Development of the Astronomy-themed Interdisciplinary Curriculum at Taipei First Girls High School

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Abstract
As a participating school of the “High Scope Project” with funding support from National Science Council of Taiwan, our team, consisting of teachers of different disciplines, worked together to design four innovative curricular modules, centering on the application of spectrum to astronomy. These curricular modules feature the use of new instruction technology on teaching, innovative practical courses, and hands-on experience of data analysis. They also incorporate real on-site observation, computer science literacy, and various science-related topics to promote students’ learning performance. The practical instruction results revealed that the curriculum, which is suitable to be an astronomy course for senior high school students, can be applied as a basic course for any astronomy-themed project and provide benefits in terms of cultivating student’s abilities in designing scientific experiments independently and conducting scientific research by themselves. Our team will devote effort to the improvement of the curriculum in the future, although we have won widespread accolade among teachers and students from other schools.

Keywords
Astronomical Data Analysis Courses; Astronomy-themed Curriculum Module

Introduction
Over the past ten years, astronomy has seen quite important progress because of the technological breakthroughs of astronomical satellites and observation techniques. Mostly, the results and findings are stored in the cloud data banks on the Internet, free to be downloaded and applied. As a participating school of “High Scope Project II,” we come up with a feasible curriculum and lesson plans, in accordance with the national outline for senior high school curricula. The teachers of different subjects in Taipei First Girls Senior High School (TFG), such as physics, chemistry, earth science, computer science, mathematics, and English, co-operated and designed an astronomy-themed curriculum that features the application of spectrum. The curriculum focuses not only on theories, but also on practice; we also incorporate information technology, in the hope that students can acquire analysis skills and apply what they learn to other scientific projects. The design of the modules allows the teacher to use them flexibly, which depends on his or her need and class time.

To fully develop the curriculum, we also enlisted the assistance of and are indebted to the professors from the Institute of Astronomy of National Tsing Hua University, the Graduate Institute of Science Education of National Taiwan Normal University, and the Graduate Institute of Library, Information and Archival Studies of National Chench University.

Development of the Curriculum
In the first year of the project, we already finished the design of the four modules as shown in FIGURE 1. The 24-class period curriculum consists of lesson plans, teaching portfolios, and worksheets and proper evaluation tools for students. We also finished pilot teaching in freshman classes and junior classes at TFG. In addition, under the guidance of the professors mentioned above, we finished the before-class, in-class, and after-class evaluations of the curriculum, which involved the teachers, students, and the courses themselves. We are in the last phase of the 3-year project presently, and endeavouuring to promote our results and the curriculum to other schools. For instance, the teacher’s manuals are to be published...
and several workshops are on the way. For further information, please go to the following website: http://203.64.52.224/.

TABLE 1 THE USE OF THE SOFTWARE IN THE CURRICULUM

<table>
<thead>
<tr>
<th>Software/Data Bank</th>
<th>Application</th>
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<tr>
<td>Sloan Digital Sky Survey</td>
<td>The SDSS is one of the most ambitious and influential sky surveys. Its data have been released to the general public.</td>
</tr>
<tr>
<td>Galaxy Zoo</td>
<td>It is an online astronomy project to assist in the morphological classification of large numbers of galaxies.</td>
</tr>
<tr>
<td>SAOImage DS9</td>
<td>It is an astronomical imaging and data visualization application.</td>
</tr>
<tr>
<td>TOPCAT</td>
<td>It is an interactive graphical viewer and editor for tabular data.</td>
</tr>
<tr>
<td>VIREO project</td>
<td>The laboratory exercises illustrate modern astronomical techniques using digital data and color images.</td>
</tr>
<tr>
<td>Audacity</td>
<td>It is a fast multi-track audio editor and recorder. We use it to specify the characteristics of waves.</td>
</tr>
<tr>
<td>Tracker</td>
<td>It is a free video analysis and modeling tool to be used in physics education. We use it to analyze the strength of light in digital photos.</td>
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</table>

In the curriculum, we make use of free online astronomical data banks, such as Sloan Digital Sky Survey and free software to analyze and synthesize data (See the TABLE 1). The courses of the curriculum are inquiry-oriented, with a marked emphasis on the manual exercises, hands-on experiments, and interactive discussion among students. Each of the four modules can be used independently to teach related subjects, or be applied together to form an orientation course for any themed projects. For students of middle education, the curriculum can be a starting point for further astronomical studies. Although the content of the curriculum incorporates cutting-edge technological findings and results, it only takes basic information infrastructure and equipment to implement the courses. As a result, the curriculum can be easily implemented in high schools, regardless of school size or location.

Incorporation of Information Technology

In the process of learning and teaching science, exploration and hands-on experience are two highlighted goals. The two goals cannot be achieved without the aid of information technology, for it makes possible the processing and analysis of large quantities of data. It can even facilitate the student’s understanding of certain concepts by visualizing them. We incorporate information technology into the curriculum in the following aspects:

1) Visualization of Concepts

We use animated pictures and video clips to help students understand and analyze.

2) Application of Software

Students can verify scientific principles for themselves through exercise, and further record the numerical data they collect, analyze the information and draw graphs. This way, we train the students to be able to conduct research and analyze findings independently.

3) Use of Online Data Banks

Students will be able to make use of the online data banks for further research and learning.

4) Application of Platforms on the Internet

With the help of the platforms on the Net, students can integrate the data they acquire from experiments; we can also provide learning and teaching materials via the platforms.

5) Use of Electronic Whiteboards

By using electronic whiteboards, the lectures can be delivered in an interactive way.
6) Use of Portable Mini Notebooks

Students can stay in their own classrooms and use software on the notebook computers to conduct data analysis. (See FIGURE 2 for detailed information)

Use of Mobile Learning Carts

To facilitate the processing of large quantities of data, our school has purchased several “mobile learning carts” (see FIGURES 3 and 4) for teachers and students alike. Together with the high-speed wireless network, TFG cloud data bank and mobile learning devices, “mobile learning” is at the tip of every student’s fingers.

1) Procedure

The teacher uploads materials to the teaching platform in the cloud data bank. By using mobile learning carts and wireless network, we can turn any classroom into an alternative “computer science classroom.” Students can download materials, operate learning devices, and upload their “output” right in their own classroom.

2) Features

(1) Considering the teacher’s need and workload, we purchased laptop computers (installed with Windows operating system). Teachers and students do not have to spend extra hours to learn how to use those devices.

(2) Restoration system is installed into the laptop computers. Therefore, every time when the computer is turned on, the settings are always the same by default. Consistent settings are indeed beneficial for teaching.

(3) With the mobile AP on the carts, teachers and students can enjoy the wireless access to the Internet; the teacher can broadcast information on the computer via the Internet, sending messages to or collecting assignments from students.

FIG. 2 INCORPORATION OF INFORMATION TECHNOLOGY IN THE CURRICULUM MODULE

FIG. 3 THE MOVEMENT OF THE MOBILE LEARNING CART

FIG. 4 THE CONTENT OF THE MOBILE LEARNING CART
<table>
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<tr>
<th>Challenge</th>
<th>Solution</th>
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<tr>
<td>1. It took time for students to shift from their own classrooms to computer science classrooms. (What’s more inconvenient, we used different computer classrooms during pilot teaching.) The actual class time, as a consequence, was shortened.</td>
<td>Designate one computer classroom for the course and inform the school authorities to ensure its availability before the semester starts.</td>
</tr>
<tr>
<td>2. If a computer classroom is used for the course, the teacher needs to install all the relevant software and teaching materials onto the computers in advance. All the software and materials can be deleted by the administrators of the computer classroom.</td>
<td>The teacher can upload relevant software and data onto the platforms on the Net. To save installation time, the teacher’s instructions must be clear and easy to follow.</td>
</tr>
<tr>
<td>3. When all the students are mass downloading in the same computer classroom, it may cause a jam in the flow.</td>
<td>The teacher can store the software-to-use or materials on the teaching platform on the Internet campus domain. When there is a jam on the Internet, the teacher and students can download the needed material from the platform to save time. Or rather, the teacher can divide the class into different groups to download different materials. Thus, the amount of downloading from the same server at the same time can be reduced.</td>
</tr>
<tr>
<td>4. The course cannot be conducted when the Internet disconnects unexpectedly.</td>
<td>The teacher can burn relevant software, data and resources to a disc and prepare adequate quantities of discs for the class. Flash drives are also recommended in case of unexpected situations.</td>
</tr>
<tr>
<td>5. When all the computer classrooms are occupied by other classes, the course cannot be conducted.</td>
<td>Mobile learning carts and laptop computers are strongly recommended because they can be used directly in students’ classrooms.</td>
</tr>
<tr>
<td>6. The standby time of a laptop computer is not long enough for the teacher to conduct the course over a longer period of time.</td>
<td>Make sure the mobile learning cart is fully charged with power. Batteries of higher performance are recommended.</td>
</tr>
<tr>
<td>7. The broadcasting system of the notebook computer or the wireless network is not stable.</td>
<td>When the broadcasting system doesn’t work well, the teacher can turn to the projector in the classroom. Students can download or upload relevant documents from and to the platform in the cloud data bank if there is a glitch with the transmission network with the teacher’s computer. When the wireless network is not stable, connect to the Internet hub with a wire.</td>
</tr>
</tbody>
</table>

**Obstacles to the Implementation and Our Solutions**

In the process of incorporating information technology into the courses, we indeed encountered some difficulties. Listed as Table 2 are some of them as well as the solutions we came up with.

We once used Apps on low-end pads and mobile devices to conduct the courses. However, as we need to analyze great amounts of data and use simulation software, we strongly suggest that you use high-end notebook computers or desktop computers. If your budget allows, high-end pads will better suit the student’s need and intuitiveness.

**Achievements and Characteristics**

The curriculum has been implemented at TFG for almost 3 years. Results indicate that the curricular modules do help arouse students’ interest in science and elevate their ability to conduct scientific research by themselves. On the other hand, the teachers also benefit quite a lot in terms of professional development, skills for team teaching, how to conduct a class, and so on. Further elaboration is as follows.

**The Improvement of the Student’s Science Literacy**

1) Incorporation of Innovative Technology and Expansion of Student’s Horizons

With the incorporation of new technology into the curriculum, we broadened students’ horizons. Moreover, students were allowed great opportunities to participate in international academic activities, such as Pan-STARRS. Students came to understand how these scientific methods were applied to the latest scientific research.

2) Addition of Hands-on Courses and Increase of Students’ Interest

We aroused students’ interest in science by providing more practical courses. Actually, more than half of the courses are hands-on lessons. Spurred by these hands-on experiences, our students were more willing to explore and think for and by them. They also output their own work, such as the synthesized spectrum photos, handmade cardboard spectroscopes, reports on observatories and telescopes, and synthesized photos of the universe by using SDSS.
3) Technology-Assisted Pedagogy and Enhancement of Student’s Informational Literacy

The students' computer literacy improved a lot due to the exposure to information technology in the courses. In each course, students all needed to use software to analyze charts and graphs, and download relevant information or astronomical data banks via the Internet. As a result, students also improved their computer literacy through the curriculum.

4) Experience of Applying Innovative Technology Motivates Students to Conduct Related Studies

Inspired by technological advances, our students were eager to embark on further relevant studies. Under the instruction of the teachers, our students could search on their own for more astronomical information on relevant websites on the Internet, such as SAO/NASA, ADS, Astronomy Query, Hershel Stripe 82 Survey, NYU Value Added Galaxy Catalog, and so forth. They even won prizes in several science competitions in Taiwan.

5) Incentive for Autonomous Learning and Boost to Self-Exploration

Students were motivated to learn more by themselves after school. Our students were required to form mini groups to discuss questions. It allowed them to learn how to cooperate, solve problems together, and explore things by themselves not only in class but also after school. For instance, our students learned how to process astronomical photos after school and found supernova SN 2013ej, whose lightness is increasing. They are the first to record the lightness of that supernova and hence make significant contribution to the studies of supernovas.

The Elevation of the Teacher's Teaching Expertise and Professionalism

1) Growth of Pedagogically Professional Communication and Interdisciplinary Cooperation

Our teachers of different subjects co-worked to design an interdisciplinary curriculum. In the process, we had professional dialogues and learned from each other. We were endowed with opportunities to learn from university professors, and broadened our horizons. Apart from the growth of professionalism, we also fostered a rapport relationship among the members of the team.

2) Challenge and Breakthrough in Pedagogy

The courses require the teachers to use innovative approaches to teaching; hence, we adjusted our teaching strategies, and used an inquiry-oriented way to teach. Through practice and exercise, we introduced knowledge and information technology to our students.

3) Innovation of Pedagogy

The teachers innovated their teaching skills through the curriculum, because they needed to apply a lot of information software when conducting courses, which in turn provides an opportunity for the teacher to innovate their teaching based on the feedback and reflections on the courses. By doing so, the teacher can optimize their teaching pattern to incorporate information technology into their lessons.

4) Refinement of Pedagogy

The teachers refined their teaching skills and pedagogy by designing the courses and writing the lesson plans themselves. Additionally, the feedback from other teachers and students in teaching demonstrations offered an opportunity for self-reflection and improvement.

5) Teachers’ Active Participation in Workshops

Teachers partook in workshops and seminars to present our project and share the results with other teachers. On those occasions, we had numerous dialogues with visionaries in the science and education community, and found opportunities for future cooperation.

Changes Occurring inside School

1) Introduction of Resources from Colleges

The instruction and resources offered from colleges during the process of our teachers' course design, such as the structured guidance from professional academic field as well as evaluation development, provided channels for academic exchange and support between high schools and colleges. This indeed is beneficial for the expansion and application of available resources.

2) Sponsorship of National Funding

With the tightened budget at high school level, the
sponsorship from the High Scope Project effectively encouraged teachers and provided necessary assistance. Furthermore, the addition of new teaching equipment required for our course modules has increased their applicability.

3) Forerunner for Learning Community
This project of inter-disciplinary course design has enabled TFG teachers to form a so-called "learning community," which would be a promising model for our featured course development with the approaching twelve-year compulsory education policy in Taiwan. In terms of both the development and implement of our astronomy-themed module courses, our experience could provide theoretical as well as practical implications for future featured course design.

Conclusions
TFG’s astronomy-themed curriculum is developed and designed by an interdisciplinary team of TFG teachers. When we designed the courses, we took into account the need of senior high school teachers, and tried to merge different teaching patterns of different subjects, from physics and chemistry to earth science and computer science. Besides, the latest observational data is oftentimes referred to throughout the curriculum. And what distinguishes our curriculum, among others, is the role we teachers play in the making of the curriculum. Most similar curricula are initiated by university professors, with senior high school teachers supporting and assisting from the outside. Unlike them, our teachers played a proactive role and designed the curriculum from scratch by ourselves. Thus, we did relate to most high school teachers on the teaching scene. We molded the curriculum into four modules, which allows teachers the leeway to choose one module to teach or to cover the four modules depending on their class time or objectives. All the teaching materials in the curriculum are accessible on the Internet; thus, the curriculum is applicable in every middle school, irrespective of the size of the school or its location. In the future, we will continue to promote the curriculum, and make some modification based on the feedback we receive in workshops. For more updates and further information, please log onto our website.

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