in Astronomy courses, and in assisting in the public outreach conducted by the societies, often involving teachers and students. After viewing the planets through a telescope, the attention of the participants are often guided by the astronomers to the most interesting objects visible in any given night, and these are often objects in the Messier list.

Looking at the objects through a telescope often means nothing to a casual or uninitiated observer. The objects often appear as faint haze or blob of light, and would generate no interest except if their characteristics are explained to the viewer. And then the object would seem to come alive, like a faint galaxy which harbors a super massive black hole at its core, or has undergone recent interactions with some galactic neighbors, or that it is even bigger than our Milky Way. A lot of things are learned when the astronomer explains.

We have learned a very vital rule in Astronomy, and

that is, knowledge comes through the telescope. The Messier Objects are some of the most viewed and studied objects in the night sky. I have learned through many years that these objects are great tools in teaching astronomy concepts to students and to the public as well.

2. RESEARCH OBJECTIVES

This research has the following objectives:

1) To find out the best methods in teaching astronomy through the Messier Objects.

2) To find out whether the Messier Objects are best taught at random or through a planned or pre-arranged order.

3) What telescopes and other devises should be used for instruction?

4) To find out the principles and concepts that could be best taught with each Messier Object.

5) To find out the best locations in conducting studies and observations of the Messier Objects.

3. RESEARCH PROBLEMS

1) What are the best methods of teaching Astronomy through the Messier Objects?

2) What are the best methods of teaching Astronomy through the Messier Objects?

3) In addition to telescopes, what other methods would be useful in better understanding the Messier Objects?

4) What the principles or concepts that are best taught with each Messier Object?

5) What are the best locations to conduct studies of the Messier Objects?

4. RESEARCH METHODS

When the RTU started offering courses in Astronomy whether as Elective or as major course in the formal programs, I was naturally one of the lecturers in some of these courses. Setting up telescopes, I often showed the students some of the interesting single and double stars. When discussions on the deep-sky objects such as galaxies, nebulae, open and globular clusters and planetary nebulae begin, I had to show examples of these objects, which turn out mostly to be Messier Objects. In years of observing, I have summarized the concepts and principles each Messier holds in a ready reference table. The table is updated from time to time.

A good 4-inch telescope of whatever type would be enough for the study of the Messier Objects if one is observing in a dark site. I have seen all of them with my 4.25-inch Astroscan in Puerto Galera, in the island of Mindoro in the Philippines and my audience was pretty much impressed with the brighter objects and could even see the fainter galaxies. However, the Astroscan has very limited use in an urban center, such as Mandaluyong City where the RTU Main Campus is located. Here, it would be best to use the biggest telescope one can get, such as the 12-inch Newtonian telescope of the RTU Department of Earth and Space Sciences. Telescopes with bigger apertures gather more light and can detect fainter objects better.

Books are useful in observing, but there are very limited books dedicated to the Messier Objects in our country. The only extensive work on the subject is by Torres in 4 volumes. It is useful, of course, but hard to read in the dark. The problem with observing is you would not be able to know which objects could be observed, except when the weather is at its finest, it is moonless, and you are observing in a really dark site. The emergence of electronic devices such as laptops, tablets, and notebooks enable the students to access information about an object easily. I ask those who have these tools to upload the basic information on the objects for use in the field. Most of these equipments have night modes.

In many years of observing, I learned that the best way of showing the objects to students is by random, or whichever appears during observing. However, there are times when the objective of the class is to study a particular type of object, such as globular clusters. I prepare a lecture on these objects before actual observing. This requires some strategy. Some of the best globular clusters in the Messier are in the region of Sagittarius, Scorpius, and Ophiuchus, three constellations that are best studied during early mornings in February, or in early evening of August to September, usually the rainiest months of the year. Most of the galaxies are in the region of Virgo, Canes Venatici, and Ursa Major. These are again best observed during early mornings in December to January.

Choosing the sites is not very easy, as I am limited by my job and residence to observe in the RTU campuses in Mandaluyong and Pasig, and in Taytay, Rizal. On almost all occasions when I have been invited to lecture in many places, I bring one or two of my telescopes. The Messier Objects are always superb in such places as Puerto Galera, Baguio City, Tanay in Rizal Province, Lemery in Batangas Province, Marinduque, and even in cities like Roxas, Bacolod and Davao. It is not advisable to observe in Boracay, as the place has lights all night. Even the main beach is light polluted.

5. OBSERVING SITES

I have categorized three possible sites for observing Messier Objects with students.

One is the campuses of the RTU. The Mandaluyong Campus is severely light polluted. Only the brightest Messier Objects are visible in this location. The other is the Pasig Campus which is becoming to be increasingly light polluted, though still not as much as the other campus.

Another site would be the suburban sites. I have conducted observations in the Assumption University's campus in Antipolo City where the Milky Way emerged clear and quite bright in early evening. Here the elusive M1, the Crab Nebula, and many of the galaxies in Virgo and Canes Venatici, needed no imagination to see. The Metropolitan Manila growth area is a vast city that extends to the provinces of Bulacan, Laguna, and Rizal, but a few kilometers' drive away from the city centers might give the observer surprisingly dark sites.

The dark site is perfect for observing the Messier Objects. In my experience, many of the faint galaxies which I could not detect with my 8-inch Schmidt-Cassegrain telescope could be detected with the very small Astroscan. The objects reveal details which the observer can study with delight, such as the strings of stars protruding out of many globular clusters, or hints of the spiral arms of galaxies, or concentric rings of planetary nebulae. With practice, even students will be able to see these features. I think the best place where the sky is darkest is where you cannot even see your eyes when extended. Many places in the Mindoro Island qualify in this criterion.

6. TELESCOPES AND OTHER EQUIPMENT

For this research, the following equipments have been used, without going into the technical details about them; an astronomer will sooner or later learn about those details. I will discuss here the value of the telescopes relative to the observation of the objects in this catalogue.

1) ***Celestron* 8*-inch Schmidt-Cassegrain telescope or C*-8.** This telescope has been my work horse since 1998. It is an f/10 instrument with a focal length of 2000 mm, but I attached a Meade focal reducer to it, effectively reducing the focal ratio to f/6.3, allowing lower magnifications and wider fields of view. It can be heavy for some people as the optical tube and the fork mount and base are about 25 pounds. I just place the telescope on top of the platform and operate it in altazimuth configuration. It originally came with a 9 × 50 straight-thru finderscope but I have upgraded to the 80-mm Lumicon straight-thru finderscope and the Stellarvue 50-mm right-angle correct image finderscope with replaceable eyepieces. I attached a Telrad finder to the telescope. The Telrad greatly facilitates locating the general position of objects, but in a light-polluted observing site the Telrad will not be enough, as the observer should find star patterns that will lead to the object being sought.

I find the C-8 to be an all-purpose telescope, and could be used to see all the Messier Objects.

2) ***Celestron* 4*-inch achromatic refractor or C*-102.** This telescope is an f/10 instrument with a focal length of 1000 mm on top of the AZ-3 altazimuth mount. I have upgraded the mount to the Sky-Watcher AZ-4 altazimuth mount which moves more smoothly on both axes but does not have slow motion controls.

The C-102 is best for single, double, and multiple for the crisp and sharp images of a long-focus refractor. It is also quite good for observing bigger open clusters and globular clusters. This telescope is acceptable for viewing the Messier Objects but may not be big enough for the fainter galaxies, except if observations are being done in a dark site.

3) ***Orion XT*-10 *Newtonian Reflector*.** My Orion XT-10 is an f/5 1255-mm focal length telescope mounted on a Dobsonian mount. It is equipped with an 8 × 50 finderscope which I supplemented by the Telrad finder. Because of the XT-10's superb light-gathering power, I find this instrument ideal for observing faint galaxies or those which have low surface brightness, and to detect dim planetary nebulae and faint open clusters and globular clusters and other deep-sky objects.

4) ***Astroscan*.** The Astroscan is a fine small telescope which can have totally unexpected performance under the skies. On one occasion, I cleanly saw Sirius-B the white dwarf companion of Sirius, at only 35×. With a primary mirror of 105 millimeters and a focal length of 445 millimeters the Astroscan is a widefield telescope that is very useful in viewing big open clusters such as the Pleiades and the Hyades, though I used it one time to observe numerous double stars in and around the head of Hydra.

5) ***Binoculars*.** Observing in a light polluted location almost always requires the services of a good pair of binoculars. My own workhorse is the Pentax PCF III 10 × 50. In searching for a relatively dim object which could not be seen by the naked eye, I pick up the Pentax first and scan the formation of stars which could lead me to my target. I then point the telescope to the probable location of the object using the Telrad. Then I recall the pattern of lead stars in the finderscope. The object, if it is bright enough, should now be in the center of the field of view of the low power eyepiece. Many of the Messier Objects can already be observed in binoculars, such as M31, M44, and M45.

7. INSTRUCTIONAL VALUE OF THE INDIVIDUAL MESSIER OBJECTS

Table 1 shows the groupings of the Messier Objects according to type and my own summary of the topics which may be discussed by the instructor upon showing the objects to their students through instruments or just through the naked eyes. These topics have been culled from many years of experience in showing these objects to the students and are most effective in bringing the

Table 1. Instructional values of messier objects.

Type	Messier Objects	Found Useful in Teaching the Following Concepts
Open Cluster,	M6 M7 M11 M16 M18 M21 M23 M25 M26 M29 M34 M35 M36 M37 M38 M39 M41 M44 M45 M46 M47 M48 M50 M52 M67 M93 M103	*Study of galactic center, young stellar populations. *Star-forming regions, young hot stars; Bok Globules, Protoplanetary disks, bright and dark nebulae.
Globular Cluster	M2 M3 M4 M5 M9 M10 M12 M13 M14 M15 M19 M22 M28 M30 M53 M54 M55 M56 M62 M68 M69 M70 M71 M72 M75 M79 M80 M92 M107	*Lives of stars, old stars, stellar distances, galaxy evolution, near globular cluster, Blue Stragglers, extrasolar planets.
Planetary Nebula	M27 M57 M76 M97	*Death of stars, white dwarfs, analogy to the Fate of the Sun.
Diffuse Nebula	M8 M17 M20 M42 M43 M78	Study of cloud of interstellar dust as active star-forming region, presence of hot young blue stars, illustrates presence of Herbig-Haro objects.
Spiral Galaxy	M31 M33 M51 M58 M61 M63 M64 M65 M66 M74 M77 M81 M83 M88 M90 M91 M94 M95 M96 M98 M99 M100 M101 M104 M106 M108 M109	*Study of spiral galaxies, effects of light pollution in seeing, black holes, star forming regions in galaxies. *Study of a non-barred Seyfert galaxy, has a high degree of central gas concentration, nucleus seems to be growing double, stars from in spiral arms.
Elliptical Galaxy	M32 M49 M59 M60 M87 M89 M105 M110	*Contains the most known globular clusters in galaxies, most luminous galaxy; strong source of X-rays, jet of material extending from a super massive black hole at the core.
Irregular Galaxy	M82	*Study of an irregular galaxy; a starburst galaxy called Seyferts, galaxy disruption caused by encounter with bigger neighbor, brightest infrared galaxy.
Lenticular (S0) Galaxy	M84 M85 M86 M102	*Study of a lenticular galaxy with some luminous sources. *A highly blue-shifted galaxy approaching the Solar System,; exhibits galactic tail due to high velocity.
Supernova Remnant	M1	*Death of stars, supernovae, contains a radio and optical pulsar, a rapidly-spinning neutron star at the center of the object.
System of 4 stars or Asterism	M73	*Study of patterns in the sky, usefulness of asterisms in the study of Astronomy, controversial whether stars are related or not.
Milky Way Patch	M24	*Study of galactic center, young stellar populations.
Binary Star	M40	*Study of double stars, stellar distances, types of double stars, stellar interactions.

understanding of Astronomy to them. The objects themselves as viewed through telescopes (except the biggest observatory telescopes in the world) would show not much detail. In fact, some students find it hard to see many of them as they are not seasoned visual observers.

Often, it would be easier to just show the Messier objects visible in any night in, say, a three-hour span of observing, instead of waiting for them to appear in the sky. Each Messier object contains enough interesting information that would capture the interest of students and develop in them an abiding interest in science.

8. DEFINITION OF TERMS

Active Galactic Nucleus. The central galactic region of galaxy in which considerable energy is generated by processes other than those operating in normal stars [3].

Barred spiral galaxy. A galaxy in which the spiral arms emerge from the ends of a bar that straddles the nucleus, rather than from the nucleus itself [4].

Black hole. A blackhole isa a compact region of space that contains a large quantity of Matter and whose gravitation field is so powerful that no material object, light or signal of any kind can s = escape from it [4].

Blue stragglers. Stars that seemingly lag behind in the aging process, appearing younger than the population from which they formed, detected in many distant star clusters and among nearby stars but never have been seen inside the core of the Milky Way galaxy [5].

Cataclysmic variable. A variable star that exhibits sudden outbursts generally arising either from the release of gravitational energy through accretion or from thermonuclear processes [3].

Dark matter. Postulated by Dutch astronomer Jan Oort and Swiss astrophysicist Fritz Zwicky-Calculation Shows that dark matter is 5 times more abundant in the universe than the standard matter, but since it doesn't emit, absorb, or reflect light, it is very tricky to spot. In fact its existence can only be inferred from the gravitational force it exerts on its surroundings [6].

Dwarf elliptical galaxy. A dE contains very little or no gas, span a range of at least 104 in luminosity along a sequence of increasing mean surface brightness with increasing luminosity. The relatively high surface brightness of a dE can mimic a normal Elliptical galaxy [7].

Globular cluster. A roughly spherical group of old stars in the halo of a galaxy [3].

Elliptical galaxy. A type of galaxy with a smooth, featureless circular or elliptical appearance, no spiral arms, and little or no interstellar gas or dust [3].

Herbig-Haro objects. A small nebula with an emission-line spectrum, found in regions of star formation [3].

lenticular galaxy. A type of galaxy with a definite disk of stars and a central bulge, but showing no sign of spiral arms and little or no interstellar material [3].

Open cluster. Open clusters Contain anywhere from a few dozen to a few hundred stars which is assumed came from the same parent nebula. Open Clusters are also called as galactic clusters because they are located with in the disk of the galaxy [8].

Planetary nebula. A shell of illuminated gas surrounding an old star that is small but hot [4].

Seyfert galaxy. A type of galaxy with a small, bright nucleus [3].

Supernova. A stellar explosion that occur at the end of a star's lifetime, when its nuclar fuel is exhausted and is no longer supported by the release of nuclear energy [9].

9. CONCLUSIONS AND RECOMMENDATIONS

The teaching of Astronomy can be accomplished better with field observations with the use of telescopes. Pictures of astronomical objects, especially if taken with the Hubble Space Telescope are stunning, but there is really no substitute to seeing the objects themselves through telescopes, no matter how featureless the objects may appear. Students like to do field observing. Looking through a telescope is an exciting experience to them.

Teaching Astronomy through the Messier Objects leads to better understanding of the concepts and principles. Further, young initiates to Astronomy find a sense of accomplishment in gathering their observations of the Messier Objects, as this is arguably the most famous listing of all. Students should be encouraged to keep a journal of their observations, and to have a Messier checklist. Students should be taught the fundamentals of sketching what they see in the eyepiece of a telescope, and to keep a record of their impressions.

Teachers should themselves familiarize themselves with the night sky, and to be able to use star maps to locate objects in the sky. In this way, the use of manually-operated telescopes would be easier.

I recommend the joining of astronomy enthusiasts to Astronomy clubs and societies to sustain their interest in the subject. They may opt to take up degree programs in Astronomy in the RTU.

Schools should have good telescopes and should have teachers with more knowledge in Astronomy. Looking through a telescope triggers the interest of students in science.

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