APPENDIX A

HANDBOOK FOR STRUCTURED INQUIRY

INTRODUCTION TO STRUCTURED INQUIRY

Purpose: To guide students in conducting inquiries into 3 phenomena

THE SESSION

General Introduction

Deliver Script

Give the Student a Tour of the Lab

Structured Inquiries into Specific Phenomena

Introduction to the Task

- Demonstrate the Phenomenon
- Elicit Prior Knowledge
- Ask students what they would do to show the correctness of their ideas or beliefs and encourage them to carry out any procedure which they suggest

Explain the Task

Assure that the Student understands the task

Inform the student that they have to tell you when they're ready

Begin the Inquiry

Support the Inquiry Non-Directively

When the student signifies readiness provide an example for them to test their idea

Determine that the Student can go no further Unassisted

Provide Guidance by:

1. pointing out inconsistencies in the student's explanations or actions, and/or
2. presenting phenomena which either disconfirm the students conceptualization or typify some feature that the student has not taken into account

Obtain a summary conceptualization of the Phenomenon

Administer PHASE II of the task (when appropriate)

Bring work on the task to a close

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When Levels of Conceptualization, Related Knowledge, and Proposed Scientific Inquiry capabilities, have been elicited to the degree possible and the student has completed the task or is unable to go further or an hour of work on the task has passed, the task should be brought to a close.

Ask student what science courses they have taken, whether or not they liked them and why.

Ask students why they chose to take part in this study

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GENERAL INTRODUCTION

SCRIPT

We're going to work on 3 experiments here today. This is part of a study on scientific discovery. The idea is that people can discover scientific concepts by investigating things.

These experiments are going to be different from the way you do most things because I'm going to ask you to `think out loud' as you work on them. That means I want you to tell me what you're thinking as you work on the experiment. Tell me what you're doing and why you're doing it; tell me what you believe, tell me if you change your mind about it -- everything that you're thinking about. If you're quiet for a long time I may ask you to tell me what you're thinking or doing.

The whole point of these experiments is not to get a right answer but to see if you can find out things that you didn't know before. I believe that if you're not already familiar with these experiments that you will discover things that you didn't know before.

For each of the experiments we'll start out with a demonstration. Then we'll talk a little bit to find out what you already know.

I'll assist you if you need help with anything, but I won't answer questions about what you should or shouldn't do. I'd like you to test your ideas out for yourself. If you see me nodding my head or saying OK it means that I think I understand what you are saying. It doesn't mean that I agree with you or what you're doing. You will be able to see for yourself if your ideas are working or not.

There are no tricks here. I won't do anything to try to fool you.

Don't be concerned about getting things right or wrong, just see what you can find out that you didn't know before.

Feel free to play around with anything you find here or to ask for other things that you may need. Some of these things are here because people before you asked for them . You can use them in any way you like. You can even rearrange the room if you like.

Try out whatever you like. Do whatever you think will help you. Ask me for assistance if you need any

[Give student a tour of the lab finding out what they know about the equipment]
[Demonstrate `Thinking out Loud'

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TASK D1 Period of the Pendulum

INTRODUCTION

Demonstrate the Phenomenon and Elicit Prior Knowledge -- [Swing it]
Have you ever worked with one of these before? Do you know what it's called? This is called a `pendulum'. Have you studied about pendulums in school? Notice how long it takes from the moment it leaves my hand until the moment it returns. That period of time is called the `period' of the pendulum.

Elicit Prior Knowledge and ideas Do you have any idea what might make the period of the pendulum longer or shorter? Are you sure of that? How sure?

Elicit student's procedures for verification of their beliefs and encourage them to try them out Is there someway you could tell whether or not that idea is correct? How would you do it? Could you show me how you would do that?

PHASE I

Explain the Task -- Your Goal is to figure out how to construct a pendulum with a given period.

For instance, imagine that I will ask you to construct a pendulum which has a period of 3 seconds or some other number of seconds.

Assure that the Student understands the task
Is it clear what you're supposed to do?
Can you explain the task to me?

Inform the student that they have to tell you when they're ready
Let me know when you're ready to construct a pendulum that has a given period.

Begin the Inquiry
Any questions?
OK, I'll leave you on your own
Don't forget to tell me what you're thinking about as you work on the task.

Support the Inquiry Non-Directively
[see GENERAL NOTES]

CONCLUSION

Obtain a summary conceptualization of the Phenomenon

What instructions would you give over the telephone to someone who needed to construct a pendulum with a given period?

APPENDIX A

TASK D1 Period of the Pendulum continued

PHASE II

If student has completed this portion of the task or gone as far as they can go in less than an hour pose the following to them:

Explain the Task

I would like you to figure out a general rule that someone could use for predicting the period of any pendulum.

How would you go about creating the rule?

What do you think it might be?

Assure that the Student Understands the Task

Can you repeat the task?
Is it clear what you're supposed to do?

Begin the Inquiry

Any questions?
OK, I'll leave you on your own
Don't forget to tell me what you're thinking about as you work on the task?

Support the Inquiry Non-directively

[See General Notes]

When the student signifies readiness

[Provide a pendulum that has a 100gm weight hanging from a 30mm string held at an angle of 45 degrees]

CONCLUSION

Obtain a summary conceptualization of the Phenomenon

What is your rule for predicting the period of any pendulum? If you had more time and/or other equipment how could you improve the rule?

Bring work on the task to a close

Thank you, I'd like to move on to the next experiment

or

[If the student has not been able to summarize the task or does not feel that they've accomplished anything, provide the following closing] I'd like to summarize the things you've discovered and then move on to the next experiment. You found that (_____ is the case) or that (_____ is not the case. [state this for as many conceptualizations as the student worked on]. Now let's move on to the next experiment.

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TASK D2 Equilibrium on the Beam Balance

PHASE I
Demonstrate the Phenomenon and Elicit Prior Knowledge Have you ever worked with one of these before, or learned about it in school? Do you know what it's called?
[Place a 20gm weight on one end of the beam while holding the beam steady] What do you think will happen when I let go? Why do you think that happened? [Place two twenty gram weights on the other side of the fulcrum about 1/4 to 1/3 the distance out from the fulcrum of the weight on the first side] What do you think will happen now when I let go?

Elicit Prior Knowledge and ideas Do you have any idea of how you might predict for any arrangement of weights whether the beam will tilt to the right, tilt to the left or stay balanced? Are you sure of that? How sure?

Elicit student's procedures for verification of their beliefs and encourage them to try them out Is there someway you could tell whether or not that idea is correct? How would you do it? Could you show me how you would do that?

Explain the Task Your Goal is to figure out where to place any combination of weights that I might give you so that the beam will stay balanced.
For instance I may give you 5 weights to put on one side and 2 weights to put on the other.

Assure that the Student understands the task
Can you repeat the task?
Is it clear what you're supposed to do?

2
Begin the Inquiry
Any questions?
OK, I'll leave you on your own
Don't forget to tell me what you're thinking about as you work on the task?

Support the Inquiry Non-Directively
[See GENERAL NOTES]

APPENDIX A

TASK D2 Equilibrium on the Beam Balance continued

When the student signifies readiness
[Provide the student with 2 20gm weights to place on one side and 5 20gm weights to place on the other side of the balance beam.]
for a second example
[Provide the student with 3 20gm weights to place on one side and 4 20gm weights to place on the other side of the balance beam.]

Determine that the Student can go no further Unassisted

Provide Guidance
1. [Point out inconsistencies in the student's explanations or actions]
2. [Present demonstrations which either disconfirm the student's conceptualization or typify some feature of the phenomenon that the student has not taken into account]

Obtain a summary conceptualization of the Phenomenon
I'd like you to provide a general set of instructions that you could give to someone over the telephone that would tell them where to place any set of weights on the balance beam so that it will stay balanced.

APPENDIX A

TASK D2 Equilibrium on the Beam Balance continued

PHASE II

If student has completed this portion of the task or gone as far as they can go in less than an hour pose the following to them:

Explain the task

I want you to figure out a way to predict for any arrangement of weights on the balance beam, whether the beam will tilt to the right, tilt to the left or stay balanced?

Imagine that I'm going to place some weights the beam and ask you to predict which way the beam will tilt or if it will balance when it is released.

Assure that the Student understands the task

Is it clear what you're supposed to do?
Can you explain the task to me?

Begin the Inquiry

Any questions?
OK, I'll leave you on your own
Don't forget to tell me what you're thinking about as you work on the task?

Tell me when you're ready to predict how the beam will behave for any arrangement of weights.

Support the Inquiry Non-Directively

[See GENERAL NOTES]

When the student signifies readiness

[Provide the student with several arrangements of weights to predict]

Determine that the Student can go no further Unassisted

Provide Guidance

1. [Point out inconsistencies in the student's explanations or actions]
2. [Present demonstrations which either disconfirm the student's conceptualization or typify some feature of the phenomenon that the student has not taken into account]

Obtain a summary conceptualization of the Phenomenon

How would you explain to someone over the telephone how to predict the behavior of the balance beam for any arrangement of weights?

APPENDIX A

TASK D2 Equilibrium on the Beam Balance continued

[If the student is well within the hour allotted for this task, have them attempt to make predictions for the balance beam with fixed hooks. In this one weights can be placed at more than one location on each side of the beam]

Bring work on the task to a close
Thank you, I'd like to move on to the next experiment
or
[If the student has not been able to summarize the task or does not feel that they've accomplished anything, provide the following closing] I'd like to summarize the things you've discovered and then move on to the next experiment. You found that (_____ is the case) or that (_____ is not the case. [state this for as many conceptualizations as the student worked on]. Now let's move on to the next experiment.

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TASK D3 Law of Floating Bodies

Demonstrate the Phenomenon and Elicit Prior Knowledge This task has to do with floating and sinking. Do you know why some things float and others sink? Have you studied this in school? If I give you this object [a 219 gm 6 x 6 x 6 cube] could you tell whether it will float or sink? Are you sure of that? How sure?

Elicit student's procedures for verification of their beliefs and encourage them to try them out Is there someway you could tell whether or not that idea is correct? How would you do it? Could you show me how you would do that?

Explain the Task Your goal is to figure out how to predict whether an object will float or sink.

Imagine that I am going to give you a cube like one of these and ask you to predict correctly whether it will float or sink.
You can use any of these objects or this equipment for your experiment.

Assure that the Student understands the task
Is it clear what you're supposed to do?
Can you explain the task to me?

Inform the student that they have to tell you when they're ready
Tell me when you're ready to predict whether or not any cube that I might give you would float.

Begin the Inquiry
Any questions?
OK, I'll leave you on your own
And don't forget to tell me what you're thinking about as you work on the task?

Support the Inquiry Non-Directively
[see GENERAL NOTES]

When the student signifies readiness
[Present items from the set of specially prepared cubes]

Determine that the Student can go no further Unassisted

Provide Guidance
1. [Point out inconsistencies in the student's explanations or actions]
2. [Present demonstrations which either disconfirm the student's conceptualization or typify some feature of the phenomenon that the student has not taken into account]

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TASK D3 Law of Floating Bodies continued

Obtain a summary conceptualization of the Phenomenon
What do you need to know about an object to know that whether it will float or sink in water, alcohol, salt water, some other liquid?

How would you explain to someone over the telephone what to do to tell if an object they have will float or sink?

PHASE II
Repeat the task with other objects (e.g. candle, high bouncing ball, white cylinders)

Bring work on the task to a close
Thank you, I'd like to move on to the next experiment
or
[If the student has not been able to summarize the task or does not feel that they've accomplished anything, provide the following closing] I'd like to summarize the things you've discovered and then move on to the next experiment. You found that (_____ is the case) or that (_____ is not the case. [state this for as many conceptualizations as the student worked on]. Now let's move on to the next experiment.

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GENERAL NOTES

Support the Inquiry Non-Directively

Whenever the student begins a new approach
How do you plan to attack the problem?
How are you going to figure it out?
What are you going to do first?
Why will you be doing that?

After task is underway
Why do you think that happened?
What are you going to do now? or What are you going to do next?
Why will you be doing that?
So...
So...what next...?
What now...?
What are you trying to find out?

To elicit conceptualizations of the phenomenon
What do you think now?
What seems to be important or makes a difference?
Can you summarize what you've found out up until now.

If Student asks the guide for direction or approval for what they propose to do
Do you remember what your task is?
What do you think would help you accomplish your task?
Do you think that would help you accomplish your task?
I want you to figure out for yourself if you ideas work or not

If student asks the guide how precise they should be
How precise can you be?
How precise do you need to be to know if you're succeeding in what you're doing

Before each prediction
How sure are you?
20% 45% 70%...?
or
no idea, not sure at all, slightly sure, fairly sure, very sure, completely sure.

concluding
Does that satisfy you?
Do you wish to continue?

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Determine that the Student can go no further Unassisted

Provide Guidance

1. [Point out inconsistencies in the student's explanations or actions]
2. [Present demonstrations which either disconfirm the student's conceptualization or typify some feature of the phenomenon that the student has not taken into account]

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GENERAL PRINCIPLES

Try to create an atmosphere of fun and play

Look for entry points to ask students questions:

1. Immediately after they have tried something
2. After they speak to you or ask a question

Try not to interrupt them when they appear to be concentrating