Using Time More Efficiently: Converting an Interview Protocol to a Survey

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Interviews are an effective method for determining student misconceptions and depth of understanding, however an interview is very time consuming both to implement and analyze. A researcher is left with the choice between applying an interview protocol broadly, but lacking time for other assessments [1]; or interviewing a subset of students and gaining a more limited picture of student understanding [2]. An alternative is to convert the interview to a survey consisting of open-ended questions that probe the same areas. This study is part of a large engineering education program of research that is examining student misconceptions in fluid mechanics and heat transfer and using hands-on learning approaches to confront misconceptions.

In this paper, we will report on the conversion, to a survey protocol, of an interview protocol designed to determine student misconceptions regarding Chemical Engineering Fluid Mechanics. By utilizing an electronically administered survey, researchers can increase the number of respondents or participants in comparison to limited interviews. In addition, researchers can eliminate transcription errors and reduce the time required to collect, manage, and analyze the data. The benefits come at a cost of flexibility, in that the researcher is unable to dynamically ask probing follow-up questions to illuminate a point. This will be mitigated by supplementing the survey with a small number of interviews targeted at key topics as determined by analysis of the survey data.

This survey protocol is currently being developed, and will be implemented and refined with students who are seniors in Chemical Engineering. Thereafter, we will examine the degree to which our survey protocol was able to leverage the benefits explicated above. This paper will report on the results, and provide practical implications for researchers on performing a similar conversion.

Introduction

The study of student conceptual understanding has become an increasingly important part of engineering education research. For example, Brown, et al. recently interviewed 50 students in order to design classroom activities specifically aimed at addressing misconceptions. One could imagine that this required a significant investment in time and money, both to conduct and transcribe the interviews. If an interview protocol can be effectively converted to an online survey implementation, transcription time can be significantly reduced.

Semi-structured interviews are used to determine conceptual understanding and misconceptions because they allow the interviewer to probe and draw out further explanations. This allows a deeper look into a student’s thought processes and a clearer picture of their conceptual understanding. A structured interview, while still useful, would not allow for follow up questions and in-depth probing. Well-crafted questions that allow for detailed answers can still be used to examine misconceptions in this case. Indeed, if we have a sufficiently studied understanding of common misconceptions within a topic, further interviews are likely to not require much probing as the initial questions could be crafted to draw out misconceptions without additional probing. In this case, a structured interview could replace the semi-structured format.
Once we have a list of questions, we can use them to create an online survey. While this would eliminate time spent conducting interviews, since the survey is already electronic, it would also eliminate the need for transcription, hence eliminating transcription errors at the same time. It will not, however, reduce the amount of time needed for students to take part in the study.

**Background**

In [author group] Burgher, et al.’s prior study, fourteen students, over two years, who had taken a required junior level course in Chemical Engineering Fluid Mechanics and Heat Transfer took part in a survey designed to identify misconceptions in fluid mechanics. This interview protocol is 37 questions long, depending on whether follow up questions are warranted. In addition to questions with textual answers, the interview protocol requested students provide equations and make sketches. This protocol may be found in the first half of the appendix. The results of this study illuminate some persistent misconceptions as well as ways to address them. In order to confirm the suspected broad presence of persisting misconceptions a new study must be undertaken using a larger sample. In order to do this efficiently we are examining alternatives to the interview technique used by [author group] Burgher, et al.

**Methods**

The interview protocol, used by [author group] Burgher, et al., encouraged students to write and sketch as they talked through the questions. These artifacts were also collected for analysis along with the interview transcripts. This provides the primary challenge to adapting the interview protocol to an online survey. How do we go about having students sketch the pressure profile through a venturi meter on an online platform with no control over the end-users’ device choice? If they have a tablet or touchscreen they might be able to draw on the screen. If using a smartphone, they could take a picture and attach it, somehow, to the survey. What of users on a more traditional computing platform?

If we bypass the problem by providing a multiple-choice series of sketches for them to select from, how is this different than a concept test? To differentiate from a concept test, and add insight into student thinking, any multiple-choice questions are followed up with a probing question asking students to explain their choice in detail. Another option, especially where there are only two choices such as with sketching laminar and turbulent flow, is to present the unlabeled graphics and have students explain which graphic corresponds to different choices and why. In the current iteration we are using both of these methods to adapt the interview protocol to a more limited format.

There are many browser-based options to deliver the survey. One can go with a low-cost service, such as surveymonkey.com. This allows for both short answer and multiple-choice questions, as we would need. In addition, surveymonkey.com provides the option to include graphics as part of the question and/or answer. An alternative option is to utilize a more expensive survey platform, which provides more options, built-in analytics, and control of the questions. The authors’ home institution recently purchased licensing for one such package, Qualtrics. In this instance, having no cost differential, Qualtrics was deemed suitable for our purposes.
Many of the questions may be converted directly to a short answer survey question. For example: ‘What are the main regimes of flow?’ does not require any alteration. Though to streamline the survey somewhat we have chosen to combine it with the second question into: ‘What are the main regimes of flow and how are they different? Please be detailed.’ Where it makes sense, questions have been combined in this manner. Survey questions may be found in the second half of the appendix.

As with the prior study subjects are selected who have completed the fluid mechanics and heat transfer course the prior semester. Rather than recruiting a small number of participants from this pool, we will contact the entire group, approximately 70 people. Even at normal survey response rates of around 20%, we anticipate having more participants than were involved with either prior survey. Though the percentage of the population involved in the survey is anticipated to be higher than in the interviews, we must acknowledge some potential shortfalls. Firstly, we lose the ability to select our sample. That is to say, we can no longer purposefully select a representative cross section of the class. In the most extreme case, is possible that only high-achieving students will respond, thus skewing the results. However if that is the case, the presence of persisting misconceptions would be especially alarming.

A second potential shortfall is that we have no control over the survey environment. There is no way to determine whether or not students refer to outside resources or try to ‘google’ answers. To address this, we have added a clause to the beginning of the survey requesting that students not look for answers and reminding them that the survey is anonymous and they receive no benefit from getting everything correct. As a further control against this behavior, we can also add a time limit to each question.

**Results**

At the time of writing, the survey has been developed, but not yet implemented. The development followed the guidelines presented in the methods section, wherein most questions were subject to only minor changes in order to make them more inherently probing or to adapt to a new format. Examples are in Table 1.

**Table 1: Examples of interview questions modified for a survey format.**

<table>
<thead>
<tr>
<th>Interview Question</th>
<th>Corresponding Survey Question</th>
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<tbody>
<tr>
<td>A) What are the main regimes of flow?</td>
<td>1. What are the main regimes of flow and how are they different? Please provide a detailed answer on the differences.</td>
</tr>
<tr>
<td>B) Can you provide a detailed answer on how they are different</td>
<td>9. Write the general mechanical energy balance for pipe flow. If you can’t remember exact terms fill in missing ones with what they represent. Again spell out any Greek letters that show up and use ^ for exponentials (^2 for squared, etc.)</td>
</tr>
<tr>
<td>A) Write the general ME balance for pipe flow. Follow-up question if incomplete: Are there any missing terms?</td>
<td></td>
</tr>
</tbody>
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The interview questions which involved having students sketch items have been replaced with multiple choice questions. Figure one shows one such question. In this case, producing a plot of pressure versus distance in a venturi meter, students are instead presented with a series of possible graphs and asked to choose which was the most accurate representation of the system’s behavior. In this we have taken some of the questions seen in Nazempour, Author’s Group, et
al. [3], and expanded it to ten possible choices. Details on the use of these questions as a portion of a pre/post quiz will be seen in a forthcoming paper. The new questions, for both pressure and velocity, may be found in the second half of the appendix.

Similarly, the question asking that students draw laminar and turbulent flow patterns and explain the difference has been adapted to asking students to choose the regime matching flow patterns and explain the difference, Figure 2.
We anticipate that 15 students out of a pool of 70 will respond to the survey, based on typical survey response rates on the order of 20%. The survey itself is likely to rediscover previously identified conceptual difficulties.

**Conclusion**

At this point, the interview protocol has been adapted to a survey that is anticipated to be able to produce similar results. The questions are similar, but have been adapted for a medium that does not provide a mechanism for students to draw sketches or plot graphs.

**Acknowledgements**

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References:


Appendix

<table>
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<tr>
<th>Concept</th>
<th>Questions Asked</th>
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| Flow Regimes Concepts: | A) What are the main regimes of flow?  
B) Can you provide a detailed answer on how they are different?  
C) Draw a representative section of pipe containing each type of flow and explain the differences. |
B) Could you please explain what each term in the ME balance represents?  
C) What is the physical reason for why pressure decreases down a horizontal pipe?  
D) Consider flow in a pipe. Where is shear stress represented in the balance?  
E) Where does the kinetic energy velocity correction factor come from?  
F) What are the values for laminar and turbulent flow?  
G) Why does the velocity decrease for flow streams that are closer to the wall?  
H) Where is the maximum velocity in laminar flow? |
| Venturi Meter Concepts: | A) Please draw a plot of pressure for the diagram. |
B) Please draw a plot of velocity for the diagram.

Apply the ME balance to the following pipe segments in the diagram and justify removal of any terms.

C) $A \rightarrow B$
D) What energy quantities change and in which direction, i.e. increase (positive) or decrease (negative)?
E) What would be the difference in total energy between points $A \rightarrow B$ assuming no frictional losses?
F) Why does velocity change through the throat?
G) For pipe segment $A \rightarrow C$?
H) Which energy quantities change and in what direction?
I) There are often energy losses in contractions and expansions. Why are these minimal in the Venturi meter?

A) Which pipe has greater pressure loss?
### Straight Pipes and Bends/Fittings

**Concepts:**
- Frictional losses
- K-value loss coefficients
- Summation of energy losses
- Linearizing loss equations to graphically determine loss coefficients
- Relative size of loss coefficient

#### B) Using the information given, how would you determine the pressure loss in the 90° elbow?

#### A) How do you determine pressure loss through a fitting? Show equation.

#### B) In pressure loss through a fitting, what is the meaning of a K-value?

#### C) What do you know about a fitting with a higher K-value versus a lower K-value?

#### D) How do you obtain a K-value experimentally?

#### E) If you were to do it with a plot? How do you determine the K-value from this plot?

### Non Circular Channels

**Concepts**
- Hydraulic Radius
- Equivalent Diameter

#### A) How do you calculate the hydraulic radius?

#### B) What is the physical meaning of the hydraulic radius?

#### C) Two piping systems have the same equivalent diameter. One is a circular pipe and the other is an annulus. Describe the physical implications of having the same equivalent diameter.
Survey Questions – Adapted from the interview protocol – This paper:

1. What are the main regimes of flow and how are they different? Please provide a detailed answer on the differences.
2. Can you tell from the flow patterns sketched on the pipes below which flow regime is which? What did you look for?

3. How would you predict if flow in a pipe is laminar or turbulent?
4. What is the Reynolds number?
5. What parameters affect the Reynolds number, and what is the equation? For the equation, please write out any Greek letters that show up, delta P / rho for example.
6. What does the Reynolds number represent physically?
7. How does this physical representation explain laminar flow?
8. How does it explain turbulent flow?
9. Write the general mechanical energy balance for pipe flow. If you can’t remember exact terms fill in missing ones with what they represent. Again spell out any greek letters that show up and use ^ for exponentials (^2 for squared, etc.)
10. Explain what each term in the mechanical energy balance represents.
11. What is the physical reason for why pressure decreases down a horizontal pipe?
12. Consider flow in a pipe. Where is shear stress represented in the balance? 
13. Where does the kinetic energy velocity correction factor come from?
14. What are the values for laminar and turbulent flow? If you don’t remember the value, which is larger?
15. Why does the velocity decrease for flow streams that are closer to the wall?
16. Where is the maximum velocity in laminar flow.
17. Pick the plot that best represents the velocity behavior along the venturi from A to C.

18. Why is that the best answer out of all the choices? Please be detailed.
19. Pick the plot that best represents the pressure behavior along the venturi from A to C?

20. Why is that the best answer out of all the choices? Please be detailed.

21. Apply the mechanical energy balance to the pipe segment A → B in the venturi diagram:
22. What energy quantities change and in which direction, i.e. increase (positive) or decrease (negative)?
23. What would be the difference in total energy between points A→B assuming no frictional losses?
24. Why does velocity change through the throat?
25. There are often energy losses in contractions and expansions. Why are these minimal in the Venturi meter?
   Consider the two pipe sections of equal length below. Which pipe has greater pressure loss?

26. How do we determine pressure loss through a fitting? Please show the equation.
27. In pressure loss through a fitting, what is the meaning of a K-value?
28. How do you obtain a K-value experimentally?
29. If you were to do it, experimentally calculate a K-value, with a plot? How do you determine the K-value from this plot?
30. How is the analysis of non-circular cross sections different from circular?
31. How do you calculate the hydraulic radius and what is its physical meaning?
32. Two piping systems have the same equivalent diameter. One is a circular pipe and the other is an annulus. Describe the physical implications of having the same equivalent diameter.