Development and Validation of ICT for Energy Management: Building Capacities towards Smart Cities through Sustainable Resource Use

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Abstract. A smart city uses information and communication technologies (ICT) to enhance the quality and performance of urban services and to reduce costs and resource consumption. Education with ICT strategies towards efficient use of resources, such as energy, will guide us on our journey towards the goal of climate change abatement and making cities smarter, since smart people make smart cities. Youth of today are the driving force of tomorrow. Through them, we can tap future generations, policies and development. This study involves designing a capacity building program and administering it to the sample with the goal of measuring the enhancement of knowledge and changing perceptions regarding energy management and energy auditing skills, pre- and post-intervention. Energy management was studied in terms of energy-related carbon emissions, renewable energy, energy conservation practices, energy efficient appliances, and energy audit. The sample constitutes 470 students from schools and colleges of selected universities in Delhi, India.

The paper will discuss curriculum analysis, which was done to appraise the inclusion of information on energy management in school and college curricula, followed by pre-intervention outcomes with respect to the sample’s knowledge, perception and skills. The paper also discusses strategies used in designing and administering the capacity building program. The program includes capacity-building aids blended with educational technology in an information-sharing mode of instruction. Interactive media such as technology based learning (mobile application, game), simulation exercises, multimedia, lectures and group discussion is used.

Keywords. Capacity Building, ICT strategies, Renewable Energy, Smart Cities, Youth

1. Introduction

Sustainability is the ability to maintain balance of a certain process or state in any system. Resources, such as water, energy, forests, minerals etc., are the backbone of every economy and provide two basic functions: raw materials for production of goods and services and environmental services. Recycling, reducing waste generation and conservation of valuable resources are our best hopes so that our ecosystems will still be capable of providing for the generations to come (European Commission, 2002). Energy is central to sustainable development and poverty reduction efforts. It affects all aspects of development - social, economic, and environmental - including livelihoods, access to water, agricultural productivity, health, population levels, education, and gender-related issues (United Nations Development Programme [UNDP], 2013). It is the prime mover of economic growth and is vital to the sustenance of a modern economy. Future economic growth depends on the long-term avail-
ability of energy from sources that are affordable, accessible and environmentally friendly (Ram & Selvaraj, 2013). The global demand for energy is rising fast as the population increases, and developing countries such as China and India are undergoing dramatic economic growth. It is estimated that the world’s energy needs will be 50% higher in 2030 than they are today (ElBaradei, 2008).

Currently, 31% of India’s population lives in cities. These cities also generate 63% of the nation’s economic activity. These numbers are rapidly increasing with almost half of India’s population projected to live in its cities by 2030. Smart cities focus on the most pressing needs and on the greatest opportunities to improve quality of life for residents today and in the future (Ministry of Urban Development, 2015). The concept of a “smart city” refers to “modern urban competitiveness that highlights the growing importance of social and environmental capital in profiling the attractiveness of a city”. This process entails the development and use of various technologies, such as information and communication technologies (ICT), which enable increasingly efficient use and consumption of energy. The establishment of communication activities and raising awareness are key components of all smart city projects, even in cases where the main focus is on the technological aspects. Communities have always been driven by such patterns. Smart technology is increasingly developed and applied, and cities are becoming increasingly responsive to their populations. However, this process is not automatic. To become smart, a city must learn to direct its inhabitants towards a more healthy, productive and sustainable lifestyle (European Commision, 2014).

Adolescence is best understood as a period of transition from the dependence of childhood to adulthood’s independence and awareness of our interdependence as members of a community. Adolescents are the main stakeholders, future policy makers and a major resource group, and they play an important role in taking up responsibilities, revolutionizing other stakeholders and acting as a catalyst for bringing about change. These future leaders have immense potential to mobilize the masses, be adaptable and link education and action in addition to being responsible consumers (Centre for Environment Education [CEE], 2005).

Education for sustainable development is a dynamic concept that utilizes all aspects of public awareness, education, training and capacity building to create or enhance an understanding of the linkages among the issues of sustainable development (CEE, 2005). For building momentum towards the energy management movement, it is thus imperative to build the capacity of the masses so that they are capable of making decisions and taking appropriate steps towards the implementation of suitable energy efficiency measures. According to the Population Council in India, (2012), “India is a young nation with 30% of the country’s population being adolescents”. Such a high proportion of young people could work in India’s favor in terms of emerging as one of the four major economies of the world by the year 2020. Their energy and enthusiasm must be guided into productive work. Their ideas and innovations should be tapped for the betterment of the society (President of India Forum, 2010). Building capacity of adolescents may help to reach the next four generations with the message to conserve and protect nature. Thus, towards this end present research has been undertaken.

2. Objectives

- To scan the inclusion of information on energy management offered in school and college curriculum
- To assess the knowledge and skills of adolescents towards energy management
- To develop a validated capacity building program towards energy management for adolescents

3. Methodology

The sample constitutes students from private school, government and students from colleges of selected universities in Delhi. Delhi is a
metropolitan city and is the educational capital of the country. It houses a number of private and government universities attended by students with various backgrounds from all over the country and even nationals of other countries and cultures. The knowledge-testing questionnaire was administered to the students to understand their knowledge level. The tool covered the knowledge testing of respondents regarding the following concepts: sustainable development, climate change, energy conservation and energy audit. The data procured was coded, scored and tabulated in accordance with a pre-decided pattern. This was done to calculate scores and comparative data to lead to results and conclusions. The data was analyzed using Microsoft Excel software. Mean and standard deviation was also used to support the analysis. Pie charts and graphs were used to represent the study findings.

4. Results and Discussion
4.1 Curriculum Analysis
Curriculum analysis was done to assess the curriculum of the sample. The analysis was done by taking views from 75 teachers in 28 schools and colleges. The curriculum was assessed with respect to inclusion of energy management, tools and aids used to teach energy and related issues and the most preferred and liked method of teaching method.

It was seen that emphasis on energy crisis, energy conservation and efficiency and linking energy use to climate change is low in school and college curriculum, as only 23% of responses were obtained for energy crisis, 26.4% on energy and its science and only 15% for energy conservation (Figure 1).

The majority (43.9%) of students expressed that information on environment was moderately sufficient. A large section (29%) found the information to be insufficient. The majority (60%) expressed that they found information on energy in curriculum to be insufficient. Also, the majority (67%) indicated that activities on energy/environment were insufficient. A large number (41%) of responses were obtained for student’s projects as the most preferred activities spearheaded in their school and college. A large number of (61%) responses in private schools indicated that workshops and seminars were held. However, games, quizzes and activities obtained very low (11.9%) responses. The initiatives taken in government schools and colleges were very low. The majority (62%) of responses were obtained for games, quizzes and activities for being the most popular and liked learning method. Workshops and seminars also obtained a large (53%) number of responses. Fewer responses were obtained for eco club activities (21%) and student projects (15%).

![Figure 1: Distribution of sample with respect to inclusion of topics on energy issues in course](image-url)
The majority of responses (61.1%) from private school respondents expressed that AV aids were used widely as indicated by Figure 2. However, in none of the government schools were AV aids being used. Only 30% of responses were obtained for the use of AV aids in colleges. Another large (61.1%) section of responses were obtained for lecture only. Use of tools and aids was seen to be low for government schools and colleges.

4.2 Knowledge Level of Participants

Knowledge Regarding Basics of Energy Conservation and Efficiency

It was observed that 53.8% and 46.6% of respondents could identify the correct meaning of energy conservation and energy efficiency, respectively. The participants were asked to classify the given actions into either energy conservation or energy efficiency. In the test, 62.3% correct responses were obtained for “switching off lights when not in use” and 50.6% for “opening the windows in summer instead of turning on the air conditioning”, identifying them as energy conservation. For the rest of the categories, fewer than 30% correct answers were obtained. It was observed that although participants knew the meaning of energy efficiency and energy conservation, they could not differentiate between the terms.

Knowledge Regarding Energy Efficient Appliances and Practices

The pretest revealed that only 22% and 17% could identify LED and T5 lights to be the most energy efficient, respectively. It was seen that the majority (71%) indicated CFL and 67% indicated T5 to be the most energy efficient lights. It was surprising to learn that most of the students were not aware of LED. Some also opined that it was very expensive compared to other lighting fixtures.

In the test, a large category (52%) opined that automatic controls lead to a reduction in automatic controls. However, when asked to identify some types of automatic controls, only 10% could name daylight sensors, and another small section indicated dimmers (7%) and occupancy sensors (6%). Respondents were asked to identify the meaning of the term “energy auditing”. In the pretest, only 18% of respondents identified the correct meaning. Half (50%) of respondents indicated energy auditing involved checking energy efficient
appliances in a building. Another section (23.3%) comprehended energy auditing to be purchasing energy-efficient appliances. Some respondents expressed they had never heard the term.

**Knowledge Regarding Electricity Bill**

It was seen that only 26.2% correct responses were obtained for unit of electricity. Respondents were not very aware of the electricity rates in the city. Nearly one third (35%) of the respondents identified Rs. 2.7. However, only a small section (13%) could ascertain the correct minimum price of electricity in Delhi. Similarly, for maximum rate, only 22% could ascertain the correct answer in the test. In the pretest, only 14% knew about sanctioned load. The participants expressed they had not heard this term earlier. An attempt was also made to ascertain the knowledge regarding current electricity slab rates. This parameter obtained very low responses; only 8% could identify the correct slab rate.

**Knowledge Regarding Concept of Climate Change and Causes**

It was seen that 35% of respondents knew the meaning of global warming, and 30% had an understanding of the concept of the greenhouse effect. Responses obtained for identifying greenhouse gases was also seen to be low (4%-28%). The largest category (60%) of respondents answered that transportation led to maximum carbon emissions. A small section (8.3%) considered energy supply to be the sector with the most carbon emissions. Respondents were also asked to list some anthropogenic causes of climate change. Very few responses were obtained with deforestation being the largest category (22%) followed by use of private transport (17%). A small section (11%) expressed increased use of gadgets and electronics was also one of the causes.

**Knowledge Regarding Concept Mitigation and Adaptation**

In this category, the respondents were asked to identify climate change’s mitigation agency, and only 9% could identify the agency. Knowledge regarding India’s commitment to reduction was also seen to be very low (10%). However, a considerable section (40%) knew the correct meaning of sustainable development.

The total score attainable in each category and the mean knowledge score attained by sample in each category was evaluated. The average percentage is seen to very low in the categories energy scenario and initiatives (17.29%), electricity bill (13.20%) and mitigation and adaptation (12.43%). This indicates that knowledge in these categories was very low. Also, in all other categories, average score percentage is seen to be lower than 40%. The total average parentage is computed to 26.34%.

The youth’s knowledge regarding energy management is tested using a knowledge-testing questionnaire. Table 1 indicates that in the pretest, the largest category (48.72%) of the respondents scored low on the knowledge test, and another section of respondents (11.9%) scored average. A small section scored high (4.89%) and very high (1.91%) on the knowledge test.

<table>
<thead>
<tr>
<th>Test Scores</th>
<th>Pre-Test</th>
<th>Pre Test (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very low</td>
<td>0-20</td>
<td>229</td>
</tr>
<tr>
<td>Low</td>
<td>21-40</td>
<td>153</td>
</tr>
<tr>
<td>Average</td>
<td>41-60</td>
<td>56</td>
</tr>
<tr>
<td>High</td>
<td>61-80</td>
<td>23</td>
</tr>
<tr>
<td>Very high</td>
<td>81 and above</td>
<td>9</td>
</tr>
</tbody>
</table>

**Table 1**

Distribution of the sample indicating the knowledge scores

4.3 Skill Level of Participants

A skill-testing questionnaire was used to understand the skills of the sample regarding energy management. Several skill-building activities, such as energy auditing, calculating energy consumption and electricity bill, identifying BEE labels and calculating energy saved by installing energy efficient appliances, were done during intervention. In the pretest, very few respondents (5.1%) could calculate the electricity consumption of the room. Only 5 of the respondents (1.1%) could calculate the electricity bill. In government schools, none of
the participants could calculate energy consumption or electricity bill.

The participants revealed that they were excited to learn energy audit calculations and wanted to experiment with more sample studies to find solutions for energy savings.

Skill test pretest scores were calculated to understand the skill level of the sample before intervention. The table indicates that the majority (62.34%) scored very low and another large section (32.13%) scored low. A very small section (1.6%) scored high on the skill test.

4.4 Training Program

Intervention will be a capacity building program, consisting of awareness raising training modules, which will be supplemented with comprehensive tools. The training program developed is discussed with respect to its content design strategy and delivery.

4.4.1 Design Strategy

Based on the pre-assessment results and review of literature, the capacity programs have helped the researcher to identify the ADDIE (Analysis, Design, Development, Implementation, and Evaluation) training strategy as the most appropriate model for present research. Learning Theories Knowledgebase (2009) describes the ADDIE model as a five-phase design that serves as the basic structure for numerous other instructional design models. Steven J. McGriff (2000) states that “instructional design is the systematic approach to the analysis, design, development, implementation and evaluation of learning materials and activities.” These are the five phases of the widely used ADDIE model (as cited in Smith, 2009).

- Analysis: During analysis, the learning problem, the goals and objectives, the audience’s needs, existing knowledge and any other relevant characteristics will be identified. Analysis also considers the learning environment, any constraints, the delivery options and the timeline for the project.

- Design: Detailed prototypes will be prepared and field tested. Also, suggestions will be sought from experts on the same.

- Development: The actual creation (production) of the content and learning materials will be done in this phase.

- Implementation: During implementation, the plan is to put into action a procedure for training the learner, and the trainer is developed. Materials are delivered or distributed to the student group. After delivery, the effectiveness of the training materials will be evaluated.

- Evaluation: Appraisal of the capacity building program will be done.

Figure 3: ADDIE Model
4.4.2 Delivery of Training Program

The training program will be framed into 3 elements:

- Introduction – The respondents are made familiar with the subject matter through informal discussions and presentations.

- Content – the subject matter is delivered using various tools, which include:
  - Presentations and videos
  - Session summary handouts
  - Pamphlets
  - Training manual

- Recapitulation – Recapitulation was recognized as an essential part of the training program. It was administered with the purpose to help respondents to recapitulate the content at the end of each session. For this, recapitulation exercises were developed for each session.

Interactive media, such as technology-based learning (mobile application, game), simulation exercises, multimedia, lectures and group discussions and training materials like newsletters, manuals, activities, etc. are being used motivate youth to integrate energy conservation and efficiency into their everyday life.

5. Conclusion

The present study dealt with assessing the awareness among adolescents regarding energy conservation with a goal to design and validate the capacity building program, which can be used as a tool to train adolescents across the country. Adolescents are influential stakeholders and future policy-makers as well as policy followers. India is a young nation, and the adolescents of the country assume many, varied roles in terms of making decisions, influencing those who make decisions and assuming responsibility for decisions made. Therefore, adolescents are targeted to reach the maximum density of the population and to bring about desired change with minimum input.

The study involved conducting curriculum analysis to assess the inclusion of information on energy management. It was seen that inclusion of information on energy management was insufficient, and very few initiatives were spearheaded by the government, schools or colleges to promote sustainability and energy efficiency. A knowledge and skill questionnaire was administered to youth targeting issues of paramount importance including sustainable development, climate change, energy conservation and energy audit. The ultimate aim was to comprehend the knowledge and understanding of students regarding energy conservation and energy auditing. The paper presents the awareness and application level of the sample, which was found to be inadequate, and is seen as the first roadblock to overcome since change in behavior can only be based on existing knowledge and understanding in the group. Based on this criteria, capacity building and a training program can be developed to generate awareness, not only among adolescents but also other stakeholders. Energy conservation, on both the supply and demand side, is dependent on acceptability by a consumer and adolescent base that is aware of the implications of the choices. This is an asset in terms of reaching the goal of sustainable development through energy conservation. There is a need to incorporate energy conservation into the value system of the country, and capacity building of adolescents towards energy conservation and related concepts will be a leap towards smarter, energy efficient cities. Such research aids in providing information necessary to encourage and influence attitudes and promote behavioral change as well as to develop relevant education and training programs.
References


