How Big Should My Sample Be?

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This is a short, simple question calling for a long, complex answer. Before it can be answered, several more fundamental questions have to be answered. Here is a typical conversation that ensues:

S: What is the most important question you have to answer in your *survey?*

R: I am looking into how teachers spend their time on evaluation-related activities. As for the most important question, I believe it is *the* number of hours a typical teacher spends on preparing an exam paper.

S: Well then, do you have any idea how many hours?

R: That is exactly what I wish to find out. If I knew, I wouldn't be conducting this survey, would I?

S: Right, but you still need to have an estimate, otherwise your question about sample size cannot be answered, How about your own experi*ence?*

R: Well, I spend two to three hours. But, I am not sure other teachers spend the same amount of time.

S: Your are right, Why not *carry* out a pilot study among your colleagues *to* find out the range?

R: Yes, my colleagues and I did talk about this. Some of us spend as much as five hours preparing a paper.

S: Good. Your two hours and your colleague's five hours ranges from 120 to 300 minutes. *So,* you have a range of 180 minutes. When we divide 180 minutes by six, it gives us a standard deviation of 30 minutes. You have just answered my first question.

S: Next, let's say you have conducted the *survey.* How much error do you allow yourself in your estimate? In other words, how precise do you want your answer to be – within a range of two, four, or eight minutes both ways?

R: What about two minutes, plus or minus? What would this mean for my sample *size?*

S: If you can settle for a more generous four or six minute error, you can afford to have a smaller sample compared with allowing only for two minutes, If you allow a two-minute error, this means the teacher's time for preparing exam papers will vary within a range of four minutes. Is this acceptable to you and to whoever uses your finding?

R: OK, let's say I only allow myself a two-minute error.

S: Good, one more question to go before we work out your sample size.

S: *After* you have conducted the survey you will be able to make a statement about the average time teachers spend on preparing exam papers. We both know this is only an estimate and you may be wrong about it; you take a risk in making such a statement, this is the nature of playing "statistical games".

R: What choices do I have?

S: Well, by convention, in educational research we take a risk of *5%* for being wrong. More positively, you have 95% confidence in making that statement about time for preparing exam papers.

R: What if I need to be more confident? Say, 1%?

S: If you are dealing with a well-researched area, that is, if there have been many studies before yours, taking only 1% risk may be more reasonable. Otherwise, you may fall into the "early closure trap" and do injustice to a useful area of research. I am not familiar with, your area, so you have to make the choice.

R: How does it affect my sample size?

S: You need a much larger sample if you are prepared only to take less risk.

R: In this case, since my area of study is rather under-researched, perhaps I should settle for a *5%* risk. After all, this has been the convention, too.

S: Good, now we *are* ready to find out the sample size you need. Before we do that, let me summarise:

- The standard deviation is 30 minutes
- The error to be tolerated is two minutes both ways.
- The risk is 5% which implies a normal deviate of 1.96

S: By plugging these three bits of information into the formula, we can calculate the sample size now:

$$n = [ZS/E]^2 = [1.96(30)/2]^2 = 864.36$$

That is to say, you need 864 teachers for your sample, if you can randomly pick them. If you were to allow a four-minute error, then the sample size you need is:

$$n = [ZS/E]^2 = [1.96(30)/4]^2 = 216.09$$

And, if you are prepared to be even less precise, allowing an eight-minute error, then the sample size is much smaller, thus:

$$n = [ZS/E]^2 = [1.96(30)/8]^2 = 54.02$$

As you can see, every time you double the error size, the sample size goes down by four times.
Of course, for a smaller sample size, your estimate will become less precise. This is the trade-off in research.

As the above formula (and example) shows, sample size is dependent on three factors, namely, standard deviation of the interested estimate in the population; the size of error in the estimate to be tolerated; and, the confidence level chosen.

Note that population size does not come into the picture. This, however, does not mean that population size has nothing to do with sample size at all. In fact, when the sample is more than 5% of a finite population, a *finite correction factor* should be used to reduce the sample size. For instance, if the 864 teachers were to be sampled from a population of, say, 6000 teachers teaching Secondary I-III, the sample size is 14.4% of the population Then, the sample size should be adjusted, thus:

$$n' = n\sqrt{(N - n)/(N - 1)} = 864\sqrt{(6000 - 864)/(6000 - 1)}$$
$$= 799.44$$

Of course, in most cases of educational research, the reduction of 65 subjects (or respondents), in such a case, may not reduce the cost perceptibily but the availability of an additional 65 respondents sometimes can be a problem. Of course, it is better to over- than under-sample.

Oftentimes, questions in educational surveys ask fox *Yes/No* answers and the results are presented in percentages (or proportions). Then, the formula is modified to:

$$n = pq(Z/E)^2$$

Here, p is the proportion of respondents who chose *Yes* and q those who chose *No*. Again, these proportions p and q must be estimated from previous studies or through a pilot study. E is the *error*, in proportion, to be tolerated. Let's say the research concerns the proportion of teachers who favour the use of objective tests. The actual phrasing of the question is "Do you agree that at least three-quarters of the marks of exam papers should be for objective items? Yes/No." Let's further assume that, based on past studies or a pilot study, 65% of *the* teachers sampled are likely to *answer Yes* and that we want the result to be so precise that there will be no more than 3% error either way. Then, for *95%* confidence, the sample size will be 971, calculated thus:

$$n = (.65)(.35)(1.96/0.03)^2 = 971.07$$

More often than not, a survey involves comparisons of sub-groups. In this case, a rule-of-thumb is that each sub-group must have at least 100 respondents. Then, the question of sample size becomes a question of the number of sub-groups multiplied by 100. For instance, if the study has four sub-groups of expert-male teachers, novice-male teachers, expert-female teachers, and novice-fernale teachers, then the minimum sample size for the study as a whole is 400 or more.

Common sense has it that the larger the population, the larger the sample should be. But, common sense can be wrong. Think of a study on how many noses a typical human *being* has. Since common observation tells us that all human beings have one nose, there is no variation (hence, the standard deviation is 0). In this case, a sample of one is sufficient to answer the research question and it does not matter what the human population *size* on earth is. Contrary to common sense, the larger the population size, the smaller the *proportion* of it need be taken as the sample. This seems to conflict with the need to consider population size in sampling, as suggested earlier. This need arises because, in most cases, a larger population allows for more variation (hence, larger standard deviation) and therefore a larger sample but a *smaller sample/ population ratio.*

This is indeed a long, complex answer to a short simple question like "How big should my sample be?" *And,* this is not yet the end as we have only looked at the most straightforward case, the simple random sample. For more complicated situations such as a stratified sample, we need to consult advanced texts on sampling procedures. Many articles have been written about sample size but there doesn't seem to be a simple answer to the simple question. Fortunately, there are tables and monographs to be found in standard texts that help answer the question in a simple way.