AC 2010-1911: TRAINING EFFECTIVENESS IN INNOVATIVE SCIENCE CURRICULUM

Stephen Snyder, Taylor University

Joshua Gates, Taylor University

Lydia Kilmer, Taylor University

Emily Paladin, Taylor University

Training Effectiveness in Innovative Science Curriculum

Abstract

In the summers of 2008 and 2009, 59 professors from 51 universities attended one of four high altitude ballooning program (HARP) workshops. The 2-day workshops were designed to equip participating professors with the materials, procedural knowledge, and educational techniques necessary to effectively implement high altitude ballooning into STEM classrooms. The first workshop was used as a pilot study to develop the assessment methods used in the subsequent workshops. The central research question was to determine if participation in the workshops enhanced the professors' ability and confidence in implementing a ballooning project into the classroom. After obtaining a Cronbach's Alpha of .92 and testing for validity, an 84 item HARP Workshop Assessment Tool© was administered as a pre-test and post-test at the beginning and conclusion of each workshop . A Repeating Measures ANOVA indicated significant growth in each of the four primary dependent variables: professor perception of their ability to intrinsically motivate students ($p < .001$, $Eta^2 = 0.31$), professor perception of their ability to promote metacognitive processes in students ($p < .001$, $Eta^2 = 0.54$), professor valuation of the HARP method ($p < .05$, $Eta^2 = 0.12$), and overall procedural knowledge ($p < .001$, $Eta^2 = 0.83$). The results indicate that the workshop's design effectively prepares professors to implement HARP into undergraduate STEM classrooms. This will ultimately allow students to have control of and be engaged in projects that expose them to the scientific method using an innovative, hands-on curriculum.

Introduction

Introduction of problem

The problem addressed in this research investigation was the training of professors to implement a program involving high altitude ballooning into the classroom. The program uses the High Altitude Research Platform (HARP) to facilitate student experiments in the environment of near space. It was the goal of the workshops to provide the professors with both the technical and pedagogical knowledge on how to execute a balloon launch experience at their home universities. The word *experience* should be emphasized because HARP has the potential to be an extended hands-on learning experience rather than just a one-day event. Therefore, time in the workshop was split between teaching the procedures of a balloon launch and articulating the possible educational techniques that could be used to maximize student learning as a result of participating in a ballooning experience. The basic itinerary of the workshops is contained in the table below.

Table 1: Workshop Schedule

Day One	
7:00 A.M.	*Registration*
7:05 A.M.	*Working Breakfast and Pre Assessment of Workshop*
8:00 A.M.	*Welcome*

8:10 A.M.	*Introductions and Overview of Goals*
9:10 A.M.	*Overview of Balloon and History of Taylor and Stratostar*
9:30 A.M.	*Introduction to the Different Payload Projects to be Implemented*
9:45 A.M.	*Introduction to Near-Space Environment and FAA Rules*
10:30 A.M.	*Introduction: Building Payloads*
11:30 A.M.	*Lunch*
12:00 P.M.	*Hands-On-Activity: Start Building Your Payloads*
2:00 P.M.	*How to Conduct a High Altitude Balloon Launch (Classroom)*
3:15 P.M.	*Field Preparation: Final Assembly of Balloon Payload*
4:00 P.M.	*Launch Balloons/Chase/Dinner*
Day Two	
7:00 A.M.	*Working Breakfast: Day One Launch and Recovery Recap*
8:15 A.M.	*Class Implementation and HARP Assessment Results*
9:30 A.M.	*Guest Speaker*
10:15 A.M.	*Data Analysis for Everyone (Intro to raw data format)*
12:00 P.M.	*Lunch*
12:30 P.M.	*Research options for Near Space*
1:00 P.M.	*Breakout Session (3): Technical, Funding, Course Implementation*
2:05 P.M.	*Implementation at Your University*
2:45 P.M.	*Nuts and Bolts of Starting a Program*
3:15 P.M.	*Post Assessment of Workshop*
4:00 P.M.	*Dinner and Closing Remarks- Focus Groups with feedback from Universities*

Relevance of program

It is a legitimate concern that the United States is currently falling behind in the area of science and technology in comparison to other countries[1]. Motivating undergraduates to enter Science, Technology, Engineering and Math (STEM) degree programs is one way to help to address this problem[2,3]. The High Altitude Research Platform (HARP) system does so by teaching the scientific method through applying experiments in the near space field. These experiments are developed by students using microelectronics (GPS, wireless, videos, miniature sensors, etc.). The program is intended to train students to practically apply theory to real-life problems to better prepare them for graduate school or employment in industry, and for students to learn to solve problems and overcome obstacles by performing original experiments in real world settings[3,4,5,6]. The workshops hosted at Taylor University trained professors to implement HARP into one of their courses to effectively impact students to learn and be motivated in science, technology, engineering, and math.

Relevance of training workshop

Without the practical technical and pedagogy applications done within the workshop the execution of the HARP educational tool would be an ineffectual event rather than an integrated methodology into the science curriculum of universities. A ballooning event is exciting but without instruction in pedagogy to integrate it into the science curriculum, it will not create an effectual change in science education.

Relevance of assessment model

It is also hoped that the triangulation model of assessment in evaluating this workshop might be helpful for others given grants from NSF to develop workshops, and to help professors to be trained in substantiating the effectiveness of the workshops. Workshops need to be rigorously assessed to evaluate the change they create. So often workshops can be attended but there is little proof that they warrant their own expense.

Background of program

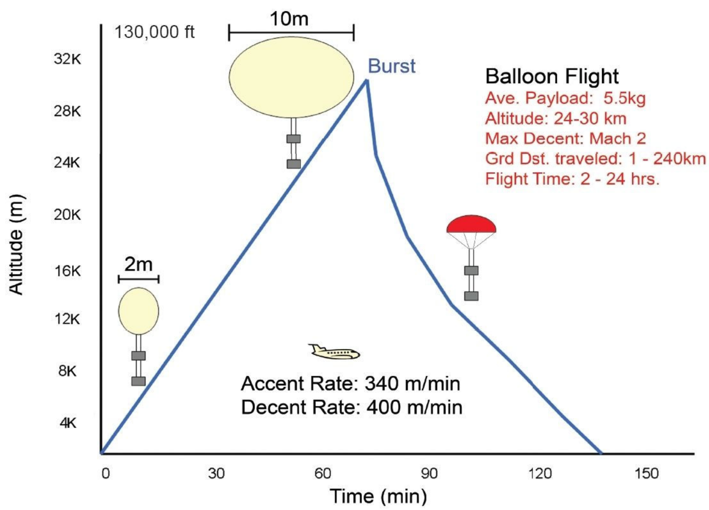
For seven years, Taylor University's HARP program has been providing students with the opportunity to apply their technical science and math instruction to interesting and relevant problems. The unique experience of a high altitude balloon launch, including team-based problem solving, prototyping, construction and direct experimentation, and the "hard" deadline of a launch gives students a taste of real-world project experience and has helped Taylor University's students be competitive as they pursue educational and career goals beyond the undergraduate level.

The HARP program was started in 2003 through an Indiana Space Grant Consortium grant and has since been the recipient of five consecutive grants for the continuation of the program, as well as matching funds from the Lilly Corporation, Taylor University's Center for Research and Innovation, and other INSGC grants which have focused on research for individual components of the system.

In Taylor University's use of the HARP program into its curriculum, students are enabled to experience every part of a truly professional research project. Once a specific problem is identified, the students are required to study the theory needed to perform their desired research. This process begins in the classroom, and as a sense of ownership builds, students quickly move on to explore the finer points of how best to perform their research. The result is that the theory presented in the classroom is retained and proceduralized into a skill[7].

The students are then required to do background research into the specifics of their chosen investigation, which enables them to ideate, prototype, build and test their own instruments. The model at Taylor University has included such experiments as the adaptation of Geiger counters for high-altitude energetic particle sensing and the modification of an electrocardiogram to sense e-fields in the atmosphere. In these kinds of projects, students begin to see links between the theories presented in the classroom and the components that they are working with; their education becomes practical as they troubleshoot, refine, and calibrate real instrumentation.

Fig: A typical high-altitude flight profile



It is at this point that students begin to experience some of the most unique aspects of an education involving high-altitude balloon experiments. There are real procedures which must be followed to ensure a successful launch, profitable data collection, and safe recovery of their payload. Students experience the excitement of a launch and the requirement for effective post-launch operations. While working in a "mission control" environment, students can keep track of their data, command and control their experiments, and keep track of the progress being made by the recovery team. The experience of how to handle operations in a stressful environment is valuable to students.

For each flight, payloads are constructed modularly and connected to the primary telemetry pod via a wireless network (using the 50 kbaud Zigbee wireless protocol). Once all of the experiment payloads have been verified and a communications link has been established between the telemetry pod, the recovery team, and the mission control center, the payload is released and ascends to altitudes ranging from 15 to 20 miles, beyond 98% of the earth's atmosphere (see fig). Throughout the flight experiment, position telemetry is reported over a 110 kbit link via 900 MHz spread-spectrum radios, and backup position data is broadcast via Amateur Radio APRS technology. During ascent, the balloon expands due to the reduced pressure, but eventually the balloon bursts and the payload returns on parachute with a vertical velocity at touchdown of approximately 1000 feet per minute, which, in fact, is gentle enough to be safely caught by hand.

Due to technical skills and the practical educational applications of integrating this curriculum tool, professors need to be effectively trained, given technical support as they implement the program, and given feedback in how effectively they are doing at integrating it into their curriculum. The goal of the workshop was to provide the training and being assured of having continual support as they implement the program.

Theory base

A Problem Based Instructional model[7] was implemented in this workshop experience. This educational model assumes that learning and doing are inseparable to the learning process. The intellectual goal of this model is to develop the professor's cognitive skills and strategies through an active participation within a community of learning[8,9,10]. In this model of learning, professors are able to see how experts tackle problems, and learn to solve problems through a mentoring process[9]. Professors are able to perform each part of the HARP program using their own balloon as they develop their own experiment and then begin to integrate it into their curriculum during the workshop.

Central assessment question

Can a two-day workshop effectively increase professor's confidence, knowledge, and skill in using High Altitude Research Platform (HARP) Ballooning in their science curriculum to intrinsically motivate students in their classrooms, value this problem based science curriculum, know how to effectively teach metacognitive planning, monitoring, and assessing when they implement this program, and have a high competence level of procedural knowledge pertaining to the execution of a ballooning experience?

Research Design

A pre-test post-test within group design was used to measure the changes each of the four previously mentioned dependent variables. Triangulation of survey, observational, and interview data from focus groups was performed to provide a valid and rich description of the workshop experience.

Definition of dependent variables

<u>Intrinsic Motivation</u>

Faculty's perception that the HARP program could increase the intrinsic motivation of their students was measured using Lepper's modified model for intrinsic motivation[11,12]. The model includes contextualization, curiosity, challenge, control, and cooperation (see Table 1). Contextualization or application means to overtly or covertly personalize knowledge to current or future life situations in order to change and grow. Curiosity is generated when new information creates inconsistencies or discrepancies in people's prior knowledge or their present expectations. Curiosity generates a feeling of wanting to investigate, become involved, or expand oneself to incorporate new information and have new experiences with the person or object that created the interest[12]. Challenge means calling a person to a demanding task that requires special effort and dedication in a supportive group. Control is the perception that one is an origin of the activities he or she attempts rather than a pawn. The student will believe he or she has self determined the activity undertaken or the product created. Cooperation means to pursue win-win situations where you and the other individual grow, accomplish tasks, and enjoy the process together. In this learning structure, knowledge is gained by support, participation and nurturing with others[14,15]. These areas of motivation will be assessed because of their strong connection to achievement, spending time on complex activities, learning and growth goals, the use of deeper and more reflective strategies for learning, more risk taking and the focus on the learning process[11].

Valuing HARP

A goal of the HARP workshop was for professors to value of the HARP program in increasing student's attitude to value science. This goal was assessed specifically by measuring the increase in faculty valuing the HARP program as a way to help students to value science the problem solving process, the calibration process, the scientific method in application to real life problems, documenting for repeatability, data analysis, metacognitive planning, monitoring and assessing, cooperation for scientific advancement, and time management for meeting deadlines.

Metacognitive Processes

The professors' confidence in using the metacognitive processes of control (planning and assessing) and monitoring of their student's cognitive processes was assessed to see if it increased through the training of the HARP workshops[16,17,18]. Metacognitive planning involves stating a goal, selecting an operation, identifying potential obstacles or errors, identifying ways to recover from the obstacles, and predicting results desired and or anticipated. Metacognitive assessing involves evaluating goal achievement, judging accuracy and adequacy of the results, evaluating appropriateness of procedures used, assessing how well one handled the appropriateness of procedures used, assessing the handling of obstacles, and judging the efficiency of the plan and its execution. Metacognitive monitoring involves keeping the goal in mind, keeping one's place in a sequence, knowing when a sub goal has been achieved, deciding when to go on to the next operation, spotting errors or obstacles, and knowing how to recover from errors or obstacles. Metacognition has been selected to be assessed because of its key role in transferring knowledge and skills[19,20], effective problem solving[21,22], thinking and learning [18, 23,24], and memory[25,26].

Procedural Knowledge

Procedural knowledge was measured by the extent to which professors leave the workshop feeling confident that they can go through the entire process of conducting a successful launch within the context of their science curriculum. Their confidence in their ability to raise support, implement curriculum, and acquire materials was measured. Participants were measured in their ability to construct pods, learn proper launch procedure, understand communications/telemetry, analyze the raw data, and apply the scientific method to the unique curriculum. These skills are imperative for a successful launch, and if professors are able to learn them well, then their chance of success implementing the HARP program is greatly increased.

Methods

Pilot Study

A pilot study was conducted on the workshop with a small number of professors to seek to improve the process of the workshop and the assessment procedures used for evaluation. These pilot study results were discussed with a program committee that was developing the workshops and an A, B, C priority list was generated that indicated what would be changed, by whom, and by what time frame.

Subjects

There were a total of 59 professors from 51 different universities participating in three workshops. There were various years of teaching experience ranging between 1-32 years among the participants but a majority did not have experience in High Altitude Ballooning or integrating it strategically into their curriculum. There were participants from ten or more different states participating in the three workshops.

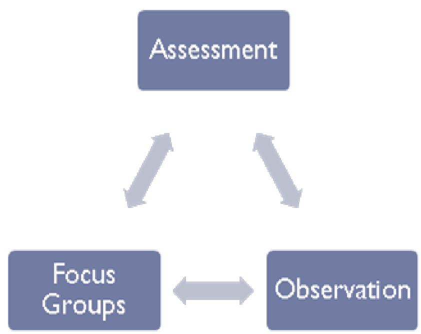
		August 2008	**June 2009**	**July 2009**
Gender	Male	11	15	19
	Female	4	7	3
Years of Teaching Experience	0-5	3	(missing)	9
	6-10	6		4
	11-15	1		3
	16-20			1
	21+	4		5
	No response	1		
High altitude ballooning experience	No	10	13	14
	Yes	3	5	6
	No response	2	4	2
Total		15	22	22

Number of universities represented	15	18	18
Number of states represented	10	10	12

Assessment Methods

A triangulation assessment approach was used to obtain the best data concerning the workshop. Data on the successfulness of the workshops from a pretest posttest survey, observations by an assessment team using multiple hats, and focus groups of the workshop participants.

Model 1: Triangulation Analysis for Holistic Assessment



HARP Workshop Assessment Instrument

A pretest and posttest for the workshop was developed from the objectives of the HARP curriculum for instructing students. The scales for the instrument were developed from important educational foci including intrinsic motivation, metacognitive processes, procedural knowledge, and content of the learning domain. The instrument was structured around likert scale questions ranging from 1 (Strongly Disagree) to 6 (Strongly Agree) with each numerical value having a specific description. Questions were constructed to determine if the professor believed that by coming to the workshop that they could help their students develop the educational foci mentioned above. For example, the in the posttest professors were asked, "Has the HARP workshop helped you have the ability to have students apply the concepts that they will learn from my classes?" Pools of questions were developed for the scales within the instrument after itemizing from critical educational constructs and asking a focus group for important content areas to include.

A pilot study was conducted on a workshop and appropriate changes were made in the instrument to increase reliability using the Cronbach Alpha method, suggestions from a focus group of participants, those conducting the workshop and a team of six assessing the workshop.

The revised pretest and posttest are parallel to one another, each consisting of 83 questions. The intrinsic motivation section consisted of 18 questions and was divided up into a contextualization (3), curiosity (3), challenge (4), control (3), and cooperation section (5). Section two, valuing the HARP method, had a six question scale. The third section measured the metacognitive processes of metacognitive planning (5), assessing (7), and monitoring (6). The last section, measured procedural knowledge (41), included raising support (4), curriculum implementation (4), instrument acquisition (7), pod construction (5), launch procedure (4), communication/telemetry (9), data analysis (4), and scientific method integration (4).

The pretest was used to measure the baseline of the participating faculty's perceived ability to effect their students in intrinsic motivation, valuing high altitude ballooning, metacognitive processes, and procedural knowledge. The similarly structured posttest was developed to measure changes in the participating faculty due to the two-day workshop. The pretest was administrated before the workshop began and the posttest was administrated at the end of the workshop.

The pre/post assessments were analyzed using Repeating Measure ANOVAs . Statistical significance was found using the following probability levels: $p<.05$, $p<.01$, $p<.001$=significant; $p>.05$= not significant. The smaller a probability value is, the smaller the probability that that pretests and posttests were the same. An Eta Squared practical significance test (Effect Size) was also calculated for each area. As a gage for practical significance, the larger the value is over .20, the more effective the workshop was in affecting change in the workshop participants. Practical significance indicates the extent to which change observed in the participants can be attributed to the workshop experience. It indicates the amount of variation of change that is due to the workshops alone.

Reliability

The Cronbach's Alpha for overall internal consistency showed $r(58) = .967$. A quality Cronbach's Alpha score includes any value equal to or above .70. The upper .90 range indicates that the HARP Workshop Assessment Tool has extremely high reliability. The reliability of the subsections of the instrument of the posttest was .927 for intrinsic motivation, .855 for valuing the HARP method, .934 for metacognitive processes, and .863 for procedural knowledge (See Table 2.).

Validity

Construct Validity was established in the assessment, as professors in Engineering Sciences were asked to help develop questions for the workshop evaluation that would accurately measure what participants had learned. The Known Group Difference method was used on the pilot study to assess the validity of the instrument. There was found to be significant differences between the pretest/posttest scores demonstrating validity of the instrument. Subsequent workshops have indicated the same differences between the pretest and posttest scores.

Observations

A team consisting of four to six undergraduate psychology majors and a psychology professor at Taylor University observed the entirety of the workshop. Each team member focused on a unique perspective during the workshop and made notes relating to this perspective. Each team member was asked to either put on a "black hat" to observe any negatives within the workshop, a "white hat" to observe all the specific events and details of the workshop, a "yellow hat" to find all the positive elements of the workshop, a "green hat" to think of any improvement suggestions that could be made, or a "red hat" to find all the aspects that the workshop participants were passionate about.

After the workshop, the research team compiled all of the notes they had made. From these observations, they categorized the comments into organization, leadership, educational process, resources, participation, and context. These categories were used to organize their observations for the workshop organizers and then develop a checklist to evaluate each improvement area that needed to be changed in the next workshop. The workshop organizers then ranked the changes that needed to be made according to their priority for change and then designated people were responsible for making changes for the next workshop. This process provided a continual improvement plan for the workshops and a second source of data for our holistic assessment of changes in the faculty that attended the workshop.

Focus groups

At the closing banquet each university was asked to give their perspective on three questions. The first question asked what was the most important thing they had gained from the workshop; the second question asked them to indicate in what class they were planning on implementing the program; and the third question asked the participants what they currently needed most from Taylor University.

Results

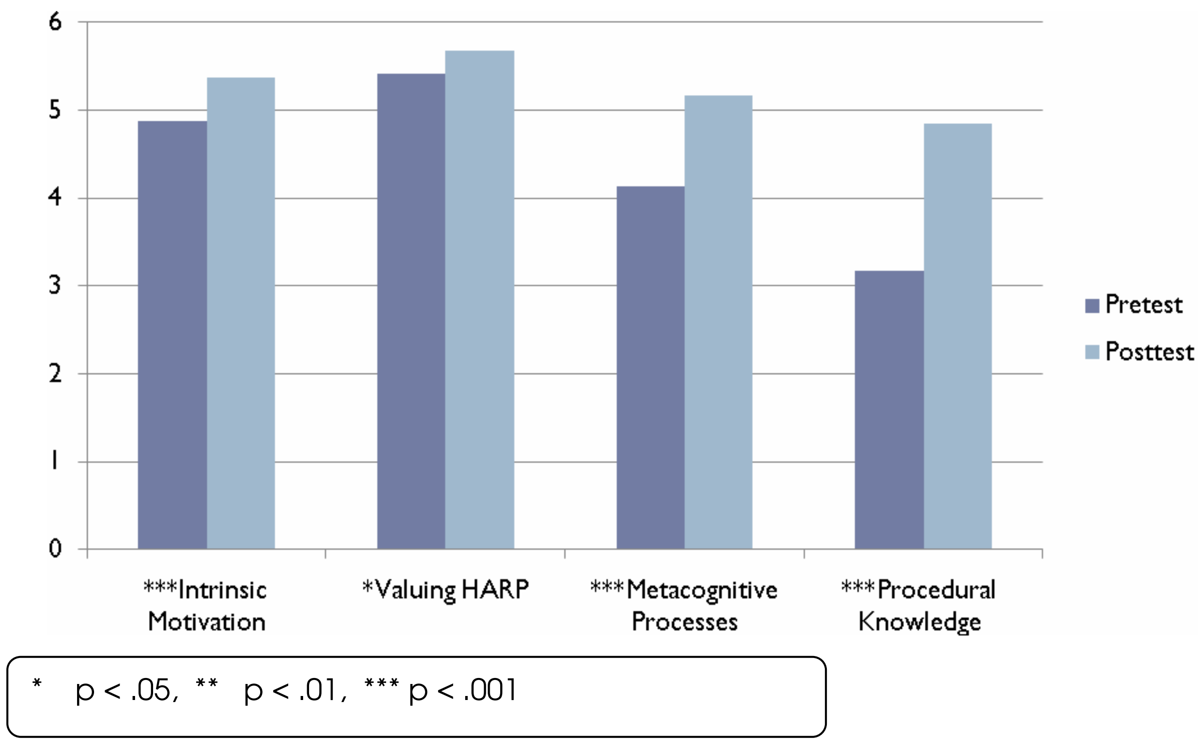
Executive Summary

All four of the primary scales under study indicated statistically significant growth from pretest to posttest ($p<.05$). Practical significance (Eta^2) was found in three of the four areas—values ranged from .31 to .85. The only area that did not indicate practical significance was Valuing HARP ($Eta^2=.12$). It is important to note that the Valuing HARP area may not have achieved practical significance because it had the highest pre-test mean (5.42), which would have left little room for growth. Those high scores indicated that the professors already valued the HARP program and saw its benefit to science. In a focus group, one professor noted that the workshop allowed him to "come away with confidence that I could really get the students excited about science." The Intrinsic Motivation scale demonstrated a mean net gain of .49 with means growing from 4.87 on the pretest to 5.37 on the posttest ($p<.001$). Valuing HARP had a pretest mean of 5.42 that grew to 5.68 on the posttest with a net gain of .26 ($p<.05$).

Metacognitive processes showed a net gain improvement of 1.03 with a pretest mean of 4.14 to a posttest mean of 5.17 ($p<.001$); the scale's practical significance was .54. Procedural knowledge had an average net increase of 1.69 with means growing from 3.17 on the pretest to 4.85 on the post test ($p<.001$), and the practical significance value for Procedural Knowledge was found to be large with an Eta^2 value of 83). *See figure 1.*

Growth in the above areas indicates that the High Altitude Balloon Research Platform Workshop is accomplishing its objectives at a very high level. Practical significance indicates the amount of variance that can be accounted for in each variable and that HARP workshops were effective for teaching individuals to launch balloons, chase and recover pods, analyze data, and implement these processes within their classrooms.

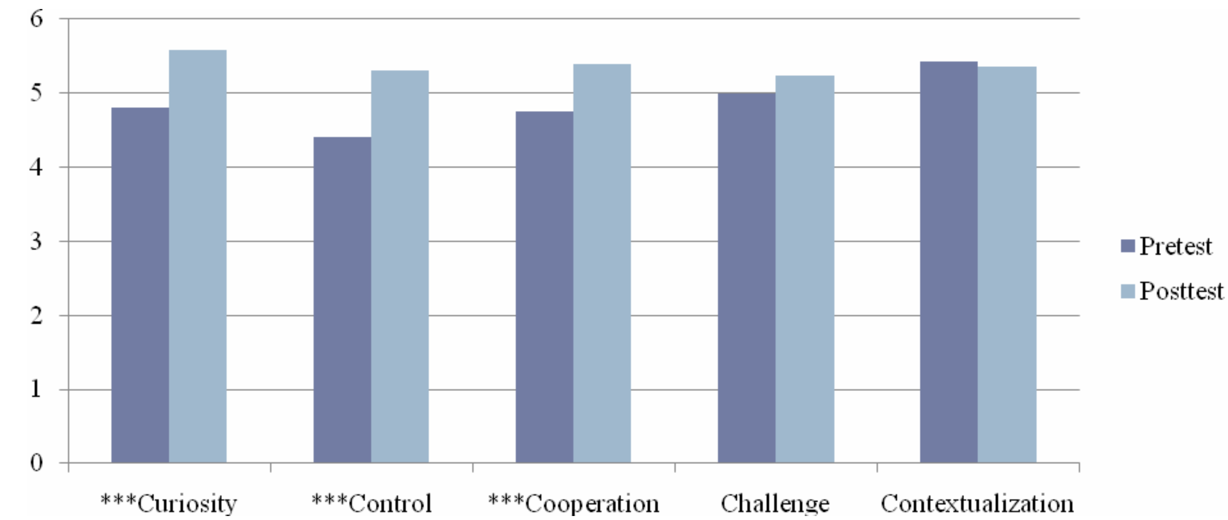
Figure 1: Pre and Post Primary Scale Comparison (6-Strongly Agree to 1-Strongly Disagree)



Intrinsic Motivation

Of the five subscales for intrinsic motivation, three were statistically significant ($p<.001$): curiosity, control, and cooperation. The two subscales that were not significant were challenge and contextualization ($p>.05$). Practical significance was found for all statistically significant scales (Eta^2 Range=.31-.55). *See figure 3.* Curiosity grew from a mean of 4.81 to 5.58 ($p<.001$) with an Eta^2 value of .31. Workshop observers noted that participants seemed "genuinely interested and curious" about the balloon launch process. Within control, there was found a statistically significant growth with the pretest mean of 4.40 rising to the posttest mean of 5.30 ($p<.001$, $Eta^2=.55$). In the focus groups, participants noted that they had appreciated the "hands-on process" of constructing their own pod. For cooperation, there was a statistically significant increase ($p<.001$) with the pretest mean of 4.76 improving to the posttest mean of 5.40 ($Eta^2=.32$). Observers noted that the participants seemed to "work well together," "socialize and interact during breaks," and to "network effectively." In challenge, the mean increased from 5.00 to 5.23, but that growth was neither statistically nor practically significant. However, challenge was not a significant goal of the workshop because of the "plug and play" nature of pod construction; rather, the purpose of the workshop was to teach participants that pod construction and balloon launches were simple and easy—to the extent that nearly any participant could successfully complete the process independent of professional supervision. Lastly, within contextualization there was a small, statistically insignificant, mean decrease of .07 (from a 5.43 on the pre-test to a 5.36 on the post test).

Figure 3: Pre/Post Mean Comparison: Intrinsic Motivation Subscales (6-Strongly Agree to 1 Strongly Disagree)

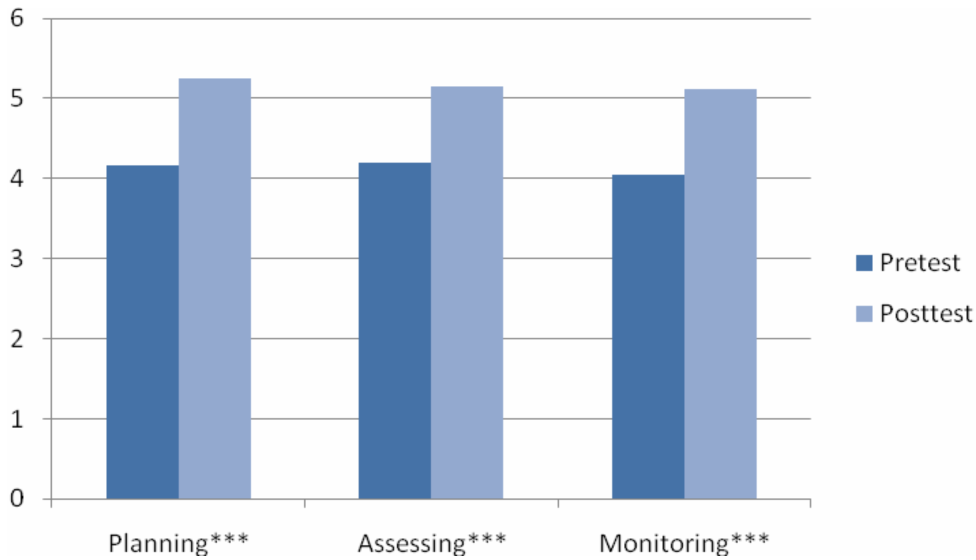


* p < .05, ** p < .01, *** p < .001

Metacognitive Processes

All three subscales of metacognitive processes indicated both statistically and practically significant growth from pretest to posttest ($p<.001$, Eta^2 range=.43-.51). Observers noted that the participants had the opportunity to plan, assess their data, and monitor their success throughout the pod construction, launch, and recovery process. Within metacognitive planning, the pretest mean of 4.16 increased to 5.25 on the posttest ($p<.001$, $Eta^2=.50$). Metacognitive Assessing means grew from 4.20 on the pretest to 5.15 on the posttest ($p<.001$, $Eta^2=.44$). And metacognitive monitoring saw significant mean growth: from 4.05 on the pretest to a mean of 5.12 on the post test ($p<.001$, $Eta^2=.51$). *See Figure 4.*

Figure 4: Metacognitive Processes Subscales Pre/Post Mean Comparison (6-Strongly Agree to 1-Strongly Disagree)

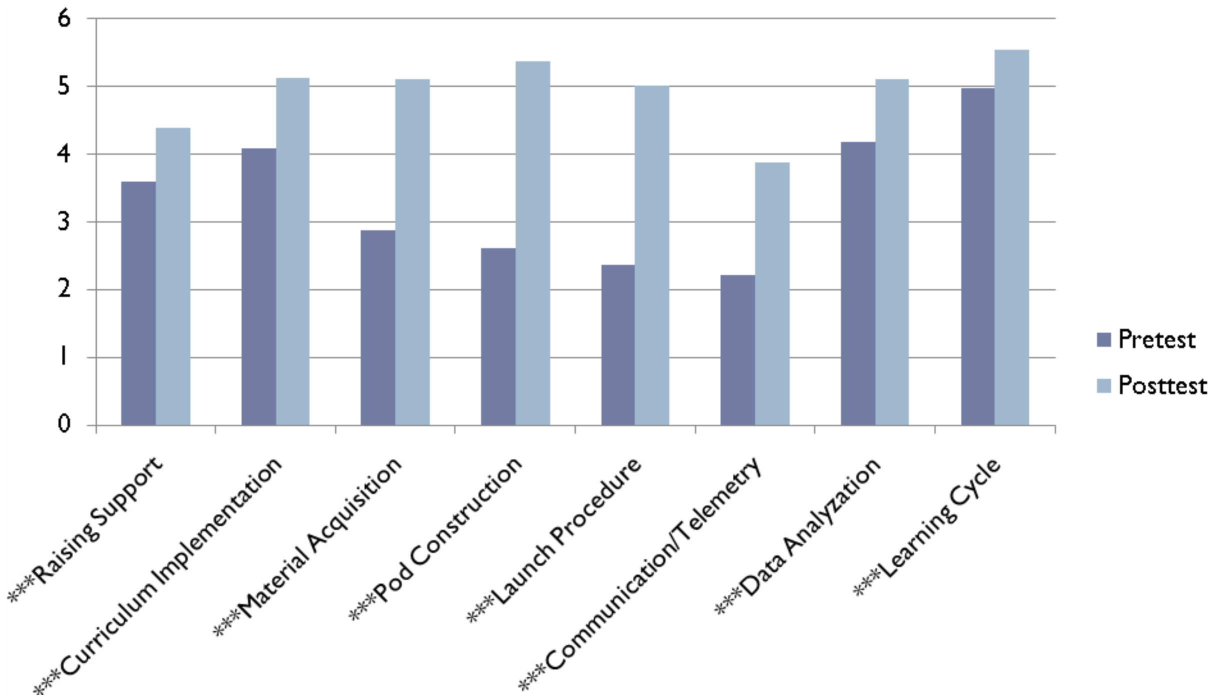


* p < .05, ** p < .01, *** p < .001

Procedural Knowledge

Of the eight subscales for procedural knowledge, all eight indicated both statistical and practical significance ($p<.001$, Eta^2 range .33-.82). This level of statistical and practical significance indicates that workshop attendees gained new knowledge of how to go through the processes of a successful launch and gained practical experience that will guide them in implementing the program at their respective universities. Raising Support indicated statistically significant growth with means improving from 3.59 to 4.39 (Eta^2=.38). In the Focus Group, participants mentioned that the breakout session on funding helped them realize how to acquire resources to conduct balloon launches. Curriculum Implementation had a pretest mean of 4.09 that grew significantly to 5.13 on the posttest (Eta^2=.53). During a Focus Group, a participant mentioned that he appreciated the "scalability of the program…that it can be applied in general education, outreach programs, and upper level sciences." Material Acquisition means increased from 2.87 on the pretest to 5.10 on the posttest with an effect size (Eta^2) in the upper medium range of .78. Participants perceived their ability to Construct Pods much higher after the post test (Pre Mean=2.61, Post Mean=5.37). Practical significance for Pod Construction was in the large range (Eta^2=.82). Launch procedure means grew from a 2.36 on the pretest to 5.01 on the posttest (large range Eta^2=.80). During the Focus Group, one participant mentioned that going through the whole process step by step "gave me the confidence to launch the balloon." Communication/Telemetry knowledge grew from 2.21 on the pretest to 3.88 on the post test (Eta^2=.69). Participants perceived their ability to Analyze Data higher after the workshop with means growing from 4.19 to 5.10 on the post test (Eta^2=.45). And growth in the Learning Cycle indicated a practical significance (Eta^2) of .33 with means growing from 4.97 on the pretest to 5.54 on the posttest. *See figure 5.*

Figure 5: Pre/Post Mean Comparison Test: Procedural Knowledge Subscales (6-Strongly Agree to 1-Strongly Disagree)



* p < .05, ** p < .01, *** p < .001

Discussion

Theory Base

The Problem Based Instructional model[1] was shown to be highly effective in educating professors through this workshop experience. This educational model assumes that learning and doing are inseparable to the learning process. The intellectual goal of this model is to develop the professor's cognitive skills and strategies through sustained participation within a community of learning[8,9,10]. By having professors be involved in each of the specific aspects of using the HARP Ballooning program during the workshop, professors perceived that they could effectively apply the program at their own university. This instructional model allowed professors to physically do each procedure, ask questions, be able to see how experts tackle problems, and learn to solve problems through a guided mentoring process[3]. In using this instructional method, the workshop taught the process of instruction they should use for their classroom as well.

Central Assessment Question

The results indicate that the two-day workshop was able to effectively increase professor's confidence, knowledge, and skill in using High Altitude Research Platform (HARP) Ballooning in their science curriculum to intrinsically motivate students in their classrooms, value this problem based science curriculum, know how to effectively teach metacognitive planning, monitoring, and assessing when they implement this program, and have a high competence level of procedural knowledge pertaining to the execution of a ballooning experience.

Of the 21 scales and subscales measured, 18 (86%) indicated statistically significant growth from pre to post testing ($p<.05$). And of the 18 statistically significant scales, 17 indicated practical significance with a range of .31 (small) to .82 (large). Growth in intrinsic motivation indicates that professors perceive that they can effectively intrinsically motivate their students using the HARP curriculum in contrast to their current curriculum. Growth in valuing HARP indicates that the professors perceive that the HARP program will increase the value that their students place on science compared to the way they are currently teaching their classes. Significant growth in all areas of metacognitive processing reveal that participants learned how communicate to their students to plan experiments by making proper goals, assessing the results and outcomes of the launch, and monitoring steps that would lead them to a successful launch. Finally, growth in all eight areas of procedural knowledge indicates that workshop attendees left with adequate skills to conduct, and pass on, launch capability to other faculty and students at their respective universities. Not only do participants indicate knowledge of the technical aspects of executing a launch, but they are also aware of how to raise funds, develop curriculum, and acquire materials.

Implications for STEM Workshops

It is hoped that the assessment procedure in this investigation could be a model for future evaluation of STEM workshops. The assessment process needs to begin with clear and measurable goals that are operationalized so that a pretest and posttest can be developed to measure changes in participants in a reliable and valid manner. It is also suggested that a triangulation process of assessment be utilized so a more holistic and complete assessment is conducted, gathering both qualitative and quantitative data. A pilot workshop that simulates the actual workshop with an assessment process is recommended. This pilot workshop allows for effective modifications in the workshop process and the assessment procedures.

Limitations

The first limitation of this investigation is that it measures professors' perceived changes, not observed differences. The area in which this is most applicable is procedural knowledge. To add to the quality of the investigation, follow-up data should be gathered regarding the success in later attempts to integrate a ballooning experience into the classroom and the professors should be interviewed regarding the effectiveness of the training after they had conducted a balloon launch. These enhancements to the design of the study are currently being implemented, but as of yet, they have not been integrated into the results.

The second limitation in the design of the present study was that it involved a pretest-posttest design rather than a true experimental design. Because of this, findings could not be deemed causational. To reduce this error the investigation measured three separate workshops which further reduces invalidity of the conclusions of the investigation.

Conclusion

Workshop Change

The training of the professors in the two-day workshop was shown to be statistically and practically significant. In each, the professors' perception of their ability to intrinsically motivate students, the professors' perception of their ability to promote metacognitive processes in students, professors' valuation of the HARP method, and overall procedural knowledge of professors significantly increased. The results indicate that the workshop's design effectively prepares professors to implement HARP into undergraduate STEM classrooms.

Workshop Assessment Model

It is hoped that the assessment procedure in this investigation could be a model for future evaluation of STEM workshops. The assessment process needs to begin with clear and measurable goals that are operationalized so that both a pretest and posttest can be developed to measure changes in participants in a reliable and valid manner. It is also suggested that a triangulation process of assessment using surveys, observations of independent researchers, and focus groups be utilized so a more holistic and complete assessment is conducted, gathering both qualitative and quantitative data. The educational variables assessed are encouraged to be included in other CCLI STEM workshop survey assessments. A pilot workshop that simulates the actual workshop with an assessment process is recommended. This pilot workshop allows for effective modifications in the workshop process and the assessment procedures.

Table 1. Definitions of Dependant Variables

Intrinsic Motivation	This scale measured how well professors perceived that they are able to facilitate intrinsic motivation when using the HARP program as they instruct their students. The scale measured **contextualization, curiosity, challenge, control, and cooperation**. **Contextualization** or application means to overtly or covertly personalize knowledge to current or future life situations in order to change and grow. **Curiosity** is generated when new information creates inconsistencies or discrepancies in people's prior knowledge or their present expectations. **Challenge** means to invite a person to a demanding but meaningful task that requires special effort and dedication in a supportive Group**.** **Control** is the perception that you are an origin of an activity not a pawn.

	Cooperation means to pursue win-win situations where you and the other individual grow, accomplish tasks, and enjoy the process together. In this learning structure, knowledge is gained by support, participation and nurturing with others
Valuing Science (the HARP Method)	It is defined as how well a professor or implementer of the HARP program is able to influence students to value science education, future discovery, as well as future careers in science. There is a specific emphasis placed on the value of the problem solving process, documentation repeatability, and data analysis.
Metacognitive Processes	**Metacognitive planning** involves stating a goal, selecting an operation, identifying potential obstacles or errors, identifying ways to recover from the obstacles, and predicting results desired and or anticipated. **Metacognitive monitoring** involves keeping the goal in mind, keeping one's place in a sequence, knowing when a sub goal has been achieved, deciding when to go on to the next operation, spotting errors or obstacles, and knowing how to recover from errors or obstacles. **Metacognitive assessing** involves evaluating goal achievement, judging accuracy and adequacy of the results, evaluating appropriateness of procedures used, assessing how well one handled the appropriateness of procedures used, assessing the handling of obstacles, and judging the efficiency of the plan and its execution.
Procedural Knowledge	It is the professors' understanding of the procedures with which they need to be skillful at to execute the HARP program. The procedural knowledge includes the ability to raising support, the implementation of curriculum, instrument acquisition, pod construction, launch procedure, communications/telemetry, data analysis, and the integration of the scientific method into the program.

Table 2. Cronbach Alphas for Scales of Survey

Scale	N (Items)	Pretest Alpha	Posttest Alpha
Intrinsic Motivation	18	.944	.927
Contextualization	3	.779	.964
Curiosity	3	.883	.842
Challenge	4	.877	.800
Control	3	.905	.713
Cooperation	5	.925	.817

Valuing HARP Method	5	.736	.855
Metacognitive Processes	18	.963	.934
Metacognitive Planning	5	.889	.872
Metacognitive Monitoring	7	.939	.783
Metacognitive Assessing	6	.927	.930
Procedural Knowledge	41	.879	.863
Raising Support	4	.769	.911
Curriculum Implementation	4	.744	.934
Material/Instrument Acquisition	7	.871	.428
Pod Construction	5	.964	.824
Launch Procedure	4	.769	.721
Communications/Telemetry	9	.939	.889
Data Analysis	7	860	.745
Learning Cycle/Scientific Method Integration	7	.926	.920

Key
Alpha > .6: Fair
Alpha > .7: Good
Alpha > .8: Excellent

Table 3. Results from three workshops. Bolded scales indicate super-ordinate scales. Non-bolded scales are sub-scales of the preceding super-ordinate scale.

1- Strongly Disagree 2- Moderately Disagree 3-Mildly Disagree 4-Mildly Agree 5- Moderately Agree 6- Strongly Agree

Statistical Significance
Red $p < .05$
Green $p < .01$

Practical Significance
Red: Small
Green: Medium

Dependent Variable	Mean Scores	Std. Deviation	F	Statistical Significance	Practical Significance Eta Squared
Intrinsic Motivation	Pre: 4.87 **Post: 5.37**	.79 .62	**23.82**	**.001**	**.31**

Dependent Variable	Mean Scores	Std. Deviation	F	Statistical Significance	Practical Significance Eta Squared
Curiosity	Pre: 4.81 **Post: 5.58**	1.11 .48	**24.26**	**.001**	**.31**
Control	Pre: 4.40 **Post: 5.30**	.83 .66	**66.50**	**.001**	**.55**
Cooperation	Pre: 4.76 **Post: 5.40**	.86 .52	**25.26**	**.001**	**.32**
Challenge	Pre: 5.00 **Post: 5.23**	.79 .65	3.49	.067	.06
Contextualization	**Pre: 5.43** Post: 5.36	.63 .71	.007	.539	.01
Valuing HARP	Pre: 5.42 **Post: 5.68**	.66 .56	7.00	**.011**	.12
Metacognitive Processes	Pre: 4.14 **Post: 5.17**	.96 .59	**64.23**	**.001**	**.54**
Metacognitive Planning	Pre: 4.16 **Post: 5.25**	1.12 .58	**52.98**	**.001**	**.50**
Metacognitive Assessing	Pre: 4.20 **Post: 5.15**	1.03 .63	**41.59**	**.001**	**.44**
Metacognitive Monitoring	Pre: 4.05 **Post: 5.12**	1.12 .71	**55.04**	**.001**	**.51**
Procedural Knowledge	Pre: 3.17 **Post: 4.85**	1.22 .76	**259.26**	**.001**	**.83**

Dependent Variable	Mean Scores	Std. Deviation	F	Statistical Significance	Practical Significance Eta Squared
Raising Support	Pre: 3.59 **Post: 4.39**	1.23 .69	**32.54**	**.001**	**.38**
Curriculum Implementation	Pre: 4.09 **Post: 5.13**	1.21 .91	**61.69**	**.001**	**.53**
Material Acquisition	Pre: 2.87 **Post: 5.10**	1.20 .68	**190.02**	**.000**	**.78**
Pod Construction	Pre: 2.61 **Post: 5.37**	1.40 .66	**245.03**	**.000**	**.82**
Launch Procedure	Pre: 2.3 **Post: 5.01**	1.26 .80	**218.20**	**.000**	**.80**
Communication/ Telemetry	Pre: 2.21 **Post: 3.88**	1.08 1.10	**120.00**	**.000**	**.69**
Analyze Data	Pre: 4.19 **Post: 5.10**	1.36 .90	**43.74**	**.000**	**.45**
Learning Cycle	Pre: 4.97 **Post: 5.54**	.86 .60	**26.70**	**.000**	**.33**

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