

A New Approach for Enhancing High School Students' Energy Literacy and Awareness of Carbon Reduction

Tung-Chung Tsai¹, Yao-Ming Chu², Tsuey-Ling Wu³, Mei-Chen Chang⁴

1. Associate Professor, Department of Education, National Taitung University
2. Professor, Department of Industrial Technology Education, National Kaohsiung Normal University
3. Teacher, National Feng-Hsin Senior High School
4. Associate Researcher, National Science and Technology Museum

1. No.684, Sec. 1, Zhonghua Rd., Taitung City, Taitung County 950, Taiwan (R.O.C.)
2. No.116, Heping 1st Rd., Lingya Dist., Kaohsiung City 802, Taiwan (R.O.C.)
3. No.257, Xinfu Rd., Fengshan Dist., Kaohsiung City 830, Taiwan (R.O.C.)
4. No.720, Jiuru 1st Rd., Sanmin Dist., Kaohsiung City 807, Taiwan (R.O.C.)

1. tsaidj0720@gmail.com
2. t1179@nknuc.nknu.edu.tw
3. doriswutaiwan@gmail.com
4. mchen0040@gmail.com

ABSTRACT

In Taiwan, knowledge regarding energy technology, energy conservation, and carbon reduction has yet to be formally implemented into senior high school curriculum. Currently, schools independently incorporate key issues into related curriculums and, as a result of education ladder systems, students have limited channels to learn about energy technology, energy conservation, and carbon reduction. Thus, methods to teach senior high school students the importance of environmental issues such as global warming and energy shortage, as well as to promote their interest in energy technology research, development, and applications are significant topics of discussion. Through the collaboration with the National Science and Technology Museum, this study adopted an informal approach in developing a workshop

designed with diverse learning styles for senior high school students, endeavoring to enhance their energy technology literacy and competency in conserving energy and reducing carbon. The participants were 60 senior high school students from two schools of different attributes. The research data was collected using a questionnaire survey, written feedback and verbal reports from the participants, and the researchers' participatory observations. Analytical findings confirm that the goals and focuses of the planned workshop activities were achieved. Students received more in-depth knowledge on topics relating to energy conservation and carbon reduction, demonstrating greater initiative and diversity in their beliefs and attitudes, and they were also willing to participate in energy conservation and carbon reduction activities.

Keywords: energy conservation and carbon reduction, energy technology literacy, senior high

school student

1. INTRODUCTION

Supported by the National Science Council (NSC), Taiwan, the researchers designed a multiple learning scenarios in Senior High School to explore the awareness of senior high school students on environmental issues, such as global warming and energy shortages, and their interest of energy technology[1]. The study members included National Kaohsiung Normal University (NKNU), National Science and Technology Museum (NSTM), National Taitung University (NTTU), The Affiliated Senior High School of National Kaohsiung Normal University (NKNUSH), and National Feng-Hsin Senior High School (FHSB).

To establish basic concepts for energy conservation and carbon reduction (EC & CR) competency, a three-day workshop with the theme, "Energy Conservation, Carbon Reduction, and Green Living." was provided to the different learning scenarios students. Multiple learning contexts were designed to facilitate the students in comprehensively recognizing the meaning and significance of energy conservation, carbon reduction, and green living. Thus, the purpose of this study is to investigate the influences that the activities in the proposed "Energy Conservation, Carbon Reduction, and Green Living Workshop" have on senior high school students and their subsequent acceptance level. The results of this study can be used as a reference for improving the organization of related activities in the future.

The activity design for the workshop included attending organized lectures, visiting the NSTM's Climate Change Exhibition Hall and LOHAS Energy Saving House, engaging in practical progression activities, experiencing the

Tzu Chi Recycling Station, touring a solar technology company (i.e., Motech Industries Inc.) and the Tree Valley Park, and participating in thematic discussions. The lectures and practical progression activities were primarily based on global warming and climate change issues to demonstrate the importance of low-carbon living; consequently enhancing the participants' thematic knowledge and introducing the influences that environmental change has on human life. In addition to guiding students to learn, the design of the activities also provided opportunities for exchanges and communication, expediting students to interact with each other and reinforcing their concept of energy conservation, carbon reduction, and green living.

This study endeavored to demonstrate the environmental damages inflicted on the earth and extant crises to the students through the workshop activities, and to help students obtain a greater understanding towards the research, development, and application of energy technology. Therefore, the objectives of this study were to investigate students' activity preferences, evaluations, and suggestions, as well as the influences that the workshop had on the EC & CR beliefs of the students, and their responses to the learning process.

2. LITERATURE REVIEW

2.1. Energy conservation and carbon reduction education

The implementation of EC & CR is to provide participants with the opportunity to face related problems. Through problem solving, the participants can put the EC & CR into action in their daily lives. Behavioral intention measures a person's relative strength of intention to perform a behavior[2]. Therefore, discussions on the

related behavior of EC & CR are primarily based on individual behavior intention.

The behavioral intentions of EC & CR can be categorized into three parts, specifically, (1) the willingness to engage in energy conservation tasks, (2) the formulation of comprehensive and effective decisions, (3) change advocacy[3]. Other studies have divided the behavioral intentions of EC & CR into four dimensions, specifically, (1) the lifestyle habits of EC & CR, which includes a self-assessment on the willingness to proactively engage in daily activities relating to food, clothing, housing and transport; (2) the initiative to obtain new knowledge on EC & CR, which includes the proactive awareness of related messages and the participation in professional growth activities in daily life; (3) the interaction with others, which includes persuading or influencing others to engage in EC & CR activities; and (4) the key factors that influence actions, which include an investigation of the possible factors that influence the willingness to participate in EC & CR activities [4].

2.2. Energy conservation and carbon reduction promotion activities

This study investigated the promotional EC & CR activities that are appropriate for senior high community service. Data regarding the promotion of EC & CR was collected from the database of Chinese journals in Taiwan, selecting 59 articles. These articles were then roughly grouped into three orientation categories, specifically (1) policy, (2) teaching, and (3) living applications.

Articles in the policy orientation category comprised investigations on the EC & CR policy, environmental policies for low-carbon societies [5],

and industrial promotion[6]. Articles in the teaching orientation category comprised investigations on the effectiveness of different teaching strategies and their application on EC & CR issues [7][8], or their implementation methods and evaluation [9][10]. Articles in the living applications orientation category had the highest proportion of the articles and comprised content of transport (i.e., bicycle actions, bicycle lane designs, electric cars, and walking), construction (i.e., green buildings, factories, cabins, and environmental planning), and manufacturing (i.e., energy conservation designs for paper, batteries, air conditioning, and wood)[12].

According to the mentioned literature, approximately two-thirds of the articles discussed daily living related EC & CR. Therefore, designs for EC & CR activities should be based on living-related issues to facilitate activity development and implementation. Subsequently, promotional activities and feasible models can be created that are suitable for teaching EC & CR to senior high school students.

3. ACTIVITY DESIGN FOR “ENERGY CONSERVATION AND CARBON REDUCTION: GREEN LIVING”

The visiting activities arranged in this study facilitated students in experiencing the importance of environmental education development and the necessity of energy technology development. In addition to using lectures as a teaching media to deliver energy technology related knowledge and experiences, this study also endeavored to stimulate students' interest in scientific research through practical activities. Thus, in addition to static teaching of knowledge, we also provided numerous dynamic experiments and practical courses, indulging students to experience the wonder and fun of practical experimentation for

themselves, stimulating the enthusiasm of more students towards the research of energy technology, and ultimately creating a springboard for follow-up research in the future.

The primary emphasis of the proposed workshop was divided into the following four parts: (1) thematic lectures; (2) promotional activities for energy technology education; (3) on-site visits to green energy industries; and (4) thematic reports on energy.

3.1. Thematic lectures

Experts and scholars from the professional field of environment and energy technology and successful education promoters were invited to provide lectures to enhance the professional knowledge of participating students. Lecture topics included environmental change, energy conservation, energy storage, and green energy.

3.2. Energy technology educational promotional activities

Excursions to the NSTM's Climate Change Exhibition Hall and LOHAS Energy Saving House were arranged. Through guidance and explanation, students acquired an in-depth understanding regarding the environment and energy technology application and enjoyed the joint participation of the visits. Staged practical activities were designed to allow students to experience operations. Through these operations, students were able to further understand energy technology application and the core content of EC & CR.

3.3. On-site visits to green energy industries

On-site visits included the following three locations and experiential focuses. (1) The Tzu Chi Recycling Station experiential activity: this visit facilitated the senior high school students in engaging in energy service-related learning and

practice activities, experiencing and realizing the reasons for the demand of EC & CR, developing positive attitudes and values regarding EC & CR, and acquiring the ability to implement and execute these teachings in daily living; (2) the Motech Industries Inc.: this visit facilitated students in gaining a basic understanding of the energy technology industry, enhancing the learning of practical knowledge, and understanding the actual operations of current energy technology industries; and (3) the Tree Valley Park: guided by the park staff, the students visited the Tree Valley Park, which is also known as Taiwan's first eco-industrial park; they experienced the commitment of the Tree Valley Park's efforts in combining art, ecology, commerce, and technology.

3.4. Thematic discussions on energy:

Students were allocated into small groups to conduct "thematic research." They researched and brainstormed the topics of waste reduction and reuse, as well as renewable energy. This research not only provides the students with in-depth understanding on the research field, but, through the previously mentioned curriculum arrangements, endeavors to clarify research methods, induce curiosity, and prepare the students for future energy technology research.

4. RESEARCH DESIGN

4.1. Sample

The main participants of this study were the students from the two participating senior high schools, that is, NKNUSH and FSHH. A total of 60 freshman students, 30 from each school, were recruited for participation. Among the students, those from NKNUSH were class-based and familiar with each other, while those from FSHH were composed of society members. Because the society had only been established for less than

a month, and because the society members had only attended the society twice prior to the research, the students of FHSH were unfamiliar with each other.

4.2. Data Collection

This study collected the research data using a questionnaire survey, written feedback from the students, and participatory observations. The questionnaires recorded data regarding the activity preferences of the students. Participatory observations were executed by the execution team members of this study, primarily responsible for the planning and execution of the workshop and assisting in data collection during activity process. Students provided written feedback daily, and the staff collected and analyzed their experiences, accordingly.

Quantitative data analysis was measured in a percentage and based on the items that students were most interested in. Regarding qualitative data analysis, the written feedback was first converted into transcripts; then, a semi-structural interview framework was adopted as the main concept to conduct thematic open coding. The correlation between the different data was compared and the summative and conceptual contents of the data were consolidated. Subsequently, data organization and analysis methods were adopted for data processing. The data ID comprised three code sets, specifically, an alphabet was used to denote student groups (A or B); a number was used to denote the student identity, and a combination number was used to denote the feedback. For example, “B1 feedback” represents the experience of Student 1 in Group B. In the process of experience data collection and analysis, the comprehension of the students was periodically confirmed, and the consistency between the analysis and the original

intention was periodically verified. After completing the transcripts, the students were asked to view the product and provide individual suggestions and feedback. This process was conducted to ensure consistency and reliability of the data.

5. RESULTS AND DISCUSSIONS

In the three-day workshop on “Energy Conservation and Carbon Reduction: Green Living,” the majority of the participants considered that the workshop was rewarding and they gained a greater understanding regarding EC & CR issues. The content and methods of the activities expanded the perceptions of the students regarding EC & CR, and further affected the students' learning attitude.

5.1. Students' preferences for different types of activities

5.1.1. Because the students for the proposed workshop came from schools with different learning contexts, they demonstrated different preferences for activity types.

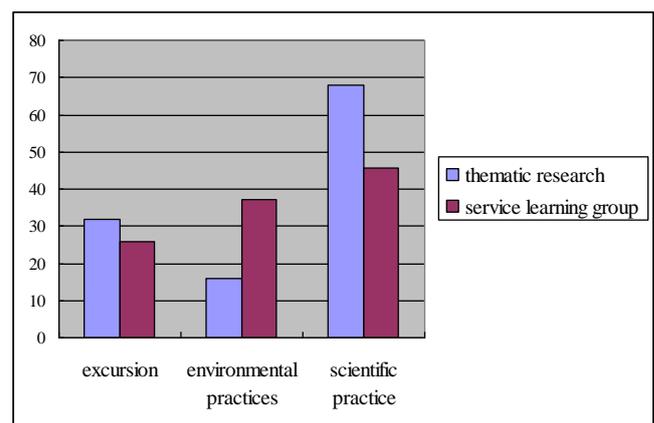


Figure 1. activities preferences by different learning contexts

From the learning context, the NKNUSH students that were allocated to the thematic research group were most interested in activities with “scientific practice” attributes (68%),

followed by the “excursion” activities (32%), but were least interested in the “practical environmental conservation” recycling activity (16%). In contrast, the FSHH students allocated to the service learning group were most interested in the “practical environmental conservation” recycling activity (45.7%), followed by activities with “scientific practice” attributes (37.1%) and "excursion" activities (25.7%),

5.1.2. Students of different gender have different preferences for the design and content of the activities

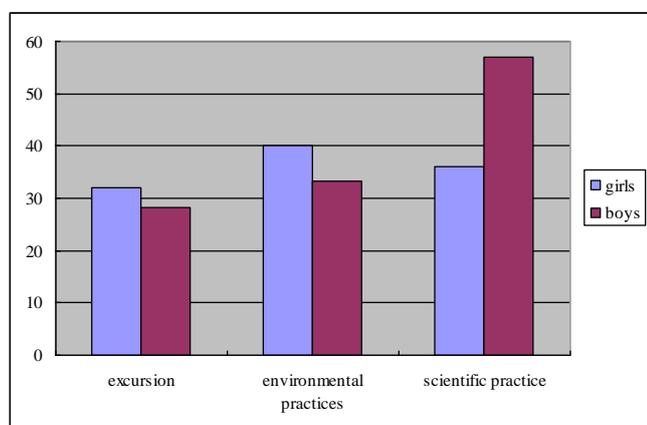


Figure 2. activities preferences by gender

Regarding comparative results based on gender, girls were most interested in the “practical environmental conservation” recycling activity (40%), followed by activities with “scientific practice” attributes (36%) and "excursion" activities (32%). In contrast, boys were most interested in the activities with “scientific practice” attributes (57.1%), followed by “practical environmental conservation” recycling activity (28.6%) and "excursion" activities (25.7%). Overall, students' acceptance of the workshop activities in sequential order was “scientific practice” (48.3%), “practical environmental conservation” (33.3%), and "excursion" activities (28.3%).

5.1.3. The reasons for the students' liking of the proposed workshop include practical operations, humorous speakers, and personal experience

Students asserted that listening to lectures had limited effects, and learning how to do things themselves had better learning effects. *“He that travels far knows much! For me, “doing” is the most important!”* (B1 feedback) Students often listened but did not comprehend the lectures, and the effect is far less than practically attempting things themselves. *“A few minutes of practice were typically more effective than listening to a lecture for 2 to 3 hours.”* (A7, A10, A23, A25, B1, B4, and B14 feedback) It is evident that students still preferred to learn through practical experience. If the lectures were too long, learning fatigue in students was exhibited, and the effect of the activities will be lost instead.

Students could learn the professional performance of high-profile lectures through specific communications media. These lectures had a better inspirational effect on the students. Therefore, some students asserted: *“I was surprised that he is actually a discovery grade character.”* (A9 feedback) *“To prevent everyone from feeling bored, interactive learning and puzzle collection were specially designed to increase our interest, and it has successfully attracted my attention to be involved.”* (A1 feedback) *“I can absorb quickly with the relaxed teaching methods and it has made me learn new knowledge.”* (B13 feedback) Noticeably, by incorporating short intensive courses and inviting speakers with authoritative knowledge and flexible lecturing skills, the learning motivation of the students can be stimulated.

Students who conducted practical recycling activities were profoundly touched in their

understanding of environmental protection awareness, specifically, “*experiencing the great feeling of giving to Earth when doing environmental protection personally.*” (B23 feedback) When students were personally involved in performing recycling work, they profoundly understood the importance of conserving resources, asserting that “*While working on the ground, I began to understand the hard work involved. Not only because of the environment, but one may also be accidentally injured.*” (B2 and B13 feedback)



Figure 3: Recycling materials emitting foul odor



Figure 4: Detailed dismantling of audio tapes

5.2. The influence that the proposed workshop has on students’ knowledge and skills relating to EC & CR

5.2.1. Influences on students’ EC & CR recognitions

Students did not demonstrate a very firm belief in EC & CR, but the content of the activities enhanced their concepts on EC & CR. Some students considered that, “*EC & CR has always been essential, and after I participated in the workshop, it has strengthened my confidence even*

more.” (A7 feedback) “*My concept of EC & CR was very weak before I attended these activities. It is time that we compensate our earth.*”(A8 feedback) “*We must constantly remind ourselves of the importance of environmental protection.*” (A11 feedback) “*...even if the enthusiasm is short-lived.*”(A17 feedback) However, the students confirmed that a positive recognition tendency around the start of the activities, “*Before the activities, I had always thought that EC & CR were very important; after the activities, I learnt more about the benefits and importance of energy conservation, and I will apply them to my daily life more actively.*”(A23 feedback)

Recognition clarification will transform into the driving force of behaviors. A student asserted, “*Although I like entitlement, I have to also learn restraint. In particular, I am proud of one thing, and that is cycling to school every day.*” (A14 feedback) “*Environmental protection is very important, and garbage should be categorized at home, not littered at will.*” (A22 feedback) “*I had initially thought that EC & CR was a matter that, even if all mankind were to work together, the deterioration of the earth’s environment could not be mitigated, but after these activities, I have come to think that as long as we do our best to protect the earth in our daily lives, there is chance to save the earth’s environment.*” (A18 feedback)

Through the participation in the activities of the proposed workshop, the students’ original misconceptions were further clarified and transformed into the driving force of their actions. This also expedited positive attitudes towards EC & CR issues.

5.2.2. Influences on the students’ attitudes towards EC & CR

5.2.2.1. Regarding attitudes towards EC & CR, students realized the “a nickel saved is a nickel earned” and “view the big picture while starting small.”

Regarding attitudes towards EC & CR, students realized the principles of “a nickel saved is a nickel earned” and “view the big picture while starting small.” and learnt that learning to communicate ideas is also a key attitude. “Believe that EC & CR can start small and subsequently change our environment.” (A5 feedback) Furthermore, “The strength of one person is small, but if everyone upholds the concept of EC & CR, this collective energy will be of great help to the earth.” (A6 feedback) Therefore, “I should give a little effort to the world. After all, I am also a resident on this earth.” (A9 feedback) “Promote environmental protection and do our part for earth.” (A10 feedback) “In short, just do it. That's it.” (A15 feedback) “Recently, there are advocates for loving the earth through EC & CR, but the mind will inevitably say with anger, ‘relying on one person is insufficient. Forget it,’ but in actuality, if on average everyone drinks a can less a day, spectacular and amazing results can be achieved in one day.” (B29 feedback) As long as there is perseverance in the things we do, subsequent success would inevitably follow, especially, “EC & CR should start from daily living and should be maintained.” (A12 feedback) “Even if the greenhouse effect is very serious, mankind can ease global warming through numerous methods of EC & CR,” (A4 feedback)

5.2.2.2. Learning to communicate ideas is also a key attitude

Learning to communicate ideas is also a key attitude. “Continuous communications with family members on EC & CR matters, recycling at

home is also done pretty well now!” (A13 feedback) “Before the activities, I felt that it was sufficient if I had done a good job myself. But after the activities, I realized that individual effort is not enough. I should exert myself to influence those around me, leading them to conserve energy and reduce carbon.” (B5 feedback) We should endeavor to achieve “Individual effort is not enough! I would also like to help more people get involved!” (B9 feedback)

The students have more positive performances towards EC & CR after participating in the proposed workshop activities, and realized that self-perseverance is the key and effort brings achievement. Thus, this type of activities encouraged students to consider the viable practices of EC & CR, to learn to influence people and matters through communications, and to achieve the goal of EC & CR.

5.2.3. Influences on students' behaviors towards EC & CR

EC & CR requires personal exertion, “Just sitting in an air-conditioned room and talking rhetorically about energy conservation is an absolute illusion. It only becomes realistic through actual practice and experience.” (A25 feedback) “After the activities, students who were usually not concerned about such topics were surprised that EC & CR has such an immense impact on daily life. Sitting by idly only causes the situation to deteriorate further. These concepts completely changed my views. This is a good thing, because at least I have learnt how to take care of our earth, as well as having the determination to participate!” (B10 feedback)

Therefore, “EC & CR cannot just stop at only conveying the concept, it needs further implementation.” (B17 feedback) “I hope that

everyone is not simply talking casually but exert individual effort.” (B18 feedback) “I always thought that EC & CR was mainly conducted by the cooperation between major factories. After the activities, I realized that, in fact, everyone can do their part for the earth, such as recycling resources, conserving water, using public transportation, and taking the stairs instead of the elevator. From now on, I must uphold the principle of reducing 1 kg of carbon per person per day.” (B19 feedback)

5.2.4. Students can achieve the learning objective of EC & CR in the activities

The majority of students accomplished their expected learning objectives of participation in the proposed workshop. “My learning objective was to learn about climate change and the difference between weather and climate. I have achieved that objective.” (A7 feedback) In addition, the planning of learning objectives also took into account each aspect of EC & CR. “I wanted to know the trends of the various energy sources in the future.” (A8 feedback) “I can gain a deeper understanding of this environment.” (A9 feedback) “I understood more knowledge about environmental protection.” (A11 feedback) “There is no end to learning..., and I learnt more knowledge about environmental protection.” (A12 feedback)

Even for students whose initial motivation for participation was unclear, after the activities, they also gained a specific level of introspection and reflections. “In fact, I did not have any objectives, but since I had spent time in participating in such an activity, I had to learn something.” (A17 feedback) “The activities inspired new views. The choice of food is also a means for EC & CR. Such as eating beef, that cow had discharged a lot of methane!” (B22

feedback)

5.2.5. Enhancing the students' learning attitude on EC & CR through the activities

“One was able to understand the structure and principles by listening attentively to the lectures and practicing the operations on-site.” (A6 feedback) “The school wanted us to participate in the activity, but my personal will was not high. After spending time participating in these activities, I still have to expect to learn something myself.” (A14 feedback) “Learning is to learn from multiple aspects and not being choosy. That is the right path! Just like this time, the variety of courses has benefited people a lot.” (A15 feedback)

“The participation in this activity is to disregard old concepts and re-learn EC & CR! To re-learn the related concepts of EC & CR without prejudice, because we are still learning, as well as slowly understanding EC & CR. Maybe there are many related concepts that are too complex for me to comprehend, but I will continue to study hard!” (B9 feedback) It is evident that the arrangement of suitable activities can inspire a positive learning attitude in students.

6. CONCLUSION AND RECOMMENDATIONS

6.1. Students of different learning contexts have differing preferences for the types of activities

Students whose learning context was thematic research-oriented had more time to concentrate on handling related thematic issues, and had more opportunities to conduct practical activities and discussions on professional knowledge. In order to solve professional

problems, the guidance of the workshop's lecture professors was incorporated to elevate the standard of the thematic research. A higher proportion of students responded that they liked the practical activities. In contrast, students whose learning context was social service-oriented preferred the environmental recycling station experience activities. This was because the activities relating to the recycling station experience was similar to their learning context. Under empathic circumstances, students were able to reflect on these experience activities.

However, students with different backgrounds demonstrated the lowest preference for the excursion activities. Upon investigation, this study found that the reason was mainly due to the influence of schedule arrangements. The planned schedule was disturbed by interference factors such as driving distances and student inefficiency when assembling outdoors. This forced the visiting time to be shortened, and caused student to generate a sense of cursoriness. Further attention should be put into this problem when planning related schedules in the future.

6.2. Most students have positive assessments on the proposed workshop

The majority of the students indicated that the arrangement of the activities for the three-day workshop had inspired their learning motivation, especially the practical activities, which is a rare type of activity in the learning context of their schools. The workshop not only enhanced their learning motivation, but also contributed to the understanding of related concepts. The practical environmental protection activities also strengthened the students' empathy. In addition, the lectures and excursion activities expanded the knowledge and skills of the students on EC & CR, and had also enriched their life experiences.

6.3. Students suggested that the EC & CR activities should return to its originality

The goal of the EC & CR activities were to cultivate the related knowledge and skills of the students. However, the activities were arranged in excessively rapid succession, which transformed these activities into formality. Knowledge cannot be absorbed effectively in such a short period of time. Lecture sessions were overly intense, resulting in information explosion. Students did not have enough time to digest the content that was provided; thus, the original goal of the curriculum design was difficult to accomplish. In addition, the resources wasted during the course of the activities were also a key factor of attention for the students. This shows that the students deeply appreciated the significance of the thematic activities.

6.4. Enhancing students' knowledge and skills regarding EC & CR

Initially, students did not demonstrate firm beliefs in EC & CR. However, the content of the activities clarified their misconceptions about EC & CR. After clarifying biased concepts, knowledge can be converted into the driving force of their behaviors. This not only facilitated students in realizing the principles of "a nickel saved is a nickel earned" and "view the big picture while starting small" and enhancing their attitude towards EC & CR, but also helped them learn communication ideals and attitudes and induced them to personally practice EC & CR.

6.5. Learning objectives were more clear and firm

The majority of the students accomplished their targeted learning objectives during their participation in the proposed workshop, concreting their learning motivations. To

accomplish their learning objectives, the majority of the students were able to initiatively ask questions to clearly understand the nature of the problems. In the course of learning, a variety of effective learning strategies were also used to enhance the learning effect; among these strategies, methods of peer interaction and initiatively searching for information on the internet all contribute to the healthy development of learning habits.

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