The Effect of Using a Standardized Lab Notebook Protocol on the Science Literacy, Biotechnology Skills and Confidence Levels in the AS Level AICE Biology Class

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Abstract: The purpose of my research proposal this year was to investigate what the impact of a professional science notebook would make on the progression of science literacy skills as defined by The National Academy of Sciences and the basic skills used in biotechnology labs in a high school AICE Biology class. The formal and final summative assessment for the implementation of this notebook will be measured in the scores of the AICE Biology students' lab practical exam on May 8th, 2012. The summative assessments for this progression were documented in the lab reports, lab notes and other basic skills that were recorded in the lab notebooks. Protocol for keeping a good lab notebook was that of the Hayden McNeil Scientific Lab Notebook and the directions presented by Dartmouth University as outlined in the back of the notebook. Every student in the AICE Biology class was issued their own lab notebook at no cost to them. This report will also include Likert Scales depicting the confidence level of the students in preparation for their AICE Bio lab practical, or better known as, Paper 3. Although the students will not take their Paper 3 until May 8th and get their results in mid August, it was concluded that the addition of the notebook to the curriculum helped to prepare them in both confidence and skills leading up to the test.

Rationale: As of this writing, I am closing out the second year that I am teaching the AICE Biology class at Rockledge High School. The AICE Bio is from the University of Cambridge Center for International Exams. This is a college credit course should the students successfully complete it and passes 3 different exams. This is the fifth year it was offered at RHS.

At first I questioned whether I was the best fit since my degree is geared more toward psychology and biomedical sciences merely being a major interest of mine. But the students have always responded well to me and the courses I have taught. So the administration approached me and offered the class in hopes of building it into one of the more popular advanced level science classes offered at RHS. It is the intent of our school to be one of the premier AICE schools in Florida and the US. A stretch goal for me was to increase the number of students registering for AICE Bio as an elective for next year. This current year had 19 students; I wanted to at least double that number.

I asked the current students enrolled in AICE Bio why they chose this course this year and they responded for two reasons; strength of schedule and the fact that I would be teaching it. Some of them had approached me at the end of the previous year about the course and I had promised them that next years' class would be incredible. That I would be attending the Bench to Bedside program offered by CPET at UF and that I would come back with some greater skills, opportunities and better intent. I did not know at the time what I would be bringing back, but I knew it would be a best fit for me, the students and the class.

So the preparations for year two were full of intent and purpose. They included:

- CPET Program Bench to Bedside 2011
- CPET equipment locker program,
- Two classroom visits from a CPET professor, Houda Darwiche, PhD
- Field trip to University of Florida for 2 advanced labs

    - pGLO
    - bacterial transformation
- Summer workshop that extended into the school year with two other AICE Bio teachers from neighboring schools totaling 40 hours at this time
- A rewrite of my previous years curriculum to better align with the AICE standards and include some of the CPET B2B material
- An online CIE course for evaluating lab practical skills for Paper 3 preparation
- A daily mental reflection of making sure I was giving this class my best effort.

On day one of the B2B program, it occurred to me that best fit to tie all of these events together would be the implementation of the notebooks. The notebook would provide a new and privileged way to keep records of all the students' work. I knew that it was time the students learn how to create and keep a professional science notebook, the time of lab handouts was over! Now that may sound novice to some scientists, but one needs to understand that I too, was a novice, and wanted to start at square one with the students. Also students are so used to hand outs, I wanted to break them of this dependency. Instead they need to know how to correctly document their work from a complete blank page. The lab practical should be handled with confidence, skills and care. I felt strongly that by implementing the notebook skills with the lab skills would be a win-win situation for the students. It is my prediction that the implementation of these notebooks will help the students pass the AICE Biology exam.

According to the Cambridge International A/AS Level Biology Revision Guide (Jones 2010), students are encouraged to build their lab skills up bit by bit, to learn that success is building on prior skills so that by the time they reach Paper 3, they have the confidence to perform the task, tabulate or graph data and write a solid conclusion, all in the allotted time slot (Jones 2010). Paper 3 may include a serial dilution that the students should be able to calculate and create with efficiency. Examples of a Paper 3 wet lab may be an investigation into one of the following:

1. The effect of an enzyme or enzyme inhibitor on a substrate.
2. Transport through a cell membrane of different solutes.
3. Testing for the presence of biological molecules.

Neither the students nor I will know the nature of this lab until they open their papers. I will be responsible for preparing solutions and labeling them and I will also have a list of the equipment they will need, but I will not be privy to the lab itself. They will not be allowed to work with their lab partners nor ask questions. It will be assumed that they have the skill set prior to these labs and may not even have the full instructions on how to complete them, in other words, Paper 3 is not so much a lab on results as it is the competencies to apply lab skills in a hypothetical situation. It is the competencies that I was predicting the lab notebook protocol will have a positive effect on. By the time the students are taking paper 3, they should be confident in calculating a dilution, correctly tabulating and graphing data, and summarizing the results due to the steady and standardized lab notebook skills they will be engaging in.

Using the creation of serial dilutions as an example, the students learning must shift from simply being able to create the dilutions (the procedures) and instead be able to conclude why they are getting results within certain ranges and not other ranges (the learning goal). Life occurs within certain pH, temperature, light and other such ranges and this is one of the goals of AICE Bio, to make predictions based on learning. The students are keeping track of all these skills in their notebooks and will always have the original to reflect back on. Therefore, by using the lab notebook protocol, the students will be actively engaged in watching their growth of skills and this will transfer over to greater comprehension of learning goals. As the year progresses and the labs increase in difficulty, students will have the competencies.

Another reason why I had decided to implement this idea is in the best interest of the students when they reach college level laboratories and beyond. According to America's Lab Report an appreciation for scientific culture and literacy has not been well cultivated in America's high schools in the last 30 years (National Academy of Sciences, 2005). They have strong evidence that most high school teachers and lab manuals often emphasize procedures over learning goals and that most high school lab experiences do not follow the instructional design principles for effectiveness identified by the National Academy of Sciences. They also state the overall lab experiences are very poor for high school students. These statements reinforced my belief that I needed to go above and beyond what was expected in just any high school science class. I believe that focusing on the proper use of documenting labs and getting away from lab hand outs, will transfer over to an increase in students' overall understanding of scientific learning goals. True comprehension and not just completion skills would be learned. I had pledged to my students that they will have a significant increase in confidence and lab skills by the end of this course.

So this year I focused on the formative assessments of four principles of instructional design that are outline by America's Lab Report. These will help lab experiences achieve their intended learning goals. These goals aligned perfectly with the AICE expectations. They are:

1. The labs are designed with clear learning outcomes in mind.
2. They are thoughtfully sequenced into the flow of classroom science instruction.
3. They are designed to integrate learning of science content with learning about the process of science.
4. They incorporate ongoing student reflection and discussion.

Therefore, by keeping the goals of the National Academy of Science and the Paper 3 expectations in mind, my area of focus was to implement the use of the notebook, hold high accountability and standards for keeping the notebook and to gauge a formative assessment of the use of these notebooks as measured on the results of their Paper 3.

Action Research Intervention: With the grant money provided by CPET and additional funds from the RHS Cambridge account, I purchased two cases of Hayden-McNeil Scientific lab notebooks for all 19 students in the class. This purchased allowed me to have some extra on hand and give some to the students in AICE Chemistry. One of the first lessons of the year was on how to keep a scientific notebook as outlined by Dartmouth College, Dept of Chemistry that is found on the back of these notebooks.

The following objectives were implemented:

1. Every lab will require the correct documentation.
    a. Placement in table of contents and pages are in order.
    b. Correct lab name, date, partners, signatures and witnesses as space provides for in the notebook.
2. Every lab will also include:
    a. Learning objective
    b. Reference or rationale for lab, including intended learning outcomes
    c. Pre-lab procedures, may include calculations or charts needed
    d. Procedures, data collections and results. This will includes steps taken, observations, graphic representations and a conclusive statement.

By implementing these tools, I was hoping to see a linear progression of science literacy, biotechnology skills and overall confidence levels in the students work. I felt that they would make fewer mistakes as their work progressed throughout the year. I was hoping to see their tabulation and graphing skills progress as they became more efficient and effective in their lab skills.

What I saw was unexpected. From the beginning I saw a very interesting phenomenon, the students had an almost coveted ownership of their notebooks, it seemed as if they were protecting their own original research and they placed a high value on keeping up with their notebooks. They treated these notebooks as if they were given an elite status. From the first lesson to the last, all of the students started turning in stellar, beautiful and well thought out lab work. An impromptu survey answered the question that they were treating their work in these notebooks much different than if they were just handing in worksheets.

Connection to Bench to Bedside: It was at this summer institute that I was first introduced to the Hayden McNeil notebook. My first overall impression was a shot of dopamine through my frontal lobe. My initial thoughts were of my AICE biology students and how professional these notebooks looked, the collegiate exposure my students would feel. I knew they would appreciate the authenticity of keeping ones own raw data for analysis, the benefits of being held in a slightly higher privileged and elevated student status that these high achieving students would feel, just by receiving this notebook. The students that take the AICE biology class are at a higher motivated level than the general student population and getting a scientific notebook like this would be like getting designer status in the school. Cognitive based research shows that the more confident a student is in his learning environment, the better they will often do.

I would like to thank those responsible for the ordering and purchasing of these notebooks last summer at the B2B institute. It may seem like a basic assumption for those trained in a science curriculum, but for someone like me who is working their way back in, it was like getting the perfect ancillary material to an otherwise packed curriculum.

When the students reference their notebooks, they will find the AICE Practical Skills set, previous years Paper 3's, the labs from CPET locker equipment rental and the labs on our field trip to University of Florida, courtesy of the Bench to Bedside Program. It is by far the best kept student notebook I have ever seen in a high school setting. See attachments at the end of this paper for examples of a students' work.

Data Collection and Analysis:

Qualitative Assessment:

When the students completed an assignment, they kept the original and turned in the carbon copy. For a visual, formative assessment, this is what I saw:

- Every student started their lab notebook with great care; the first couple of activities were turned in with very detailed notes.
- Students with an artistic aptitude had a very hard time not erasing mistakes; it was hard for them to leave a 'mistake' on their paper and learn to just cross it out.
- Students that were used to only handing in 'perfect and blemish free' papers also had a hard time learning to simply cross out a mistake and leave it on the paper.
- Students that did not have the two previous aptitudes loved the fact that they could cross out any mistake and simply go on without any negative repercussions.
- If a student was pressed for time, labs became sloppy and not very detailed. They would leave out some of the learning objectives, so I learned to give more class time and direction.

Likert Scale of Student Assessment of Lab notebooks and their skills:

To judge the effectiveness of the lab notebook from the students' perspective, they were asked to answer a Likert scale questionnaire on how the felt the notebook prepared them. The questions and mean scores from my class are as follows:

The following scale is to rate your own progression on your lab skills as they relate to the use of your lab notebook. Please answer honestly. 1=strong agreement, 2=agreement, 3=neutral, 4=disagreement, 5=strong disagreement

At the beginning of the school year:

1. I felt confident of my basic lab skills.	2.6
2. I knew how to properly record labs in a notebook.	2.6

3. I was excited to get a lab notebook. 1.8
4. I promised myself to keep the lab notebook as a "legal document". 1.8

During the school year:

5. The lab notebook has increased my awareness for proper documentation. 1.6
6. By keeping the notebook it has increased my organizational skills. 2.2

For preparing for the AICE exams:

7. The use of this notebook is helping to increase my confidence for Paper 3. 2.1
8. The use of this notebook has increased my efficiency skills for labs. 2.1
9. I will refer to this lab notebook to review for the exams. 1.8

This data shows me that although the students came into this class with a solid set of lab skills, the addition of the notebook has increased their confidence for Paper 3 and their organizational skills for keeping a cleaner, legal notebook. The fact that they can have an easy reference to their notebook to help them study for their exams instead of a bunch of returned, loose papers also scored very high on this scale.

Quantitative Assessment:

There are a couple of items that I wanted to quantify with this action research proposal. The first being an increase in scores concerning Paper 3, an increase in the number of students attempting the A Level exam and the last being a stretch goal of increasing enrollment for the 2012-2013 school year.

The data as of April 4, 2012 is as follows:

School year enrollment for AICE Bio	Number of students enrolled	Taking AS level exam	Taking A level exam	Pass rate overall and pass rate for Paper 3
2010-2011	24 (no notebooks)	24	2 (both pass)	10 pass AS; 7 pass paper 3
2011-2012	19 (year notebooks implemented)	19	14 (pass rate released in Aug)	TBD
2012-2013	70 requests	Should be 70	To be determined Projection: 35	TBD

In referring to the stated learning objectives for correctly keeping a notebook, the students started out with very high scores, had a slight dip mid year, then as the preparations for Paper 3 started increasing, the scores once again increased. They were assessed using the following measures:

1. Correct documentation for learning 10/50 points
2. Documentation of the lab 40/50 points

Other quantitative assessments included the skills that I learned during the year from the CIE Assessing Lab Practical Skills on line course I took. I used it to gauge their success for a practice Paper 3.

The students were given a practice run of a Paper 3 on March 1, 2012. The lab was a restriction enzyme lab that also included a titration. They did not know the nature of the lab before hand. This lab came after the completion of numerous practice skills, notes and labs through out the school year. Most of the students had the correct equipment out and were ready to go; I made corrections at a couple of lab stations. The students had a very difficult time and most would have failed the lab had it been a true Paper 3, however, they had very good documentation throughout. I gave them passing grades for the valiant effort. We did another practice run March 19th using a food identification lab and the students had gained more confidence and scored higher this second time. However, it was the proper documentation that really stood out.

Conclusion:

I feel the implementation of the use of the Hayden-McNeil Scientific Notebook and the notebook keeping skills from Dartmouth University, Dept of Chemistry was a success. The most powerful observation made this year was the intent and the purposes that the students took considering the seriousness of this course. Not one student slacked and did not use their notebook. There are no grades lower than a C and I am predicting an overall pass rate for the AICE exam as 16 out of 19 and a pass rate of 16 out of 19 for a pass rate on Paper 3.

Literature Cited:

Jones, M. (2010). *Cambridge International A/AS Level Biology Revision Guide*. London: Hodder Publication.

Singer, S., Hilton, M., Schweingruber, H. (2005). *America's Lab Report: Investigations in High School Science*. Washington D.C.: National Academy of Sciences.

How to set up a lab notebook (1997-2011). Trustees of Dartmouth College. Retrieved August 14, 2011, from www.dartmouth.edu/~chemlab/info/notebooks/how_to.html

Budget and Justification:

The $200 stipend from Bench to Bedside was used to purchase:

- $295.34 on two cases of Scientific Lab Value Notebooks
- Cost of field trip to UF ~ $1250 including $900 bus fare was provided by Rockledge High School, Cambridge Funds. Cambridge Funds are from a monetary collection from students having passed AICE exams. RHS has decided that funding this field trip to UF for the labs is a worthy cause to support. The students are aware that the true cost of this trip is to pass the

AICE Biology exam to replenish the funds. Students were charged $10 for this trip.

Permissions:

Lab safety contract
Out of county field trip forms

Modifications to original research proposal: I had no modifications to the original proposal.

Learning's from Action Research Proposal: I would like to say that due to the novelty of using these notebooks, the students took their notebook skills more seriously and studiously. The all felt equitable and on the same level with each other and they also felt a bit more privileged than some of the other science students. Not once did any student have to ask to borrow notebook paper, no one ever lost a lab or even forgot to do one. There was two separate occasions that I thought a student did not do or turn in a lab and the student was able to produce the original. On two other occasions' students thought they turned in a lab and there was still a carbon copy still under the original.

All in all, I personally learned the value of keeping a professional, scientific notebook. I have learned the necessity of assessing these lab skills on a higher order than simply a completion grade. I have learned by presenting the students with an equitable yet elevated status of having something that was not provided before or for anyone else, the students will appreciate and use these note books.

Next year I will ask the school to again provide these notebooks. I will also be pursuing grants for purchasing them, once I can provide the data that they helped.

Dissemination:

There are three opportunities for me to share my learning experiences and information from the Bench to Bedside Summer Institute:

1. Department level: I have shown my colleagues in the science department here at RHS and other schools the opportunities that I have had with CPET and have shown them the notebooks that were purchased with the monies provided. This was simply informal sharing.
2. School level: I have permission from the administration to present my research at an in-school in-service. Not so much to prove how effective the notebooks were, but more to show how to write effective research and self evaluation of one's own teaching practices. Outside of the science department, most teachers will forget the valuable lesson of identifying an independent variable to measure effectively a dependent variable. In today's public schools, teachers are held to student achievements mostly by looking at test scores, FCAT scores and other standardized test scores. I can use the example that I have provided and the effect on the scores to further justify

implementation of the purchase of more notebooks to improve student performance.

3. District level: Along with other CPET and Bench alumni, we have already shown other science teachers the CPET program and what it has done for us at a county wide science inservice. I plan on doing this again next year along with the findings from this Action Research Proposal.

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2. I knew how to properly record labs in a notebook. ____
3. I was excited to get a lab notebook. ____
4. I promised myself to keep the lab notebook as a "legal document". ____

During the school year:

5. The lab notebook has increased my awareness for proper documentation. ____
6. By keeping the notebook it has increased my organizational skills. ____

For preparing for the AICE exams:

7. The use of this notebook is helping to increase my confidence for Paper 3. ____
8. The use of this notebook has increased my efficiency skills for labs. ____
9. I will refer to this lab notebook to review for the exams.

The following scale is to rate your own progression on your lab skills as they relate to the use of your lab notebook. Please answer honestly. 1=strong agreement, 2=agreement, 3=neutral, 4=disagreement, 5=strong disagreement

At the beginning of the school year:

1. I felt confident of my basic lab skills. 3
2. I knew how to properly record labs in a notebook. 4
3. I was excited to get a lab notebook. 3
4. I promised myself to keep the lab notebook as a "legal document". 4

During the school year:

5. The lab notebook has increased my awareness for proper documentation. 1
6. By keeping the notebook it has increased my organizational skills. 2

For preparing for the AICE exams:

7. The use of this notebook is helping to increase my confidence for Paper 3. 1
8. The use of this notebook has increased my efficiency skills for labs. 3
9. I will refer to this lab notebook to review for the exams 1

The final tabulated results were:

The following scale is to rate your own progression on your lab skills as they relate to the use of your lab notebook. Please answer honestly. 1=strong agreement, 2=agreement, 3=neutral, 4=disagreement, 5=strong disagreement

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The following pages are examples of one students' work.

Page one: AICE Skills Set #1: Investigation into size and scale of microscopic tissue
Page two: CPET UF field trip lab: pGlo gene transformation lab
Page three: AICE Paper 3 trial: Plasmolysis

These three examples show exemplary work from one student. This same student is claiming that this lab notebook has kept her more disciplined than ever in preparing for this AICE exam.

1 Practical 1: Investigation into size & scale of microscopic tissue — Date: 8-16-11
Name: Alexis Beagles — AS Biology

Objective: This practical focuses on microscopic technique and using graticules and stage micrometers to determine size and scale in biological cells and tissues.

Reference: AS Biology Practical Skills

Intended learning outcomes:

- using the calibrated eyepiece graticule to determine the size of microscopic organisms.
- correct plan diagram drawing and labeling
- comprehension of magnification and scale
- correct use of lab notebook
- Importance of validating or repeating results.

Gather: microscope, eyepiece graticule, stage micrometer, tissue slide.

Calculations: actual size (object) = $\frac{\text{image size}}{\text{magnification}}$ (or) magnification = $\frac{\text{image size}}{\text{actual size}}$

1cm = 10mm

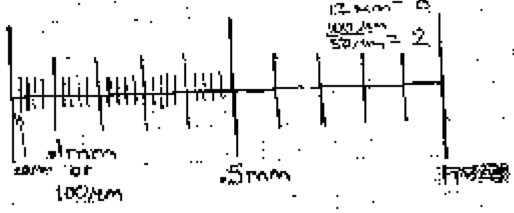
100µm in 1mm

$\frac{1000\mu m}{5\mu m} = 20$

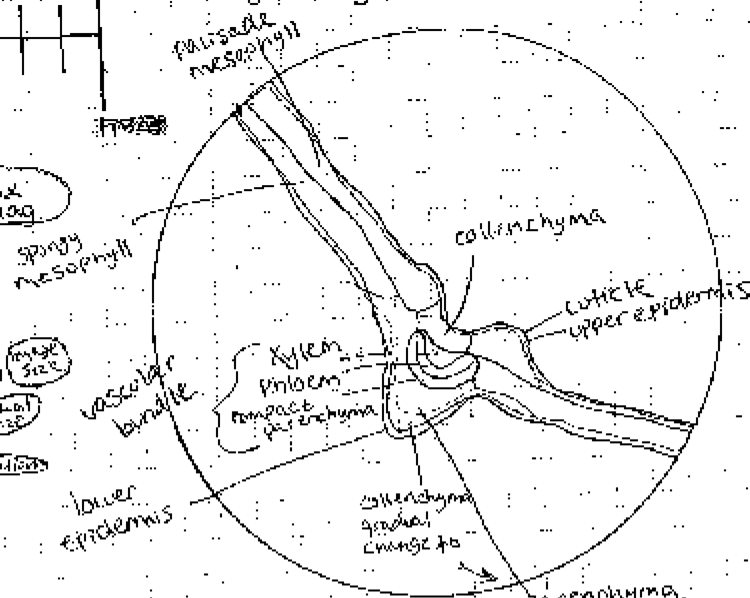
$\frac{1000\mu m}{12\mu m} = 8$

$\frac{1000\mu m}{500\mu m} = 2$

~~low mag~~
low mag = 20µm
med mag = 8µm
high mag = 2µm



Slide 11 on low power mag 4x



- vascular bundle:

13mm = 1300µm (image size)

8µm × 14mm = 112 µm (actual size)

$\frac{1300}{112} = 11.61$ (magnification)

11.61 x Med. pwr.

Signature: Alexis Beagles 8-23-11 — Witness: [signature] — Date: 8/23/11

EXPERIMENT: UF Lab Gene Transformation (pGlo) | DATE: 2-24-12

NAME: Alexis Broyles | COMPANIONS: Will Santos

Lab procedures:

Add "transformation solution" ($CaCl_2$) to +pGlo & -pGlo tubes, put on ice. Place a single colony of bacteria in each tube. Put back on ice. Add pGlo plasmid DNA to the +pGlo tube only, put on ice (1 min.) 4 plates: +pGlo → LB/amp, LB/amp/arab; -pGlo → LB/amp, LB. Heat shock the 2 tubes, then back on ice. Add LB nutrient broth to tubes, add to plates → transformations / controls. Stir around & take back to RHS :)

Hypothesis: ~~the plates with pGlo~~ The +pGlo plates are the only ones capable of growing because they have the pGlo plasmid DNA, while the -pGlo plates do not. Arabinose will cause the colonies to glow. LB nutrient broth makes it grow.

Data: — there was contamination (Bacilli, Spirolia, Cocci)

plates	Day 1	Day 2
+pGlo LB/amp	nothing	grow/no glow
+pGlo LB/amp/arab	nothing	grow + glow
-pGlo LB	substancial growth	more growth
-pGlo LB/amp	nothing	no growth

34 colonies

48 colonies

Conclusion:
- ampicillin is an antibiotic
- amp resistance is problematic for superbugs
- arabinose is a growth factor, gene regulator

Room for error:
- possibly didn't pick up a colony
- didn't change or keep equipment sterile
- maybe ampicillin is inhibiting growth

SIGNED: Alexis Broyles | DATE: 2-24-12 | WITNESS: Will Santos | DATE: 2/24/12

8b | Plasmolysis lab (potato strips) | 10-25-11

Alexis Bayles | Will Santos

Investigating the effect of immersion in sucrose solutions of different concentrations on the changes in lengths of potato strips

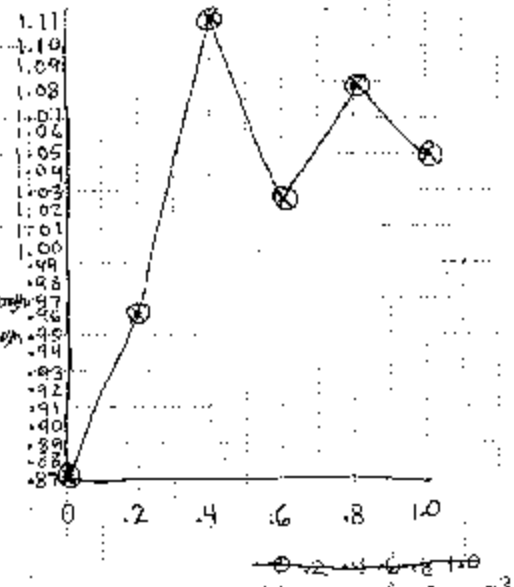
	volume taken of 1.0 mol dm-3 solution/cm3	volume of distilled water added/cm3	concentration of solution produced/mol dm-3	
A	10	0	1.0	100%
B	8	2	.8	80%
C	6	4	.6	60%
D	4	6	.4	40%
E	2	8	.2	20%
F	0	10	0	0%

ABC measurements - 20mm x 8mm originally

DEF measurements - 20 mm x 11 mm

Solutions	original size/mm	new size/mm	change in size	mean percentage change of length
A	20,20	19,19	1	.05
B	20,20	18.5/18.5	1.5	.075
C	20,20	20,19	0,1	.025
D	20,20	18,18	2	.1
E	20,20	19,23	1,3	.6
F	20,20	23,23	3	1.15

Effect of Plasmolysis in different sucrose concentrations



sucrose concentration/mol dm-3

Alexis Bayles | 10-25-11 | Will Santos | 11/1/11