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DEVELOPING A NEW TEACHING APPROACH FOR TRAINING OF ENGINEERING FACULTY IN HIGHER ORDER THINKING SKILLS (HOTS)

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ABSTRACT

It is generally perceived that there is a lack of motivation among engineering students to strive for real learning and to take responsibility for what they learn. At the same time, engineering teachers feed information concerning their course without any context, application, or use beyond the upcoming term-end examination. There is a need to shift the focus from teaching paradigm to learning paradigm and engage students at all levels in real-life learning projects from the world of work.

Due to rapid technological changes and advances that are taking place almost on a daily basis, it is imperative that engineering students are made aware of critical thinking and creative thinking when they are studying and learning engineering concepts and principles and their applications.

The learning experiences gained by a faculty trainer in training a select group of engineering faculty in the Bloom's Taxonomy of educational objectives and on the importance of higher order thinking skills are reported in this paper.

INTRODUCTION

A new teaching approach for the training of a select group of engineering faculty (in particular, faculty of electrical engineering) was developed at ASC (Academic Staff College). The learning experiences gained in adopting this new approach are presented here. In an undergraduate engineering education program, the three critical educational elements are: (1) creative learning environment and learning communities, (2) mentorship, and (3) hands-on practice in all subjects and at all levels. There is a lack of motivation among engineering students to strive for real learning and to take responsibility for what they learn. All too often, it seems, engineering teachers feed students information without any context, application, or use beyond the upcoming quiz or midterm examination. Unless we engage students at all levels in authentic learning projects from the world of work and real-life situations and foster self-direction in learning, our students will fall behind their peers in navigating global challenges that require design, team work, communication, lifelong learning, and creativity

Meg Draeger (Draeger 2011) has observed that educators, especially those of us in engineering education, must strive to make life-long education relevant and real beginning in early childhood and encourage active learning by all students, not just the gifted or those with special needs. There is a need to move from a typical instructional paradigm to a learning paradigm, where the primary purpose of a college is not to merely give instructions but to produce learning (Barr and Tagg 1995).

CRITICAL THINKING

Critical thinking involves understanding the context, recognizing underlying assumptions, scrutinizing arguments, understanding varying interpretations from different perspectives, apprising positive and negative aspects, judging ideas, and exploring alternatives.

CREATIVE THINKING

Creative thinking involves thinking and acting differently from the standard, customary, and habitual ways. Creative thinking considers the problem on hand from many viewpoints and perspectives and arrives at a solution for the present and the future.

IMPORTANCE OF CRITICAL THINKING AND CREATIVE THINKING IN ENGINEERING EDUCATION

Due to rapid and technological changes and advances that are taking place almost daily, an engineering student must constantly expand his/her horizons beyond simple accumulation of information and knowledge relying on the basic engineering principles. Exercises and problems are to be so designed and discussed that they will enhance critical thinking skills among the engineering students. Questioning the underlying assumptions, probing the reasons and evidence, considering many viewpoints/perspectives, and considering the implications and consequences are the essence of critical thinking. The solutions to the problems posed usually involve the use of all the skills discussed in Bloom's Taxonomy. Engineering educators and teachers should be exposed to the training programs that will enable them to think critically and creatively. Only then will they be in a position to make their own students think critically and creatively.

THE TRAINING SCENARIO

VIT University, Vellore, India, has many laurels to its credit, including many of its engineering and technology programs having been accredited by the United States accrediting agency ABET (Accreditation Board for Engineering and Technology). The training scenario and the context in which the new approach was developed are described below.

All the trainee faculty members belong to the School of Electrical Engineering and all of them are post-graduates viz., Master in Technology or Master in Engineering, specializing in different areas of electrical engineering and electronics. The faculty members belong to the age group of 25-50 years. Total number of faculty trained is 31; some of them are newly recruited faculty members, with less than two years' experience (30%), and others have teaching experience of two to ten years (70%). The training program is part of the continuous Faculty Development Programs that the institution organizes from time to time, so that the current and best practices in the teaching–learning process can be taught to the faculty trainees. Faculty members are highly motivated to learn and to practice new pedagogical skills in their classrooms.

In order to introduce the concept of HOTS (**h**igher-**o**rder **t**hinking **s**kills), it was felt that a discussion session on Bloom's Taxonomy of Educational Objectives would facilitate the understanding of HOTS. The faculty members, through discussion and interaction, can arrive at different ways by which they can test the HOTS of the students. Hence, the discussion approach was adopted to introduce this concept through a training program.

METHODS

The methodology and the steps followed are as suggested by Cambridge International Certification for Teachers and Trainers (Barker, 2009). The steps adopted are:

1. Identification of the choice of approach
2. Activity chosen for the new approach
3. Identification of objectives of the training program
4. Managing the learning approach
5. Obtaining feedback

EXPLANATION ABOUT THE CHOICE OF APPROACH

The newly recruited faculty members, in general, undergo training programs in soft skills, new educational methodologies, and use of ICT (information and communication technology). VIT University's mandate has been that its students, especially students pursuing engineering and technology programs, should be trained in critical thinking and creative thinking, and more questions in the testing and evaluation of students' performance should be in HOTS, about 75% or higher in the end-of-semester examinations. This mandate is in tune with the "Goals of a University" as expressed by R. L. Kirby (Kirby, 2010).

1. PLANNING AND PREPARATION PHASE

(a) ACTIVITY CHOSEN FOR THE NEW APPROACH

The activity chosen for the approach used the discussion method to explain Bloom's Taxonomy of Educational Objectives, followed by writing test questions using HOTS. Printed course materials and handouts containing information on different levels of educational objectives were used as resource materials during the training sessions (Table 1).

(b) LEARNING ENVIRONMENT CHOSEN FOR THE ACTIVITY

A smart classroom with LCD projector and other facilities was chosen for the first half of the session. In the second half of the session, the participants could sit in groups in the Micro-Teaching Laboratory of Academic Staff College having the LCD projector, speakers, and movable chairs to discuss and deliberate on the inputs given by the resource person/ trainer.

(c) GENERAL LEARNING OBJECTIVE OF THE ACTIVITY

General learning objectives are to familiarize the faculty with the various levels of Blooms Taxonomy of Educational Objectives and to help them analyze their test questions with their fellow participants, identifying and discussing the level of Bloom's Taxonomy that corresponds to each question.

(d) SPECIFIC LEARNING OBJECTIVES OF THE ACTIVITY

• To set the context of the discussion, an introductory session on paradigm shift, viz., from teaching paradigm to learning paradigm, was emphasized.

• To inform the faculty about the nature and significance of learner centricity and active learning, (i.e. active involvement of the participants in the learning process).

• To enable the faculty to drive the paradigm change from teaching to learning and to reiterate the importance of the use of higher-order questions during classroom instruction and in testing and evaluation.

• To explain the different levels of thinking in the cognitive domain and thereby bring out the importance of HOTS to analyze the test questions written by the faculty with respect to the Table of Specifications (Table 2; Brahadeeswaran 2005) and to arrive at the proportion of HOTS in their set of test questions. (It is expected that the proportion of HOTS questions is to be about 75% or more and the remaining can pertain to questions of LOTS (lower-order thinking skills), such as definitions of certain terms and recall of factual information.

• To follow up the discussion and to increase the use of HOTS in test-question writing later on.

2. MANAGING THE LEARNING APPROACH IN PRACTICE

The learning approach in practice is characterized by the roles played by the trainer and the learners.

(a) THE ROLES OF THE TRAINER

• Prior discussion with the faculty colleagues and the heads of the departments about the training program and its importance to the faculty.

• Explanation of the benefits of the program to the faculty.

• Announcement of the date, venue, and schedule of the training sessions and their detailed contents of instructional events. Identification of the faculty for attending the program and informing them. (Thirty-one faculty members were identified.)

• Preparation of instructional material on Bloom's taxonomy and points for discussion.

• Presentation session on Bloom's Taxonomy with appropriate slides and video clippings.

• During the presentation, the products of each level in Bloom's Taxonomy were discussed in terms of learning outcomes that the learners can exhibit (Kirby 2009). This promoted the faculty participants to think what innovative learning outcomes (e.g., a new design or a new exercise) they can expect from their students after the instructions in the class. Given clearly defined learning outcomes, the teacher can provide a carefully structured set of learning activities using diverse methodologies, instructional materials, and appropriate evaluation strategies.

• Soliciting feedback through an open discussion where participants raise questions and responses provide reinforcement of the various levels and terms associated with Bloom's Taxonomy. Further clarifications are also given at this point.

(b) THE ROLES OF THE LEARNERS

• Active involvement in the discussions and carrying out various activities as per instructions.

• Raise questions to improve their clarity on the concepts explained.

• Apply the principles learned in the first half of the session in the analysis of the test questions through discussion with the trainer and with the fellow participants. (The discussion with the group itself was a new learning experience for the trainees.)

(c) HOW WERE THE LEARNERS INVOLVED?

• The entire session on Bloom's Taxonomy was an interactive session. For a common understanding and to facilitate discussion, initial inputs on six different levels of Bloom's Taxonomy were given (Adithan and Murugavel 2007).

• Each level with illustrative verbs and examples highlighting their importance in promoting active learning was explained (Table 3). A small quiz was administered whereby the faculty members were asked to state to which level of Bloom's Taxonomy the item in the quiz belonged (Table 4; Hopper 2007)

• During the initial discussion, many questions were posed to the learners to make them conversant and familiar with the different levels of Bloom's Taxonomy. The faculty members were asked questions to lead them to critical thinking and creative thinking through the chart of Bloom's Taxonomy (original and revised; Table 1).

• In the afternoon session, the participants were divided into groups based on their specializations or disciplines. They were asked to analyze their end-of-the-term test questions and arrive at the percent of HOTS and LOTS questions. In addition, each group presented two questions corresponding to their subject matter on each level of Bloom's Taxonomy and the views of fellow participants were considered and discussed. Thus, the participants put into practice concepts learned in the morning session.

3. STEPS TAKEN TO GUIDE AND SUPPORT LEARNERS

Guidance was offered to the participants at every stage of the interaction. They were given a number of examples to understand the taxonomy better. Answers to questions were provided immediately for clarity. They were guided in their thinking process through relevant questions. Correct answers were acknowledged with enthusiasm and appreciation. Concepts were repeated two or three times for better reinforcement.

4. ELICITING FEEDBACK FROM THE LEARNERS ON THE APPROACH ADOPTED

Learners were asked to discuss the importance of HOTS in their writing of test questions. Opportunity was given to the participants to voice their concerns and difficulties, if any, in the implementation of this concept through an open-house discussion at the end of the first session. This opportunity gave a platform for the faculty members to discuss the efficacy of the training given and the feasibility of incorporating the knowledge acquired in the writing of test questions and its acceptability to their own faculty colleagues and to the students to whom they will administer the tests incorporating their ideas.

Oral feedback was obtained from the participants. The enthusiasm exhibited by the faculty in the afternoon session in the activities that involved them clearly showed the interest the training has kindled in them towards the topic and its importance. (It may be noted that many faculty members are not aware of "Bloom's Taxonomy of Educational Objectives", though to some extent they know about the terms *definition, application,* and *analysis).*

Feedback was also obtained from a colleague acting as a professional observer or mentor who was attending the session throughout the training program.

5. STEPS TAKEN TO ANALYZE THE LEARNERS FEEDBACK PROFESSIONALLY

At the end of the session, the trainer had an informal discussion with some of the participants to find out more about the session: its utility, effectiveness, and scope for improvement that probably was not brought out in the open house. The trainer also conferred with the professional observer to clarify certain observations and suggestions obtained on how to make the presentation and the training session more effective and convincing, leading to action. In this context, it was felt that more examples from the field of electrical engineering and electronics could have been given to relate better with the subject matter, knowledge, and experience of the faculty.

The examples given, though general in nature, were somewhat challenging, enabling them to think, analyze, and discuss. The participants were challenged to which level a particular question or activity belonged, such as *Knowledge* or *Application*?, *Application* or *Analysis*?, *Analysis* or *Synthesis*? After receiving their responses, an explanation was given as to the correct response.

RESULTS

EVALUATING THE LEARNING OUTCOMES OF USING THE NEW APPROACH

The faculty participants were introduced to the Bloom's Taxonomy of Educational Objectives and a clear understanding of HOTS and LOTS was made.

Because the number of participants was small (31), the learning outcomes achieved by using this discussion approach were analyzed using a questionnaire rather than a rigorous statistical analysis. Our conclusions from administering the questionnaire follow.

(a) The faculty understood the significance and benefits of using HOTS to enhance the critical thinking and creative thinking of the students.

(b) Faculty participants understood the correct level of "Critical thinking" and "Creative thinking" in the hierarchy of the Bloom's Taxonomy.

THE PRACTICAL, PROFESSIONAL OUTCOMES THAT THE TRAINER EXPERIENCED IN PLANNING, PREPARING, AND ADOPTING THE NEW APPROACH

The trainer learned the importance of effective planning and organizing a discussion session of this kind in the context of a training program as an ongoing faculty development activity of Academic Staff College at VIT University. The trainer and the facilitator realized that there is a need to provide more examples relevant to the particular engineering discipline, viz. electrical engineering. At the same time, the participants have been encouraged to put forth their views on the points discussed and how these ideas can be incorporated in their classroom teaching. The trainer has also been sensitized about the need to give answers to all the questions raised by the trainees then and there as a means of providing immediate feedback.

During the final phase of the training program, a group activity involving analysis of end-of-semester test questions with respect to HOTS was carried out by the participants using a table (Table 5). Each participant computes the proportion of HOTS questions in the test written by him in his subject. Table 6 shows the consolidated list of the proportion of HOTS questions for various electrical engineering subjects that the faculty handles. Feedback has also been obtained for further improvements to be incorporated in this new learning approach.

MODIFICATIONS REQUIRED TO MAKE THE TRAINING SESSION MORE EFFECTIVE NEXT TIME

A bank of examples from different engineering subjects incorporating Bloom's Taxonomy needs to be developed, and additional exercises are required to elucidate the Bloom's Taxonomy levels for further understanding, for using it in classroom instructions, and for writing reliable test items. Systematic analysis of the question papers, viz., percent of HOTS and percent of LOTS in the particular subject question paper, needs to be done by the group for study, for discussion among the faculty, and for further improvements.

DISCUSSION

The discussion method is an important learning approach to facilitate effective classroom instructions. A well-designed and structured discussion on Bloom's Taxonomy was planned and successfully executed for a group of faculty trainees in the electrical engineering and electronics discipline.

The questions posed by the participants and difficulties experienced in the writing of test questions with emphasis on higher-order thinking skills (HOTS) were addressed, facilitating reinforcement of the various levels and active learning.

Ensuring full participation of the faculty trainees during the discussion and in the learning process has been the major challenge to the trainer and has been successfully met to a great extent.

Organizing a program of this type with a new learning approach focussing on discussion during the sessions provided a rich learning experience both for the trainer and for the faculty trainees.

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TABLE 1. **Position of Critical Thinking and Creative Thinking in the Hierarchy of Bloom's Taxonomy of Educational Objectives**

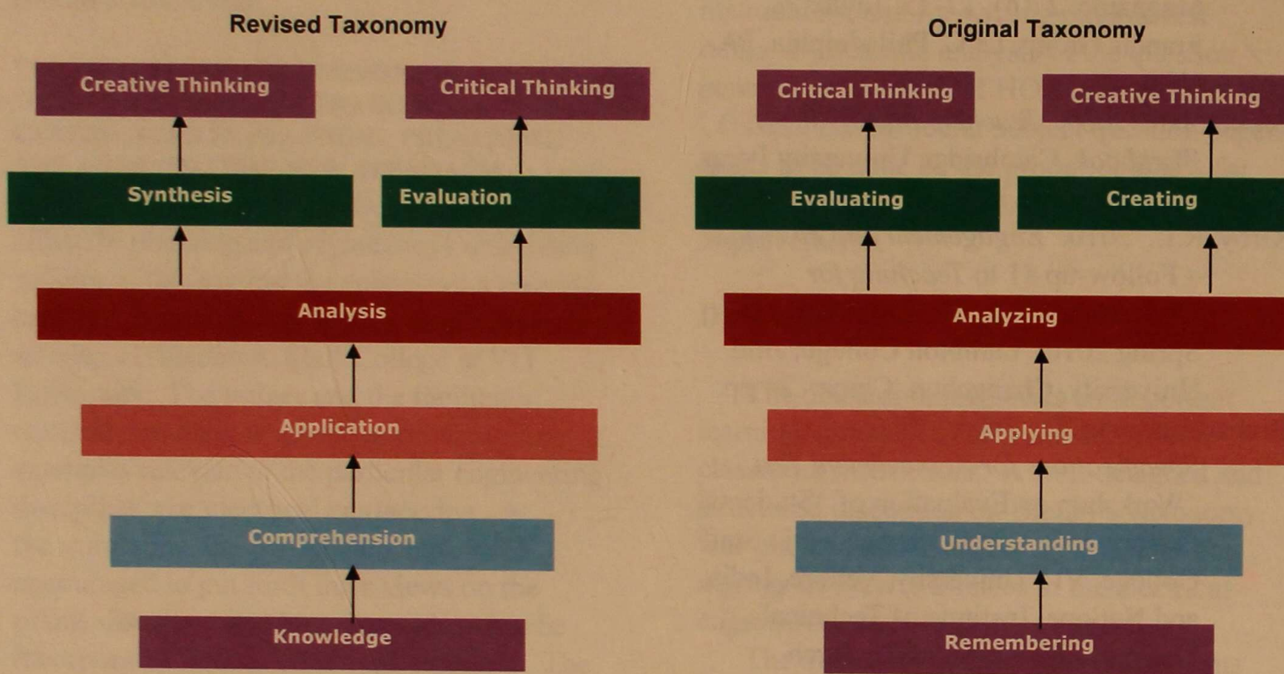


TABLE 2. Table of Specifications (a Sample)

Programme : B.Tech Electrical Engineering
Semester : V Semester (3^{rd} Year)
Subject : Computer communication and Networks (Code Number 05EEE006)
(Numbers indicates % of grades allotted.)

Abilities → / **Subect** (Name of the Unit) ↓	Lower Order Abilities		Application & Higher Order abilities	Total
	Knowledge	Comprehension		
1. Network Design	3	5	7	15
2. LAN Access methods and Standards	3	3	9	15
3. Packet Switching Networks	3	5	12	20
4. TCP/IP Architecture	2	5	18	25
5. Advanced Network Architecture and Security Protocols	2	3	20	25
Total	13	21	66	100

The Table of Specifications serves as a blueprint for the construction of the test/examination. Questions are prepared matching the specifications of the table. The distribution of grades is shown in the table. There may be topics which do not lend themselves to the pursuit of certain abilities.

TABLE 3. Blooms Taxonomy

BLOOMS TAXONOMY

Benjamin Bloom created this taxonomy for categorizing different levels of competency to be developed in learning a subject. The taxonomy also provides a useful structure for categorizing test questions.

Competence	Skills Demonstrated	Question Cues		
	Lower Order thinking Skills (LOTS)			
Knowledge	• Observation and recall of information (from memory) • Knowledge of dates, events, places • Knowledge of major ideas • Knowing of subject matter	**List** **Define** **Tell** **Describe** **Identify**	**Show** **Label** **Collect** **Where** **Tabulate**	**Quote** **Name** **Who** **When**
Comprehension	• Understanding information • Grasp meaning • Translate knowledge into new context • Interpret facts, compare, contrast • Order, group, infer causes • Predict consequences	**Summarize** **Describe** **Interpret** **Contrast**	**Predict** **Associate** **Distinguish** **Estimate**	**Differentiate** **Discuss** **Extend**
	Higher Order Thinking Skills (HOTS)			
Application	• Use information • Use methods, concepts, theories in new situations • Solve problems using required skills or knowledge	**Apply** **Demonstrate** **Calculate** **Complete** **Illustrate**	**Show** **Solve** **Examine** **Modify** **Relate**	**Change** **Classify** **Experiment** **Discover**
Analysis	• Seeing patterns • Organization of parts • Reorganization of hidden meanings • Identification of components	**Analyze** **Separate** **Order** **Infer**	**Connect** **Classify** **Arrange** **Divide**	**Compare** **Select** **Explain**
Synthesis	• Use old ideas to create to create new ones • Generalize from given facts • Relate knowledge from several areas/ disciplines • Predict, draw conclusions	**Combine** **Integrate** **Modify** **Rearrange** **Substitute**	**Plan** **Create** **Design** **Invent** **What If?**	**Compose** **Formulate** **Prepare** **Generalize** **Rewrite**
Evaluation (Judgment)	• Compare and discriminate between ideas • Assess value of theories, presentations • Make choices based on reasoned argument • Verify value of evidence • Recognize subjectivity	**Assess** **Decide** **Rank** **Grade** **Test**	**Recommend** **Convince** **Select** **Judge** **Measure**	**Discriminate** **Support** **Conclude** **Compare** **Summarize**

TABLE 4. Sample of Quiz items raised during the training session

What level of Bloom's Taxonomy would the following activities represent?

1	Finding the main idea of a paragraph		Comprehension
2	Summarizing an Article		Comprehension
3	Finding the lowest common denominator for fractions		Analysis
4	Finding the correct answer to a multiple choice question	a. b c.	Knowledge/Application
5	Appraising the damage to your wrecked car		Evaluation
6	Listing the States and Capitals		Knowledge
7	Making a fruit cake		Synthesis
8	Comparison shopping for the best buy		Evaluation
9	Writing an essay for English class		Synthesis

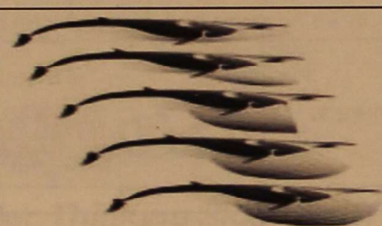
10	Computing your GPA (Grade Point Average)		Application
11	Define Newton's Laws of Motion?		Knowledge
12	Choose the best design from amongst the various alternative designs given		Evaluation
13	Arrange the steps of doing the experiment in the correct sequence		Analysis
14	Composing a music		Synthesis

TABLE 5. Bloom's Taxonomy Analysis of Test Paper

Subject : ______________________

School of Electrical Engineering

Bloom's Taxonomy Analysis

Date:	(numbers indicate the marks allotted to the question)					
	LOTS		**Higher Order Thinking Skills (HOTS)**			
Test Item/ Question Number	**Knowledge**	**Comprehension**	**Application ***	**Analysis**	**Synthesis**	**Evaluation / Judgment**
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						
11						
12						
13						
14						
15						
16						
17						
18						
19						
20						
Total :						

Actual	**Desirable**
Know + Comp = %	20 - 25% (30%, max)
App + Ana + Syn + Eva = %	70 - 75%

* For the analysis, "Application" level is considered a higher-order thinking skill. In Engineering education, students study many principles, rules, laws, and equations, but it is also desirable that they know and learn the practical applications of those principles, rules, laws, and equations in different areas of engineering and technology.

TABLE 6. ANALYSIS OF QUESTION PAPERS WITH RESPECT TO HIGHER-ORDER THINKING SKILLS IN THE SCHOOL OF ELECTRICAL ENGINEERING

Subject No.	Subject	% of questions corresponding to LOTS & HOTS	
		Know+Comp (LOTS)	App+Ana+Syn+Eva (HOTS)
1.	Analog Integrated Circuits	25	75
2.	Electric Drives & Control	19	81
3.	Optoelectronic Instrumentation	64	36*
4.	A/C Machines	20	80
5.	Control Systems	15	85
6.	Semi Conductor devices & circuits	20	80
7.	Digital Signal Processing	37	63
8.	Power systems Analysis	27	73
9.	Power system Protection& Switch Gear	10	90

* This figure is considered very low. The faculty handling this subject has been advised to modify his instructional strategy so that the level of classroom instruction is raised and accordingly questions of higher-order thinking skills can be written in the end-of-the-semester examinations.

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Skip one line and begin the first paragraph of text. Single-space the text. Start each new paragraph by indenting 0.25" (1/4") using a tab, not the space bar. Do not skip a line between paragraphs. Standard abbreviations may be used. The abstract should contain a brief statement of (a) the objectives of the study, (b) the method of study used, (c) the essential results including data and statistics, (d) the conclusions, and (e) the source of support (if applicable). Figures and tables cannot be accommodated. Please check the abstract for misspellings, poor hyphenation, and poor grammar. The text of the abstract should not exceed 250 words.

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The cover sheet for each manuscript should include the title (bold, 12-pt. New Times Roman font) of the paper followed by the names and business addresses of all authors. The corresponding author should be indicated by an asterisk and include a business phone number, fax number (if available), and e-mail address (if available)

b. Organization of Manuscripts

Each manuscript shall start with an abstract (no more than 250 words) that should summarize the primary results. In general, the introductory abstract will replace a summary. This abstract should be suitable for sending to international abstracting services for immediate publication in the event that the paper is accepted for publication in the *Proceedings*.

The following sequence is suggested for organizing a paper: Introduction, Materials and Methods, Results, Discussion, Acknowledgments, and Literature Cited.

The text should be double-spaced (New Times Roman 12 pt. font size), and pages should be numbered consecutively in the top right-hand corner of each page preceded by the author's last name.

Major section headings (**INTRODUCTION**, **METHODS**, etc.) are to be bold and all caps and subsection headings should presented in 10-pt font size, in all caps but not bolded.

Using a tab, not the space bar, indent each paragraph 0.25" (1/4").

c. Grammatical Considerations

Place two spaces between the period at the end of one sentence and the first letter of the next sentence.

Hyphenate compound modifiers and compound words. A modifier made up of an adverb (other than adverbs ending in *-ly*) + adjective, adjective + noun, or two nouns is a compound or unit modifier. E.g., *plum-pox-resistant, transgenic plum*, where *plum-pox-resistant* is the compound modifier (hyphens are boldface for emphasis). Note: chemical names used as modifiers are not hyphenated except when misinterpretation is likely. Examples: 1. Iron sulfide containing bacteria is commonly found ... ; 2. Iron sulfide-containing bacteria are … (In example 1., a sample of iron sulfide that contains bacteria within it is the subject; in example 2., the bacteria contain iron sulfide and *bacteria* is the subject.

Include a comma after each member in a series of words that form a list in a sentence, form a series of modifiers modifying the same item, or for a series of phrases, as this sentence itself exemplifies. E.g., *...dogs, horses, antelope, and trout*... A different example exemplifies an important exception: When an adjective or noun acting as an adjective is conceptually very closely related to the immediately following noun, as *big* in *big apple*, it is not considered part of the series of modifiers modifying the noun.

Thus in *...moldy, green, foul-tasting big apple ...* commas follow all of the modifiers prior to *foul-tasting*, but because *big* is closely associated with apple, it is not in the series; hence *foul-tasting* is the last modifier in the series (it could have been preceded by *and*).

Latin epithets used in scientific names for animals and plants follow a different set of rules than English names, even "official" English names. The guideline for English names is based on the rule "only proper nouns are capitalized in sentences". E.g., *coastal plain oak, raspberry horntail sawfly* would not be capitalized in a sentence. Capitalize the first letter of the first word in a sentence and capitalize the first letter for each major term in titles, figure captions, and table headings. Note: the symbol *pH* always has a lowercase *p* and uppercase *H*; it should not be the first "word" in a sentence, caption, or title if things can be conveniently rearranged.

Spell out numbers "one" through "nine"; use numerals for numbers higher than nine. As with *pH*, avoid beginning sentences, captions, and titles with a numeral.

There exist hyphens, en-dashes, and em-dashes, and each has a use. One should distinguish especially between the hyphen (the shortest of these marks) and the en-dash (the intermediate in length of the three). The en-dash should be used in two-word concepts (e.g., *nickel–metal hydride battery*) and spans of time (e.g., *for the period January–June*), among other situations. In "Word" for PCs, the en- and em-dashes are available in the "Special Characters" tab of the "Symbol" sub-menu, which is under the "Insert" menu. In Macintosh computers, the en-dash is also available directly when the "alt/option" key is held down while striking the hyphen key.

For other grammatical considerations please consult a good scientific writing reference, such as the *Scientific Style and Format: The CSE Manual for Authors, Editors, and Publishers* by Council of Science Educators Style Manual Committee.

4. Figure, Illustrations, and Table Preparation

Each table or figure should be supplied with a legend sufficiently complete to make the table or figure intelligible without reference to the text. Footnotes may be used in connection with tables and figures where necessary. Footnotes should be avoided whenever possible in the text itself. Complicated formulas should be prepared with care in a form suitable for camera copy reproduction. Avoid such formulas in the text. Acceptable fonts include Times, New Times Roman, Arial, Courier, Helvetica, and Symbol. Table and figure format should follow those in issue **79***(2)* or later.

Example Table:

Table 1. Synthesis of PIT tag retention rates from American eel studies.

Study	Location of Study	Duration	Eel Length (mm)	Tag Location	Tag Retention
Thomas (2006)	Laboratory	6 months	$\geq$ 500	Dorsal musculature	100%
Morrison and Secor (2003)	Hudson River, NY	2 months	Mean = 457	Visceral cavity	89%
Verdon and Desrochers (2003)	St. Lawrence River, NY	1998-1999	Mean = 471.7 (1998) Mean = 468.7 (1999)	Behind the head	98%
Verdon et al. (2003)	Richelieu River, Quebec	1997-1999	Mean = 379.7	Dorsal Musculature	93.9%

Prepare figures and illustrations to be close to the expected size within the publications, with a width of no less than 3 inches (column width) or 6.5 inches for full-page width.

All illustrations and photographs will be published in black and white or grayscale. Use shaded fills for shapes and graphs. For figures with bars, shading, diagonal, and horizontal lines are allowable. Each bar fill-type should be clearly distinct. All drawn lines must be greater than 0.25 pts (0.1 mm) thick. All figures should have a white chart area. See WVAS *Proceedings* **79***(2)* or later for example formatting.

The recommended file format and resolution for various types of line drawing and photos are:

• Black and white line art, use 1000 dpi minimum resolution

• Half tone and grayscale – use minimum resolution of 600 dpi

• Images and photos need to be in grayscale with a minimum resolution of 600 dpi

All illustrations should be submitted electronically as a separate file for each figure. Acceptable file format are TIF, PDF, Microsoft PPT, DOC, or XLS. No other formats are accepted at this time.

Please note: Illustrations, graphs, and photos that do not comply with the recommended format will be returned to the author for correction. The manuscript will not be considered for review until it is resubmitted with the required corrections. Figures and tables covering more than one page should have the figure or table number repeated at the top of each of the other pages followed by the word "continued" within parentheses. Data, legends, and other identifiers that appear within a figure or table need to be large enough in the published version to be easily read.

5. Literature Cited

References shall be collected at the end of the manuscript as "Literature Cited" and must be cited in the text.

- Citations within text:

References should be cited by author and date within the text. Separate multiple citations with a semicolon.

- Example citations within text:

Single author: (Dare 2003)
Two authors: (Buzby and Deegan 1999)
Multiple authors: (Feldheim et al. 2002)
Multiple citations: (Buzby and Deegan 1999; Feldheim et al. 2002)

- Citations at the end of paper:

The title of the papers cited and the inclusive page numbers must be given.
The article title should be italicized and the journal name should be in normal font.
Bold the volume number, italicize the issue, and present page numbers in normal font.
End each citation with a period.
Citations should be formatted with hanging indentation of 0.5".
Do not skip a line between citations.

- Example journal citations:

Buzby, K. and L. Deegan. 1999. *Retention of anchor and passive integrated transponder tags by arctic grayling.* N. Am. J. Fish. Manage. **19**(*4*): 1147-1150.

Dare, M.R. 2003. *Mortality and long-term retention of passive integrated transponder tags by spring Chinook salmon.* N. Am. J. Fish. Manage. **23**: 1015-1019.

Feldheim, K.A., S.H. Gruber, J.R.C. de Marignac, and M.V. Ashley. 2002. *Genetic tagging to determine passive integrated transponder tag loss in lemon sharks.* J. Fish Biol. **61**: 1309-1313.

Example book citation:

Stacey, M. and S. A. Barker. 1960. *Polysaccharides of microorganisms*. Oxford Univ. Press. London. 228 pp.

Freemark, K. and B. Collins. 1992. *Landscape ecology of birds in temperate forest fragments* in J. M. Hagan, III and D. W. Johnston (eds.), Ecology and Conservation of Neotropical Migrant Landbirds, pp. 443-454. Smithsonian Institution. Washington, D.C.

6. Submission of Revised Manuscripts

All manuscripts accepted by the peer reviewers that need to be revised must be done according to instructions and submitted to the editor either by e-mail or on a compact disk.

7. Proof

If galley proofs are sent to authors for corrections they should be made on margins of the proof. Proofreader's marks may be found in dictionaries and in style manuals (e.g., "Style Manual for Biological Journals"). Changes in text after the manuscript is in galley proof are quite expensive and in general are not permitted. Galley proofs must be corrected and returned promptly (within ten days).

8. Reprints

A reprint order blank will be sent with the galley proofs. This should be returned with the corrected proof.

9. Cost of Publication

Authors will be billed by the Academy for pages in excess of the maximum allowed (see item 1). The cost of figures that require half-tone screens, such as photographs, will also be billed to the authors. Currently, a page charge of $15.00 per page is in effect, and the author will be sent a pro forma invoice to see if payment can be secured from the author›s institution, company, research grant, etc. Failure to honor page charges will not prevent publication of a paper, but will greatly assist the publication program of the Academy.