answer is correct, another constellation is displayed on the monitor. When the student has proposed two incorrect answers, the name of the displayed constellation is shown on the screen after which the next constellation is displayed. When this program mode is stopped, the computer show how many correct answers a student gave.

The second of the programs calculates the coordinates of a planet for an arbitrary moment of time and displays them on the screen along with the surrounding constellation. This program allows a preliminary detailed preparation for night observations in "laboratory conditions."

Our experience shows that the natural interest of pupils and students in the sky combined with their desire to handle computer techniques increases their motivation and their respective active participation in observations. Their preliminary acquaintance with the constellations on the screen of the monitor lessens considerably the moderate possibility that they would not recognize them in their natural appearance in the sky. This fact is of utmost importance for future teachers, who could swiftly train themselves for each separate observation and analyze easily both the constellations visible for the planned moment of observation and the visibility and location of the planets among the stars in laboratory conditions.

At the same time, a rapidly increasing wish to compare the materials learned with the aid of the computer with the natural appearance of the constellations on the celestial sphere under suitable conditions finally leads to the natural individual learning of the constellations.

The described positive features of the programs and the absence of suitable conditions in heavily populated cities for carrying out night observations (an obstacle for the quality training of teachers for such observations) make the suggested programs very effective and useful.

INTERACTIVE COMPUTER PROGRAMS FOR TEACHING ASTRONOMY

S.R. Prabhakaran Nayar & Rebecca T. Thomas
University Observatory, Kerala University, Observatory Hill, Trivandrum, India

1. Introduction

Astronomy is the most popular and oldest of all sciences and it has had profound influence on human thought. Unfortunately, astronomy does not find an appropriate place in our school-college syllabi. This may be due to the fact that teaching of astronomy encounters a large number of problems with regard to visualization and practical experiments. Popularization of astronomy depends heavily on a large variety of astronomical events, such as the arrival of comets, eclipses, supernovae, *etc.* Visualization of dynamics in several directions, wide variance of time scales, concepts of space, *etc.*, create problems in teaching/learning processes in astronomy. Our world of human experience is limited to within a narrow frame, whereas in astronomy we speak of size, time, and temperature in gigantic scales. To bring all these parameters onto the human level, one has to think of effective teaching aids and the right type of techniques. We have been using a large number of tools in teaching astronomy, including star charts, globes, models, photographs, slides, *etc.* Microcomputers act as an effective medium in teaching astronomy. They can even replace most of the above mentioned teaching aids (Hunt, 1986; Marx and Szucs, 1985; Sparkes, 1986). A microcomputer can also act as a textbook, a blackboard, or even a planetarium. The computer acts also as a mediator between the student and the model of some real-life situation. The process of building and using models, called *simulation*, helps us to investigate systems that would otherwise be inaccessible. We have developed a set of software to teach basic concepts in astronomy, such as the solar system, constellations, and the physics of stars. We have explored the possibilities of making the software interactive, using the observed data so that a real life situation can be experienced by the users, just as for practical experiments.

2. Microcomputers in Astronomy Teaching

The available teaching software for microcomputers can be grouped into a few major categories: 1) Planetarium-type software — which uses the monitor screen to show the position and motion of stars, sun, moon, planets, and other objects in the sky for any place or time, according to the user's choice. These programs are technically of high quality, and this type of software can be well used in education to present the basics of the clockwork universe. 2) Celestial-mechanics software — useful in revealing the finer details of Keplerian motion. The concepts of gravity and the central gravitation field, the solar system and the revolution of planets, and elliptical orbits and their comparison with realistic models can be shown using this category of software. 3) Astrophysical software — compared to the other two types, it has a wider scope in teaching astrophysics, showing stellar/solar models, evolution of stars, *etc.* Instead of restricting the software to techniques like page turning or routine-type description, one can think of a genuine interactive system where the models built could be used to simulate real life situations and comparison can be made with the sets of observations. Interactive video systems are a relatively new technique. Video recorders guided by microcomputers promise to make interactive picture-and-movie presentations possible.

3. Interactive Software for Teaching Astronomy

In interactive software, the user has an active role in the software operation. The interaction can be carried out in a large variety of ways. In this paper, we have restricted the interaction to the use of keyboards. Software for teaching astronomy at an introductory level can be generally grouped into three categories, as given in Table 1: 1) Solar system; 2) constellations; and 3) physics of stars. In this course, in addition to routine software techniques, we have explored the possibility of making some of the software segments interactive so as to make them efficient teaching material. The solar-system group consists of two segments. The first is a graphic representation of the orbits of planets. For convenience and for clarity, the inner and outer planets are represented in separate frames. From the details of the orbit, one can visualize the relative orbital motion of planets and other phenomena like planetary conjunctions, oppositions, *etc.* By selecting the proper initial epoch and accurate orbital parameters, one can visualize and learn many of the planetary phenomena of the past or future. The second part of the solar system program is a quiz to identify a given planet for which the properties are given. The parameters selected for the program are planetary mass, size, density, orbital period, orbital radius, number of satellites, orbital velocity, inclination of the orbital plane with the ecliptic, major constituents of the atmosphere, surface temperature, *etc.* The user can ask questions regarding one of the parameters of the selected planet and from the answer given by the computer make the guess. The software selects one of the planets at random and continues selection until all the planets are selected. This program was found to be very interesting for introducing details of the planets among children.

The part that introduces constellations consists of a few frames describing important constellations of the night sky and starts with some of the stories associated with them. The learner is introduced to important constellations, prominent stars, directions in the night sky, and stories associated with them in the epics. The program can be compared with planetarium software.

The segment on physics of stars gives an introduction to the concepts of apparent magnitude, distance to stars, absolute magnitude of a star, color of stars, meaning of color, surface temperature, *etc.* With the examples of prominent stars and with this background, the H-R diagram is introduced, explaining the hierarchy of stellar evolution. An attempt is also made in this part to develop interactive software to find the position of a star in the H-R diagram (Kaufmann, 1978) as it evolves, taking the sun as an example. As an initial step, one can simulate the evolutionary track of a star in the H-R diagram by giving a set of data points corresponding to certain initial conditions. This method will be modified by using equations describing evolutionary parameters or simulating the evolution of a star using available computer codes.

4. Conclusion

Astronomy is the fastest developing science and it requires support at the basic level. The teaching of astronomy encounters a large number of difficulties and teaching materials and tools may help to a large extent to overcome these difficulties. The use of microcomputers is one of these tools. We show that the microcomputer can be made more effective by preparing interactive rather than non-interactive

https://doi.org/10.1017/S025292110008667X Published online by Cambridge University Press

software. The interaction can be either in the form of a question/answer type, which give a familiarization or an introductory course in a specified topic, or in the form of an interactive real-life situation, as in the case of planetary motion or stellar evolution. The interaction can be effected either by using the specified data points collected from the observations or calculations or by simulating the real -life situation with the help of computer codes. This type of software opens up a new field of experimental work for astronomy students, showing stellar evolution, orbital motions, and other astronomical phenomena.

References

1. Hunt, J.J. (1986) *Cosmos — An Educational Challenge*, GIREP Conference Proceedings (ESA SP-253).
2. Kaufmann, W.J. (1978) *Stars and Nebulas*, W.H. Freeman and Co. (then San Francisco, now New York).
3. Marx, G., and Szucs, P. (1985) *Microcomputers in Science Education.* Microscience International Workshop, Hungary 20-25 May.
4. Sparkes, R.A. (1986) *Microcomputers in Science Teaching*, Hutchinson Co. (U.K.).

Table 1. List of interactive and non-interactive astronomy software.

Category	Name of the Program	Description
Solar System	Solar 1	Introduces the concepts of orbits.
	Solar 2	Relative sizes, relative velocities, *etc.*, for inner and outer planets separately.
	Planet X	Interactive quiz to expose the user to elementary ideas about planets.
Constellations	Rasi	Familiarization of some of the important stars and constellations.
Stellar	Star 1	Introduces the concept of color, spectra, and surface temperature.
	Star 2	Introduction to H-R diagrams.
	Star 3	Evolution of sun in H-R diagrams.
	Star 4	Stellar magnitude.
	Star 5	Interactive quiz to familiarize with parameters of important stars.

https://doi.org/10.1017/S025292110008667X Published online by Cambridge University Press