Deriving Right Sample Size and Choosing an Appropriate Sampling Technique to Select Samples from the Research Population During Ph.D. Program in India

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ABSTRACT

Purpose: *The purpose of this article is to explain standard formulas available for deriving sample size, the essence of every component of formulas, and available techniques for selecting samples from the research population in turn, guiding the Ph.D. scholars to finalize appropriate sample size and sampling technique.*
Design/Methodology/Approach: *Postmodernism philosophical paradigm; Inductive research approach; Observation data collection method; Longitudinal data collection time frame; Qualitative data analysis.*
Findings/Result: *As long as the Ph.D. scholars can understand an appropriate sample size and available sampling techniques and make mindful choices of sample size and sampling technique across various stages/phases of the research to answer their research questions they will be able to determine (on their own) all the other choices in succeeding steps of doctoral-level research such as i) data collection instrument and iii) data analysis techniques.*
Originality/Value: *There is a vast literature about how to derive the sample size and how to select samples from the research population. However, only a few have explained them together comprehensively which is conceivable to Ph.D. scholars. In this article, we have attempted to explain every component of sample size formulas and capture most of the sampling techniques briefly that would enable Ph.D. scholars in India to glance through and make a scholarly choice of appropriate sample size and sample selection techniques.*
Paper Type: *Conceptual.*
Keywords: Research Methodology; Research Design; Research Process; PhD; Ph.D.; Coursework; Doctoral Research; Sample Size; Research Population; Population Size; Sample Proportion; Margin of Error; Confidence Interval; Confidence Level; Non-random Sampling; Random Sampling; Non-probability Sampling; Probability Sampling; Judgemental Sampling; Purposive Sampling; Quota Sampling; Dimensional Sampling; Convenience Sampling; Snowball Sampling; Simple Random Sampling; Systematic Sampling; Stratified Sampling; Cluster/Area Sampling; Multistage Sampling; Postmodernism

1. BACKGROUND :

Various research studies have identified factors affecting the Ph.D. success rate across the world. “To name a few a) scholar-supervisor/guide relationship; b) mentorship; c) dissertation process; d) role of the department; e) role of peer qualities; f) transformational learning experience provided; g) level of curiosity and interest in reviewing the existing literature; h) planning and time management skills; i) level of creative thinking and writing skills; j) amount of freedom in the research project; k) level of a supportive environment for Ph.D. scholars’ well-being; l) higher-education practices; m) supervisors’ research capabilities and gender; n) expectations set by the research environment; o) Ph.D. scholars’ expectations; p) support network; q) level of Ph.D. scholars’ socialization with the research community; r) Ph.D. scholars’ navigation system; s) different terminologies for various components

of doctoral-level research are given by different disciplines creating undue confusion in scholars' minds; t) data collection methods which just play the role of data collection and it is just one of the steps of the doctoral-level research process being portrayed as the research methodology/design; u) scholars' inability to identify their genuine interest in a fact/phenomenon/reality/truth/dependent variable, intensive review of existing literature, locating an important research gap, and finally formulating a research question; v) a lower level of clarity about the most important and indispensable step of the doctoral-level research process i.e., choosing an appropriate research philosophical paradigm that lays stepping stones toward answering the research question in a scientific and scholarly way; w) a lower level of clarity about the most important and indispensable step of the doctoral-level research process i.e., choosing an appropriate research approach/reasoning that paves path for decision concerning data collection and analysis; x) a humongous confusion among Ph.D. scholars in India about the difference between research methodology/design and research data collection methods; y) lower level of clarity and the beginning of the Ph.D. journey without a clear understanding of the essence of research data collection time frames" [1-53].

Furthermore, in reality, a majority of stakeholders in the research education system have a lower level of clarity about the most important and indispensable step of the doctoral-level research process i.e., deriving the right sample size and selecting samples that are true representatives of the research population. A majority of them guide the Ph.D. scholars to begin the journey without educating the scholars about the most important aspect/objective/purpose of deriving the right sample size and choosing an appropriate sampling technique to select samples from the research population. They also mandate that scholars use certain standard sample sizes and sampling techniques that are commonly used in a discipline or the one with which they are comfortable. In addition, there is a humongous confusion about the difference between sample size and sample proportion, and the convenience sampling technique being misinterpreted as the one that is most convenient for the scholars to select samples from their research population. This lower level of clarity and the beginning of the Ph.D. journey without a clear understanding of the essence of deriving the right sample size and choosing the appropriate sampling technique used in selecting samples from the research population is making it difficult for Ph.D. scholars to complete the journey successfully and most importantly if some scholars complete their Ph.D. journey successfully, their awareness about the reasons for their decision about the sample size and sampling technique is very low. We believe that if the scholars can begin their Ph.D. journey by allocating a higher level of focus and time toward understanding the right sample size and sample selection techniques their journey will be with a very lower level of complications and with a higher level of awareness about their choice of sample size and sampling technique. But this reality is knowingly or unknowingly, intentionally, or unintentionally suppressed by a majority of stakeholders in the research education system in India. In other words, this *suppressed reality* has resulted in creating humungous confusion among Ph.D. scholars in India about the key components of the sample size derivation formula viz., sample proportion, the margin of error/confidence interval, and confidence level, and the purpose/objective/deliverables of each sampling techniques.

One thing Ph.D. scholars must always remind themselves of throughout their Ph.D. journey is the fact that they will be awarded a Ph.D. degree for doing doctoral-level research. Doing doctoral-level research and generating research outputs such as research articles and a thesis determines the probability of success in getting a Ph.D. degree. The first step of the doctoral-level research process is identifying research gaps and formulating a research question, the second one is choosing an appropriate research philosophical paradigm, the third step is choosing an appropriate research approach/reasoning, the fourth step is choosing the appropriate research data collection method choice, the fifth step is choosing an appropriate data collection time frame, and the sixth and seventh step is to derive the sample size and choosing samples from the research population respectively [46-53]. It is thus inevitable and imperative that Ph.D. scholars understand statistically derive the sample size and choose one of the sampling techniques to select samples from the research population. The doctoral-level research which is the single most important requirement of the Ph.D. program is cognitively demanding and intends to create researchers who can create new knowledge or interpret existing knowledge about reality by using different perspectives, paradigms, and reasoning. Knowledge sharing requires autonomy, good quality time, a stress-free brain for deep thinking, and the freedom to look for more meaningful findings. This is the single most important reason for making doctoral-

level research flexible wherein the scientific and scholarly world gives autonomy to Ph.D. scholars to formulate their question and answer it within 3-6 years using an appropriate research approach/reasoning. Nevertheless, only 50% of scholars admitted to Ph.D. in India completed, and that too in ten years whether or not they are aware of the importance of reasoning in doctoral-level research [46].

Appropriate sample size and selection of samples from the research population depends upon i) the type of the research question (descriptive; relational; causal) [49]; ii) the research philosophical paradigm (positivism; interpretivism; critical realism; postmodernism; pragmatism) [50]; iii) the research approach/reasoning (deductive; inductive; abductive) [51]; iv) time available for scholars to collect data [46]; v) data collection method and method choice [52]; vi) resources that are available for scholars to collect data [46]; vii) data collection time frame choice [53]. Deriving sample size and choosing an appropriate sampling technique for choosing samples from the research population is one of the most important decisions scholars need to make during their Ph.D. journey. We strongly recommend scholars know their competence, research environment, and support system before finalizing the sample size and sampling technique. Do note that the sample size and sampling technique tells us 'From How Many' and 'From Whom' to collect research data [48].

2. OBJECTIVE :

There is humongous confusion among Ph.D. scholars in India about the difference between two standard formulas for deriving sample size, every component of these two formulas, and various available techniques to select samples from their research population. Furthermore, deciding the right sample size and selecting samples that are representative of the research population is one of the most important choices scholars are required to make during the doctoral-level research process. *Owing to such confusion the key objective of this article is to explain standard formulas available for deriving sample size, the essence of every component of formulas, and available techniques for selecting samples from the research population in turn, guiding them to finalize appropriate sample size and sampling technique.*

3. DERIVING SAMPLE SIZE :

Deriving sample size is required to finalize *'From How Many'* respondents/participants/subjects/ cases/groups/units of analysis/samples we require to collect the research data [48]. Deriving the sample size step is one of the easiest steps in the doctoral-level research process as the Ph.D. scholars will get the help of a 'Facilitator' famously known as Statistical Techniques [47]. Scholars might think about whether they are good at Mathematics/Statistics. However, they need to be cognizant of the fact that, Statistics is not Mathematics! and does not require talent or previous association with subjects concerning Mathematics/Statistics. It just requires hard work, and more than the hard work requires scholars to focus on the purpose of deriving sample size and the role of statistical techniques. Scholars need not be an expert in Mathematics or Statistics and most importantly they are not required to memorize the formulas. They just need to know why they have taken the help of a particular formula. Statistics also uses numbers, but numbers are not the primary focus. It is a form of inductive reasoning that uses mathematics as one of its tools to discover new knowledge. It is a thinking tool and science of learning from data [46].

We know that scholars are interested in studying a population/universe/group of their research question, but unfortunately, it is impossible to collect research data from the entire population of the research question. For example, if the key objective of the research is to understand the relationship between 'online teaching mode' (Independent Variable) and the 'learning levels' (Dependent Variable) of students studying for a master's degree in Psychology in India (Units of Analysis) which means the population of the research question is 'ALL' the students enrolled in a Master of Psychology program in India. Now one can imagine how difficult it is for scholars to reach out to every student of Psychology (Master's) admitted across 28 States and 8 Union Territories of India. Hence, experts in the field of Statistics have discovered a 'Sample' which is a smaller and more manageable version of a larger population of the research question. It is a subset containing characteristics of a larger population and represents the population as illustrated in figure A (All the white patches in the population are the samples selected from the population). The use of samples allows scholars to conduct research with more manageable data and on time. Statistical techniques help scholars scientifically arrive at an ideal sample size for their research and the only way to avoid Statistics during

this step is to collect data from the entire population (known as Census). However, Statistical techniques can only help scholars derive the sample size through standard formulas, but they need to know and decide on a few components of these formulas as discussed below [55-71].

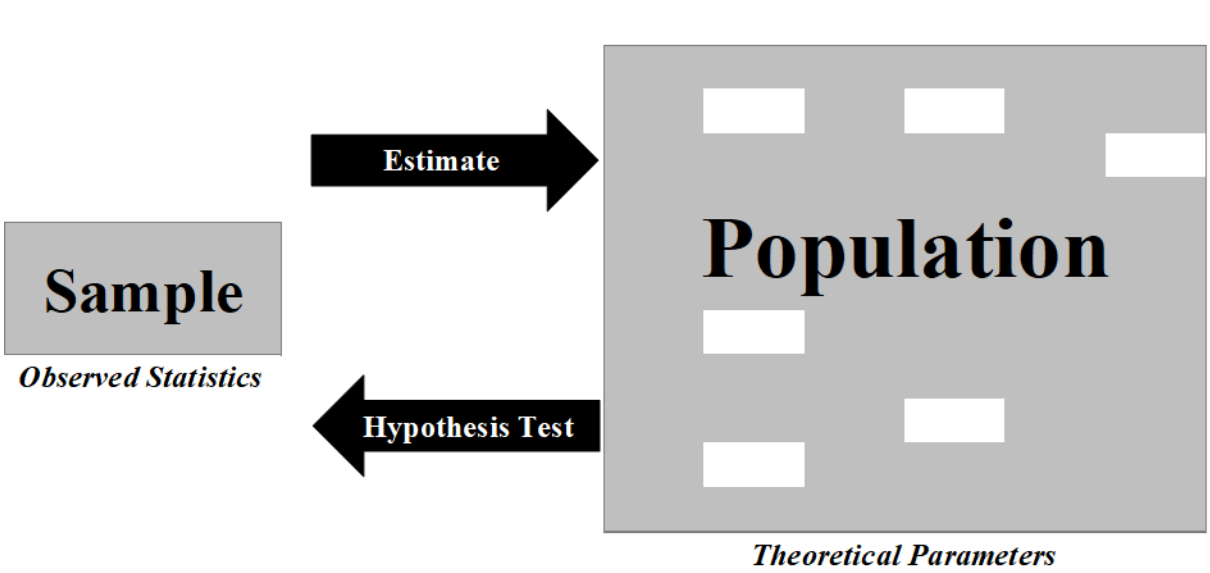

Fig. A: Population and Sample [54]

3.1. Decision 1 - Population Size :

The size of the overall population scholars wish to examine should be taken into consideration when deciding on the sample size. A population is an entire group that scholars want to conclude about, and it is from the population that a sample is selected, using various sampling techniques. The research population size may be known such as the total number of employees in a particular company or the total number of full-time Ph.D. scholars in Uttar Pradesh, and in some cases, the population size is unknown such as the number of working women in Ahmedabad. But there is a need for a close estimate, especially when dealing with relatively small or easy-to-measure groups of people.

3.2. Decision 2 - Sample Proportion :

Sample Proportion is required to determine the appropriate sample size for estimating the proportion of the research population that possesses a particular property/character/common element (criteria). Defining the Sample of the research is an important task, and scholars are the only persons who have a better understanding of the criteria of the sample. Sample Proportion can often be determined by using the results from a previous study (similar), or by running a small pilot study. If scholars are unsure, scholars can use 50% as the Sample Proportion (safer side), which is conservative and gives the largest sample size. However, be aware that scholars can only copy the Sample Proportion of a similar previous study and they are not allowed to copy the sample size of any previous studies (read and understand this sentence once again). 50% sample proportions meant that about 50% of the research population is expected to 'meet the criteria' of the definition of samples of the research study. For example, if we decide to choose 50% as the sample proportion to calculate the sample size that means we are sure that 50% of the research population is owing a car if we are studying the experience of car owners or 50% of the research population can speak more than one language if we are trying to understand the communication skills of people who speak more than one language or 50% of the research population was isolated during Covid-19 lockdown if we are trying to understand the experience of home isolation. Be aware that this decision is purely left to scholars' discretion and no one can question this decision as long as scholars can justify/defend their decision on the Sample Proportion.

3.3. Decision 3 - Margin Of Error (MOE) and Confidence Interval (CI) :

The MOE/CI tells scholars how confident they can be that the results from a study reflect what they would expect to find if it were possible to survey the entire research population being studied. It is

usually a plus or minus (±) figure. MOE is represented in ± % points, whereas CI is represented in ± absolute value. Let us assume that a scholar has decided on ±5% points MOE while calculating the sample size which means, this scholar is fine in allowing only ±5% points mistake in his/her claim/finding of the research. Usually ±5% points MOE is set by the scholars for sample size calculation. For example, if we have found that about 90% of 50 B.Com students (Samples) we selected out of a total of 350 B.Com students at Srinivas University (Research Population) have agreed that 'online teaching mode' (Independent Variable) has a positive impact on the 'learning levels' (Dependent Variable) and hence we have concluded our research as *'Online Teaching Mode has Positive Impact on Learning Levels of B.Com Students at Srinivas University'*. Now the meaning of ±5% points MOE is that if another Researcher selects another 50 B.Com students at Srinivas University who were not part of our previous samples, then we are confident that between 90% (-5%: 45 students) and 95% (+5%: 48 students) would also agree that the online teaching mode has a positive impact on their learning levels as during our research 90% of the students agreed.

3.4. Decision 4 - Confidence Level (CL) :

The CL is the percentage of probability or certainty that the MOE/CI would contain the true population parameter when we draw a random sample many times. It is expressed as a percentage and represents how often the percentage of the research population who would pick an answer lies within the MOE/CI. For example, a 99% confidence level means that should we repeat an experiment or survey over and over again, 99 percent of the time, our results will match the results we get from a research population. In other words, there is only a 1% chance that the results from the research population will be less or more than the MOE/CI. Usually, a Confidence Level of 95% is acceptable if scholars belong to disciplines other than Basic Sciences, Medical Sciences, Clinical Studies, Engineering, Technology, or Health sciences else it needs to be kept at 99%. Do note that the higher the Confidence Level set during the research higher the reliability and validity of our research claim/finding/conclusion.

Formula 1 - Population Size Known :

Sample Size; $= N*X / (X + N - 1)$ Where, $X = Z_{a/2}{}^2 * p*(1-p) / MOE^2$ (1)

- **'N'** is Population Size
- **'p'** is Sample Proportion
- **'MOE'** is the Margin of Error
- **'Z'** is a Critical value. It is a mathematical constant defined by the Confidence Level chosen. Standard values for **'Z'** are; for 85% CL 1.440; for 90% CL 1.645; for 95% CL 1.960; for 99% CL 2.576.

Formula 2 - Population Size Unknown :

Sample Size $= Z_{a/2}{}^2 * p*(1-p) / MOE^2$ (2)

- **'p'** is Sample Proportion
- **'MOE'** is the Margin of Error
- **'Z'** is a Critical value. It is a mathematical constant defined by the Confidence Level chosen. Standard values for **'Z'** are; for 85% CL 1.440; for 90% CL 1.645; for 95% CL 1.960; for 99% CL 2.576.

Once the scholars have made all the above four decisions their work is done. Now they need to enter the numbers of all these decisions into the standard sample size formula to derive the sample size for the research data collection. There are two formulas for calculating the sample size [55] such as i) formula 1 when we know the exact size of the research population (1), and ii) formula 2 when we do not know the research population size (2). Once scholars have derived the sample size, they need to remember to set their sample size as 20% higher than what they got from the formula. The additional sample size is always necessary as there are chances that the samples chosen by the scholars might not respond to all their questions/treatments/interventions or they might answer a few questions without much deliberation, or they might not turn up when scholars start the data collection process.

4. CHOOSING SAMPLES FROM THE RESEARCH POPULATION :

Once the scholars have finalized 'From How Many' to collect the research data, now in the next step of the doctoral-level research process they need to finalize *'From Whom'* (respondents/ participants/subjects/cases/groups/units of analysis/samples) to collect the research data that are representing the population of their research question. Selecting appropriate samples from the research population is also one of the easiest steps as the scholars' task is to only choose one of the nine techniques. Choosing the right samples from the research population is also known as the Sampling/Sampling Technique. Though the procedure of selecting a sample differs according to the type of sample selected, certain fundamental rules remain the same that are listed below.

- The research group or universe or population must be defined precisely.
- Before choosing the sample, the unit of analysis/sample should be defined. A clear description of the sample based on the scholars' research questions is mandatory. For example, Gender (Male/Female); Age; Marital Status (Married/Unmarried/Divorced); Occupation (Working/Non-working); Disease (New/Chronic/Hereditary/Non-hereditary); Customer (New/Existing).
- The appropriate source list which contains the names of the units of a research group or universe or population from which the sample is to be selected should be prepared beforehand in case it does not already exist.
- The size of the sample to be selected should be pre-determined as discussed in the previous step.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48
49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64
65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80
81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96
97	98	99	100	101	102	103	104	105	106	107	108	109	110	111	112
113	114	115	116	117	118	119	120	121	122	123	124	125	126	127	128
129	130	131	132	133	134	135	136	137	138	139	140	141	142	143	144
145	146	147	148	149	150	151	152	153	154	155	156	157	158	159	160
161	162	163	164	165	166	167	168	169	170	171	172	173	174	175	176
177	178	179	180	181	182	183	184	185	186	187	188	189	190	191	192
193	194	195	196	197	198	199	200	201	202	203	204	205	206	207	208
209	210	211	212	213	214	215	216	217	218	219	220	221	222	223	224
225	226	227	228	229	230	231	232	233	234	235	236	237	238	239	240
241	242	243	244	245	246	247	248	249	250	251	252	253	254	255	256
257	258	259	260	261	262	263	264	265	266	267	268	269	270	271	272
273	274	275	276	277	278	279	280	281	282	283	284	285	286	287	288

Fig. 1: Population frame

There are two main categories of Sampling Techniques viz, Non-random/Non-probability Sampling and Random/Probability Sampling [72-103]. Assume that our research population is a Research Methodology Classroom with 288 Ph.D. scholars in it. The Sample Size derived using formula 1 (population size is known) is 58 (keeping p=0.95; MOE=0.05; CL=95%). Let us now understand different types of Sampling Techniques with examples using this research population. Firstly, as we know the research population size we can create a frame of the research population as shown in figure 1 by giving each of the Ph.D. scholars a number or code.

4.1. Judgemental/Purposive Sampling :

It is a Non-random/Non-probability Sampling Technique. In this type, we purely consider the purpose of our research, along with the understanding of the target population. For instance, when we want to understand the thought process of scholars interested in enrolling in a 'Post-doc' program after their Ph.D., our Sample selection criteria will be, asking a simple question to all the 288 scholars i.e., "are you interested in doing a Post-doc program after Ph.D.?" And those who respond with a "no" are excluded from the sampling. We will choose the scholars who said 'yes' to our question as our 58

Samples. This technique is illustrated in figure 2 with Samples being selected and highlighted with a grey-colored filling.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48
49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64
65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80
81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96
97	98	99	100	101	102	103	104	105	106	107	108	109	110	111	112
113	114	115	116	117	118	119	120	121	122	123	124	125	126	127	128
129	130	131	132	133	134	135	136	137	138	139	140	141	142	143	144
145	146	147	148	149	150	151	152	153	154	155	156	157	158	159	160
161	162	163	164	165	166	167	168	169	170	171	172	173	174	175	176
177	178	179	180	181	182	183	184	185	186	187	188	189	190	191	192
193	194	195	196	197	198	199	200	201	202	203	204	205	206	207	208
209	210	211	212	213	214	215	216	217	218	219	220	221	222	223	224
225	226	227	228	229	230	231	232	233	234	235	236	237	238	239	240
241	242	243	244	245	246	247	248	249	250	251	252	253	254	255	256
257	258	259	260	261	262	263	264	265	266	267	268	269	270	271	272
273	274	275	276	277	278	279	280	281	282	283	284	285	286	287	288

Fig. 2: Sampling frame for Judgemental/Purposive sampling

4.2. Quota/Dimensional Sampling :

It is a Non-random/Non-probability Sampling Technique. Quota sampling is where we take a very tailored sample that is in proportion to some characteristic or trait of the research population. For example, if our research population consists of 50% female and 50% male, our sample should reflect those percentages. If the Research Methodology classroom has 50% Male and 50% Female scholars then firstly we will divide our research population into two parts (Male and Female) as highlighted with red frames in figure 3 and we will select 29 males and 29 females from each part of our sampling frame as illustrated in figure 3**.** with samples being selected highlighted with a grey-colored filling.

4.3. Convenience Sampling :

It is a Non-random/Non-probability Sampling Technique. In situations, wherein we have nearly no authority to select the sample elements, it is purely done based on proximity. Unfortunately, this technique is misunderstood by many Ph.D. scholars in India as choosing samples that are convenient for them. The convenience Sampling Technique must be chosen only in case the distance between the scholar and the sample is very long and it is impossible to collect research data from them. For example, if we are interested in understanding the impact of the Research Methodology class using a face-to-face interview (Survey method) that requires us to meet the sample in person then we might want to choose 58 scholars who are staying very close to (proximity) our place of stay/research/study. In this case, our sampling frame might look like the one illustrated in figure 4**.** with samples being selected highlighted with a grey-colored filling.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48
49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64
65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80
81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96
97	98	99	100	101	102	103	104	105	106	107	108	109	110	111	112
113	114	115	116	117	118	119	120	121	122	123	124	125	126	127	128
129	130	131	132	133	134	135	136	137	138	139	140	141	142	143	144
145	146	147	148	149	150	151	152	153	154	155	156	157	158	159	160
161	162	163	164	165	166	167	168	169	170	171	172	173	174	175	176
177	178	179	180	181	182	183	184	185	186	187	188	189	190	191	192
193	194	195	196	197	198	199	200	201	202	203	204	205	206	207	208
209	210	211	212	213	214	215	216	217	218	219	220	221	222	223	224
225	226	227	228	229	230	231	232	233	234	235	236	237	238	239	240
241	242	243	244	245	246	247	248	249	250	251	252	253	254	255	256
257	258	259	260	261	262	263	264	265	266	267	268	269	270	271	272
273	274	275	276	277	278	279	280	281	282	283	284	285	286	287	288

Fig. 3: Sampling frame for Quota/Dimensional sampling

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48
49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64
65	**66**	**67**	**68**	**69**	**70**	**71**	**72**	**73**	**74**	**75**	**76**	**77**	**78**	**79**	**80**
81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96
97	98	99	100	101	102	103	104	105	106	107	108	109	110	111	112
113	114	115	116	117	118	119	120	121	122	123	124	125	126	127	128
129	**130**	**131**	**132**	**133**	**134**	**135**	**136**	**137**	**138**	**139**	**140**	**141**	**142**	**143**	**144**
145	146	147	148	149	150	151	152	153	154	155	156	157	158	159	160
161	162	163	164	165	166	167	168	169	170	171	172	173	174	175	176
177	178	179	180	181	182	183	184	185	186	187	188	189	190	191	192
193	**194**	**195**	**196**	**197**	**198**	**199**	**200**	**201**	**202**	**203**	**204**	**205**	**206**	207	208
209	210	211	212	213	214	215	216	217	218	219	220	221	222	223	224
225	226	227	228	229	230	231	232	233	234	235	236	237	238	239	240
241	242	243	244	245	246	247	248	249	250	251	252	253	254	255	256
257	258	259	260	261	262	263	264	265	266	267	268	269	270	271	272
273	274	275	276	277	278	279	280	281	282	283	284	285	286	287	288

Fig. 4: Sampling frame for Convenience sampling

4.4. Snowball Sampling :

It is a Non-random/Non-probability Sampling Technique. The process of Snowball sampling is much like asking our subjects/respondents/participants/groups/units of analysis/samples to nominate another one with the same characteristic/trait as our next Sample. We will then observe the nominated samples and continue in the same way until obtaining a sufficient number of samples. For example, if we are interested in understanding the key objective of scholars in the Research Methodology classroom to enroll in the Ph.D. program then we know that a majority of the scholars will not be giving an honest answer. In this case, Snowball Sampling Technique is the appropriate technique to select samples. Here we will ask the scholar who has honestly answered our question and use this scholar to select other scholars based on the nomination process. In this case, our Sampling frame might look like the one illustrated in figure 5, with samples being selected highlighted with a grey-colored filling.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	**15**	**16**
17	**18**	19	20	21	22	23	24	25	26	27	28	29	30	**31**	**32**
33	34	**35**	36	37	38	39	40	41	42	43	44	45	46	**47**	**48**
49	50	51	**52**	53	54	55	56	57	58	59	60	61	**62**	63	**64**
65	66	67	68	**69**	70	71	72	73	74	75	76	**77**	78	79	**80**
81	82	83	84	85	**86**	87	88	89	90	91	**92**	93	94	95	**96**
97	98	99	100	101	102	**103**	104	105	106	**107**	108	109	110	111	**112**
113	114	115	116	117	118	119	**120**	121	**122**	123	124	125	126	127	**128**
129	130	131	132	133	134	135	136	**137**	138	139	140	141	142	143	**144**
145	146	147	148	149	150	151	152	153	**154**	155	156	157	158	159	**160**
161	162	163	**164**	165	166	167	168	169	170	**171**	172	173	174	175	**176**
177	178	179	**180**	**181**	182	183	184	**185**	**186**	187	**188**	189	190	191	**192**
193	194	**195**	**196**	197	**198**	199	**200**	201	202	203	204	**205**	206	207	**208**
209	210	**211**	212	213	214	**215**	216	217	218	219	220	221	**222**	223	**224**
225	**226**	227	228	229	230	231	232	233	234	235	236	237	238	**239**	**240**
241	**242**	**243**	244	245	246	247	248	249	250	251	252	253	254	255	256
257	258	259	**260**	261	262	263	264	265	266	267	268	269	270	271	272
273	274	275	**276**	**277**	278	279	280	281	282	283	284	285	286	287	288

Fig. 5: Sampling frame for Snowball sampling

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48
49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64
65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80
81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96
97	98	99	100	101	102	103	104	105	106	107	108	109	110	111	112
113	114	115	116	117	118	119	120	121	122	123	124	125	126	127	128
129	130	131	132	133	134	135	136	137	138	139	140	141	142	143	144
145	146	147	148	149	150	151	152	153	154	155	156	157	158	159	160
161	162	163	164	165	166	167	168	169	170	171	172	173	174	175	176
177	178	179	180	181	182	183	184	185	186	187	188	189	190	191	192
193	194	195	196	197	198	199	200	201	202	203	204	205	206	207	208
209	210	211	212	213	214	215	216	217	218	219	220	221	222	223	224
225	226	227	228	229	230	231	232	233	234	235	236	237	238	239	240
241	242	243	244	245	246	247	248	249	250	251	252	253	254	255	256
257	258	259	260	261	262	263	264	265	266	267	268	269	270	271	272
273	274	275	276	277	278	279	280	281	282	283	284	285	286	287	288

Fig. 6: Sampling frame for Simple Random sampling

4.5. Simple Random Sampling :

It is a Random/Probability Sampling Technique. A probability sampling in which we simply select samples from the research population randomly. This technique ensures that each sample of the research population gets an equal chance of being selected. For example, if we are interested in understanding the impact of the Research Methodology class using an online questionnaire (Survey method) then we might choose 58 scholars randomly. In this case, our Sampling frame might look like the one illustrated in figure 6**.** with samples being selected highlighted with a grey-colored filling.

4.6. Systematic Sampling :

It is a Random/Probability Sampling Technique. A type of probability sampling method in which samples from a larger research population are selected according to a random starting point but with a fixed, periodic interval. This interval is also called a Sampling Interval which is calculated by dividing the overall research population size by the desired sample size (in this example 288÷5 = 5). We will select a scholar after a sampling interval of 5. In this case, our Sampling frame might look like the one illustrated in figure 7. with samples being selected highlighted with a grey-colored filling.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48
49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64
65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80
81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96
97	98	99	100	101	102	103	104	105	106	107	108	109	110	111	112
113	114	115	116	117	118	119	120	121	122	123	124	125	126	127	128
129	130	131	132	133	134	135	136	137	138	139	140	141	142	143	144
145	146	147	148	149	150	151	152	153	154	155	156	157	158	159	160
161	162	163	164	165	166	167	168	169	170	171	172	173	174	175	176
177	178	179	180	181	182	183	184	185	186	187	188	189	190	191	192
193	194	195	196	197	198	199	200	201	202	203	204	205	206	207	208
209	210	211	212	213	214	215	216	217	218	219	220	221	222	223	224
225	226	227	228	229	230	231	232	233	234	235	236	237	238	239	240
241	242	243	244	245	246	247	248	249	250	251	252	253	254	255	256
257	258	259	260	261	262	263	264	265	266	267	268	269	270	271	272
273	274	275	276	277	278	279	280	281	282	283	284	285	286	287	288

Fig. 7: Sampling frame for Systematic sampling

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48
49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64
65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80
81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96
97	98	99	100	101	102	103	104	105	106	107	108	109	110	111	112
113	114	115	116	117	118	119	120	121	122	123	124	125	126	127	128
129	130	131	132	133	134	135	136	137	138	139	140	141	142	143	144
145	146	147	148	149	150	151	152	153	154	155	156	157	158	159	160
161	162	163	164	165	166	167	168	169	170	171	172	173	174	175	176
177	178	179	180	181	182	183	184	185	186	187	188	189	190	191	192
193	194	195	196	197	198	199	200	201	202	203	204	205	206	207	208
209	210	211	212	213	214	215	216	217	218	219	220	221	222	223	224
225	226	227	228	229	230	231	232	233	234	235	236	237	238	239	240
241	242	243	244	245	246	247	248	249	250	251	252	253	254	255	256
257	258	259	260	261	262	263	264	265	266	267	268	269	270	271	272
273	274	275	276	277	278	279	280	281	282	283	284	285	286	287	288

Fig. 8: Sampling frame for Stratified sampling

4.7. Stratified Sampling :

It is a Random/Probability Sampling Technique. Involves the division of a research population into smaller sub-groups known as Strata. In stratified random sampling or stratification, the strata are formed based on samples' shared attributes or characteristics such as the 'discipline' of Ph.D. in the Research Methodology classroom example. All the research population elements are categorized into mutually exclusive and exhaustive groups (5 strata, 11 from each = 58 in this example). For example, if we want to ensure scholars from all the disciplines in the Research Methodology classroom are given an equal chance of being selected, we will first create Strata of each discipline (Allied Health Sciences, Education, Engineering, Social Sciences, and Management) and then randomly select scholars from each Strata. In this case, our Sampling frame might look like the one illustrated in figure 8. with samples being selected highlighted with a grey-colored filling.

4.8. Cluster/Area Sampling :

It is a Random/Probability Sampling Technique. Involves the division of a population into smaller sub-groups known as Cluster. The clusters are formed based on samples' shared attributes or characteristics such as scholars under a Research Supervisor/Guide in addition to a discipline (Allied Health Sciences, Education, Engineering, Social Sciences, and Management). Here we will divide the research population by discipline and then within each discipline, we will choose 'all' scholars under a specific Research Supervisor/Guide. Do note that the randomization is only in choosing the Research Supervisor/Guide and not the scholars under a Supervisor/Guide. In this case, our Sampling frame might look like the one illustrated in figure 9, with samples being selected highlighted with a grey-colored filling.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48
49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64
65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80
81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96
97	98	99	100	101	102	103	104	105	106	107	108	109	110	111	112
113	114	115	116	117	118	119	120	121	122	123	124	125	126	127	128
129	130	131	132	133	134	135	136	137	138	139	140	141	142	143	144
145	146	147	148	149	150	151	152	153	154	155	156	157	158	159	160
161	162	163	164	165	166	167	168	169	170	171	172	173	174	175	176
177	178	179	180	181	182	183	184	185	186	187	188	189	190	191	192
193	194	195	196	197	198	199	200	201	202	203	204	205	206	207	208
209	210	211	212	213	214	215	216	217	218	219	220	221	222	223	224
225	226	227	228	229	230	231	232	233	234	235	236	237	238	239	240
241	242	243	244	245	246	247	248	249	250	251	252	253	254	255	256
257	258	259	260	261	262	263	264	265	266	267	268	269	270	271	272
273	274	275	276	277	278	279	280	281	282	283	284	285	286	287	288

Fig. 9: sampling frame for Cluster/Area sampling

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48
49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64
65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80
81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96
97	98	99	100	101	102	103	104	105	106	107	108	109	110	111	112
113	114	115	116	117	118	119	120	121	122	123	124	125	126	127	128
129	130	131	132	133	134	135	136	137	138	139	140	141	142	143	144
145	146	147	148	149	150	151	152	153	154	155	156	157	158	159	160
161	162	163	164	165	166	167	168	169	170	171	172	173	174	175	176
177	178	179	180	181	182	183	184	185	186	187	188	189	190	191	192
193	194	195	196	197	198	199	200	201	202	203	204	205	206	207	208
209	210	211	212	213	214	215	216	217	218	219	220	221	222	223	224
225	226	227	228	229	230	231	232	233	234	235	236	237	238	239	240
241	242	243	244	245	246	247	248	249	250	251	252	253	254	255	256
257	258	259	260	261	262	263	264	265	266	267	268	269	270	271	272
273	274	275	276	277	278	279	280	281	282	283	284	285	286	287	288

Fig. 10: sampling frame for Multi-stage sampling

4.9. Multistage Sampling :

It is a Random/Probability Sampling Technique. The research population is partitioned into groups, like cluster sampling, but in this design new samples are taken from each cluster sampling. Two-stage sampling is used when the sizes of the clusters are large, making it difficult or expensive to observe all the units inside them. For example, if we are interested in knowing the impact of the Research Methodology course on the Ph.D. scholar and decide to choose Multistage Sampling. We will firstly divide (Stage 1) the entire population by their discipline, secondly, we will divide the scholars in each discipline by their gender (Stage 2), and lastly we will divide the scholars in each gender by their Ph.D. type (Full-time and Part-time; Stage 3). Only after the three stages of division, we will then randomly choose the samples from each stratum. In this case, our Sampling frame might look like the one illustrated in figure 10, with samples being selected highlighted with a grey-colored filling.

4.10. Choosing an Appropriate Sampling Technique :

After understanding all the available Sampling Techniques, scholars might be thinking that all of them sound good but how do choose one of them? We recommend scholars consider the following while they choose a Sampling Technique to select samples from their research population.

- The level of homogeneity in the population.
- Existing knowledge about the variables and units of analysis of the research question.
- The level of accuracy and precision required to claim the research findings.
- Cost and time required for Sampling Technique chosen.

We suggest scholars avoid Non-random/Non-probability sampling techniques unless it is the last resort. Use them during the early/exploratory stages/phases of the research. Do note that the higher the difficulty level of the sampling technique lesser the error in the research findings/claims. And irrespective of the sampling technique scholars decide to choose, always try, and select at least 20% more samples than the derived Sample Size. There are chances that the samples chosen by the scholars might not respond to all their questions/treatments/interventions or they might answer a few questions without much deliberation, or they might not turn up when scholars start the data collection process.

5. CONCLUSION :

Among the two main Sampling Techniques available Random/Probability sampling is the most preferred among scholars belonging to the Basic/Natural Science, Engineering, and Technology disciplines, and Non-random/Non-probability sampling is the most preferred for scholars belonging to other disciplines in India. We understand the Ph.D. program is time-bound and hence using one of the Non-random/Non-probability sampling techniques during the Ph.D. program is acceptable. But knowingly or unknowingly, intentionally, or intentionally a significant majority of researchers in India use Non-random/Non-probability sampling techniques even after the completion of the Ph.D. program. The fear among Indian researchers is that Random/Probability sampling techniques require

a lot of time investment, they are complicated, and most importantly the research output in the form of research article publications will slow down drastically. The mere pressure on Ph.D. scholars and Ph.D. holders in India to publish a certain number of research articles which is connected to their performance measurement is also one of the key reasons for this. Ph.D. scholars and Ph.D. holders must be aware that a scholarly description, explanation, or claim about a reality/fact/truth/effect/dependent variable and a piece of complete knowledge about reality is complete only when they are derived from collecting and evaluating data using multiple sampling techniques i.e., ensuring an equal opportunity was given to each sample of the research population to get selected.

It is the responsibility of every stakeholder in the research environment and system to ensure that the scholars are made aware of every step involved in carrying out doctoral-level research in addition to the purpose, objective, and key deliverables of various available sampling techniques for them to choose an appropriate one to achieve their key research objective during the Ph.D. journey. Designing robust coursework that is intended to create awareness about the essence of sample size and sampling techniques is an appropriate way of fulfilling this responsibility. As long as the Ph.D. scholars can understand an appropriate sample size and available sampling techniques and make mindful choices of sample size and sampling technique across various stages/phases of the research to answer their research question they will be able to determine (on their own) all the other choices in succeeding steps of doctoral-level research such as i) data collection instrument and iii) data analysis techniques.

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