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PROBABILITY AND NON-PROBABILITY SAMPLING - AN ENTRY POINT FOR UNDERGRADUATE RESEARCHERS

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ABSTRACT: *This paper aims at presenting a practical approach through simple explanations of the different types of sampling techniques for undergraduate, or novel researchers, who might struggle to understand the variations of each technique. Hence, this paper is an entry point to the initial familiarisation of these techniques as it does not limit to present the but also its application in real contexts exemplars. Embedding the explanations in real situations should help the readers to make more sense of each technique whilst helping them in their initial decisions of which technique could be more suited for their studies. The exemplars relate to educational contexts within the country of Malta. However, they can be easily associated with similar educational contexts. In the last section, an application of two non-probability sampling techniques – convenience and voluntary sampling - in a research project about the use of formative assessment during COVID19's first lockdown will be shared.*

KEYWORDS: probability sampling, non-probability sampling, qualitative research methods, quantitative research methods.

INTRODUCTION - THE CONTEXT

Due to my professional role in the country of Malta, a European member small island state, the practical application of each sampling technique will be related to this educational context. Hence, a brief introduction to the Maltese educational context is necessary for a better understanding of the exemplars. Formal education starts at the age of 5 in Year 1 of the compulsory cycle of education and remains obligatory until the age of 16 or the full completion of Year 11, locally also known as Form 5. Non-formal education within each primary school starts at the age of 2 years 9 months because it caters for students who will turn 3 years old by December of the same year for the October intake and by the end of April for the February intake (Ministry For Education and Employment, 2017). This admission procedure applies for the state sector as the non-state one comprising the Secretariat for Catholic Education and the Private Independent admit their youngest students in one intake, October of each year. The state sector catering for around 60%, (National Statistics Office, 2012; National Statistics Office, 2014), of the total student cohort adopts a college system run by a Head of College Network, (Ministry of Education Youth and Employment, 2005), where each cater for a cluster of primary schools acting as feeders to the Middle School (MS), which hosts 11-12 years-old, in turn the MS feeds the Secondary School (SS) catering for 13-15/16 years old students. The non-state Secretariat for Catholic Education with an educational provision for around 30% of the students residing in Malta has a mixed system of colleges and non but their variation from the state schools lies in the joined educational experience of the MS and SS students into what they refer to as SS. A similar approach is adopted by the Private Independent sector but some

schools have different administrations for the MS section and the SS one. Notwithstanding these differences, all the sectors are bound to follow the general aims and principles of the *National Curriculum Framework For All (*NCF), a legally binding document, which include high quality inclusive education, skills for active citizenship and employability, and lifelong learning (Ministry of Education and Employment, 2012).

Research Issue and Purpose

Carrying out a research study and reporting it in a dissertation is the most complex and challenging component of a course of study. It is more so for undergraduate students as it is likely to be their first time to have embarked on such a process which requires tough decisions on the research questions, methods, methodology and design amongst others. Understanding these terms is already demanding; not to mention the alignment between them if the research is to be considered credible, valid and trustworthy (Sikes, 2004). Reaching this end implies that the student must start with the end in mind (Trafford & Leshem, 2002). Undergraduate students, or novel researchers, who still struggle with establishing a narrow focus for their study find it very difficult to see how the pieces of the puzzle should connect. This issue has been experienced first-hand with the first group of undergraduate students within the Bachelor of Education course programme at the Institute for Education (IfE) following my course on qualitative research methods. In the first lecture, my dismay about their anxiety levels was huge that I was perplexed about how to calm them down to start discussing the challenging concepts with the qualitative research domain. This concurs with Papanastasiou and Zembylas's (2008) construct of "research methods anxiety" (p. 2), defined as "…the overwhelming fear, uncertainty and stress…" Should I have been unaware, or ignored, the students' emotional state, I would not have been able to "…tackle them early…" (p. 11) to start the teaching and learning. In doing so, I responded to the students' needs I a formative way by understanding where they were and adjusted the teaching plans accordingly (Wiliam, 2007, 2011, 2013). Ignoring the students' level of readiness would have kept them in their fixed mindset that qualitative research methods is beyond their competence's levels (Dweck, 1986, 2000, 2010), and consequently neither learning nor teaching would have taken place.

In reflecting on this situation and how future local and international undergraduate students can be assisted to "…become more informed consumers and producers of research…" (Tuli, 2010, p. 98) thereby controlling their frustration levels, is the purpose of this paper. The driving force for such collation is Pan and Tang's (2004) recommendation on the provision of practical application, real-life stories and exemplars to ease "…the students' understanding of what is being taught and its usefulness…" (Papanastasiou & Zembylas, 2008, p. 11)

LITERATURE REVIEW

Rationale for using sampling techniques

Research is an activity driven by an overarching research question which, in turn, defines the scope and purpose of the investigation (Cohen et al., 2018). Careful planning

is imperative as in the process the researcher must decide on the parameters of what type of research method would be more suited for that investigation – quantitative or qualitative – and how the participants should be recruited and accessed (Guthrie, 2010). Whichever method is opted for, the investigation is a finite activity because it is time bound, thus setting limits on the researcher in terms of what would be humanely feasible to do or not in a particular time-frame and with the available resources (Alvi, 2016). Such preliminary pre-sampling work determines the extent of the data collection exercise. If a census is not needed, or not practical to carry out, a sample is the most appropriate (Kolb, 2011). Such scenarios are needed when it is not possible, or not necessary, to study the whole group, (Henry, 2009; Vehovar et al., 2016) and therefore, the researcher would resort to a sub-group of the target population – a sample. Establishing the sub-group to work with makes the research more manageable. Choosing a sampling technique depends greatly on the goal, and type of the research, what Cohen et al. (2011, 2018) refer to as the fitness for purpose. Contemporary studies are merging the two methods, a very positive move as it provides the much-needed balance between the qualitative and quantitative research methods (Tashakkori & Teddlie, 2010). For years, the latter has been regarded of high calibre than the former because of its strong reliability and generalization. Whilst this fact cannot be denied, it should not be used to devalue the other as both have their strengths and weaknesses which need to be outweighed according to the purpose of study. In research, if it is carried out well within the parameters of rigour, both methods and the researcher using them should be equally valued.

The sampling techniques available in these contrasting research methods worlds are outlined in Table 1 below.

Probability Sampling	**Non-Probability Sampling**
Simple random sampling (SRS)	Convenience Sampling
Systematic sampling	Purposive Sampling
Stratified sampling	Quota Sampling
Cluster sampling	Dimensional Sampling
Stage or multi-stage sampling.	Snowball Sampling

Table 1. Sampling Techniques in Quantitative and Qualitative Research

Deciding which technique to use requires not only a clear research goal but also a self-reflective exercise about the research project by asking whether the study sample group:

- is homogenous (shares the same characteristics),
- is heterogenous (different characteristics),
- needs an exhaustive list of the population,
- is widely spread requiring travelling (Alvi, 2016).

It is noteworthy pointing out that a sample population can be treated as homogenous in one study while heterogenous in another (Alvi, 2016; Kolb, 2011). For instance, if a

researcher aims at unravelling the level of job satisfaction, then men and women must be treated differently and perhaps even in different groups according to age and/or years of experience. Conversely, the same group would be treated as homogenous if the IQ level among the company's employees needs to be investigated.

Following this preamble about rationale for using certain sampling techniques, the next section delves into each research method to discuss the sampling techniques most associated with it together with an application exemplar of that technique.

Explanatory Research

This type of research commonly known as quantitative research uses probability sampling techniques, also known as random or representative sampling (Alvi, 2016). Probability, a topic taught as part of the secondary mathematics syllabus, is synonym with keywords like random, fair, roll, dice, coins and probability spaces. The simplicity with which it is presented at this level of compulsory education is the root of what probability sampling is. In fact, Karwa (2019) in a Youtube video, (2019, 03:15-05:21) refers to probability sampling as randomization implying that the targeted population sample has a known, equal, fair and a non-zero chance of being selected, (Brown, 2007; MeanThat, 2016), thus ensuring equity between prospective research participants. This fair chance is calculated in a very simple way, like the probability of getting an odd number on a dice. The formula for the basic probability draw is

$$\frac{Sample\ Frame}{Total\ Population}$$

Sample frame is the list of participants to be taken from the population (MeanThat, 2016).

The major benefits of using random sampling is the liberty from human judgement bias and subjectivity, (Taherdoost, 2016), because the participants' selections are based on robust mathematical calculations supported by readymade software and websites like random number generators as on https://www.random.org/ and sample size calculations as on https://www.qualtrics.com/uk/experience-management/research/determine-sample-size/ . Another benefit of random sampling is the possible calculation of statistical estimates underpinned by the sampling or probability theory upon which the rigour, credibility and robustness of the study can be assessed (Brown, 2007) while also raising the confidence level set by the researcher (Landreneau & Creek, 2009). Confidence level is the certainty guaranteed by the researcher that the population characteristics have been well-captured by the sample (Taherdoost, 2016; Vehovar et al., 2016). The most widely accepted confidence levels are 90%, 95% and 99%, (Cohen et al., 2018), meaning that 90 or 95 or 99 people out of 100 will really represent the whole population (MeanThat, 2016). Identification of the confidence level depends on the confidence interval which is the margin of error. In social research, a 5% margin is an acceptable error range implying that if 44% of the respondents' report that they are satisfied at school, it can be safely concluded that the range of positively satisfied staff lies between 39% and 49%. Such quantification is another strong asset of probability

sampling as with a good confidence level within a good sample size the findings can be generalised to the population – the inferential leap can be made (Alvi, 2016). If the population is less than 50, probability sampling is inappropriate, however a sample of at least 30 participants is always recommended (Cohen et al., 2018; MeanThat, 2016). Deciding the right sample size requires a good design of the study, (De Vaus, 2001), because high numbers are not always necessary (Kolb, 2011). The Goldilocks or Russian doll principle is very apt here, (Clough & Nutbrown, 2012), the right amount for the right purpose. In the case of quantitative and heterogenous studies, large numbers are usually expected whereas in qualitative and homogenous ones, a low sample size is sufficient (Daniel, 2012). This author associates the quantity of sample size with the level of importance, something which I do not concur with as in such amalgamation, the qualitative study might be devalued. It is true that the largest the sample size, the smaller the error, however, in qualitative data, researchers are after thick descriptions (Tracy, 2013). Albeit being pro qualitative, it is my belief that any type of study which conforms with the rigour expected within its branch is valid and important because it adds new knowledge. Hence, in defining the sample size, other arguments should be brought forth like availability of resources and widespread of participants because as a rule of thumb there should be a directly proportional relationship between the size and the resources available. Contrastingly, the downsides of probability sampling include the need for significant resources, like cost, time and workforce as it will be highlighted in the following discussion of the sub-branches techniques falling within the random domain.

Types of Randomised Sampling Techniques

This section discusses each one of the sampling techniques identified in Table 1. The simplest method used is referred to as simple random sampling (SRS) which consists in giving a fair chance to every member within the sample frame because its draw is very straight forward (Kolb, 2011). The drawing procedures involves the placing of names or numbers in a container or using a more high-tech device to generate the list needed. Despite its fairness, validity and simplicity of analysis, (Acharya et al., 2013), the downsides of SRS are its cost, the need for a list of the whole population, which might not always be available or necessarily have the most recent one, the construction of a sample frame and high sampling errors thus leading to low precision (Ghauri & Grønhaug, 2005). Applying SRS in practice could look like the exemplar situation in Figure 1.

A Head of School (HOS) of 500 primary students would like to know the students' position about the amount of HW assigned. Interviewing everyone would be a daunting task so the sample size is calculated as follows:

Population = 500 Confidence Level = 95% Margin of error = 5%

Inputting these values in a sample size calculator, e.g. qualtrics.com, has returned an ideal value of 218 participants meaning that this amount must be drawn in the ballot system. In a random number generator of a list of 25 numbers as that is likely to be the largest class population, the HOS can identify which students to involve. The Google random generator returned 24, 9, 13, 14, 12 etc., hence the HOS will pick the students registered with that index number on the class list for the sample.

Figure 1:Exemplar of SRS in practice

The adage goes that 'to err is human' and consequently, such errors must be considered showing also the researcher's humbleness and integrity in admitting the possibility of errors. The margin of sampling error is the "true population value for the target population and the estimate based on the sample data" (Henry, 2009, p. 9). The total error is based on the equation of bias and sampling variability which involves a triad category system of non-systematic and systematic errors as well as errors derived from standard deviations (Henry, 2009).

Generating the list needed for the exemplar situation in Figure 1 is a very time-consuming exercise and thus, another type of sampling might be more appropriate like systematic (SS) or stratified sampling (STS).

SS differs from SRS not only because it is easier to carry out, (Sharma, 2017; Thomas, 2020), but also due to the even spread of the members chosen, (Karwa, 2019), as the internal gap is used in selecting the participants after a random start where a sample list is not a mandatory requirement (Taherdoost, 2016). Notwithstanding the positive aspects of high validity, easy verification and a simple drawing system, Acharya et al. (2013) alert us that only the first number is randomly chosen which then determines the next number according to the kth interval. An application of SS within the same situation presented in Figure 1 would look like that portrayed in Figure 2.

The kth number for a population of 5oo students is calculated by the formula $\frac{\text{Number of items}}{\text{Desired Sample Frame}} = \frac{500}{218} = 2.29$. Hence, the random first number using a calculator number generator can be either 1 or 2 or because it's past 2, it can include 3 as well. Then, if 2 is drawn and the interval is 3, the next student in the sample would be the one registered with an index number of 5, 8 and so on.

Figure 2: Exemplar of SS in practice

Whereas SS is characterised by the sequential process for choosing the participants, stratified sampling categorises members in sub-groups, (Sharma, 2017), not necessarily of the same size but recommended to be close in that, (Statistics and Theory, 2020), according to pre-defined strata that is exhaustive and exclusive to that group (Thomas, 2020). There are instances as presented in Figure 3 below where the group size is beyond the researcher's control, e.g. in the case of gender. In STS, each group is homogenous because the members share the same characteristic but heterogenous between groups as the features differ and therefore, group comparisons can be made, (Acharya et al., 2013), in a manageable way due to the narrowing down of the attributes' spread (Hayes, 2020). With this variety across groups, STS allows for the inclusion of a wide spread of the population's attributes, however, Cohen et al. (2011); (Hayes, 2020) warn us that such method is not recommended when too many variables are involved. Instead, it is feasible to use when random sampling is not possible due to the small size of the sample. Furthermore, McLeod (2019) points out that human bias is greatly controlled implying that both the validity and generalisability are very high. STS uses the procedure outlined below to stratify the population into groups.

i. Decide the population (e.g. 500 students)
ii. Choose the strata, say Year 1 boys, Year 1 girls etc.
iii. Calculate the number of subgroups.
iv. Apply a random sampling method, e.g. SRS or cluster sampling to constitute the sample.

Population of 300 boys and 200 girls in a primary school.
Strata – year group and gender so group 1 comprises Yr1 boys, group 2 Yr 1 girls and so on.

Each year group has 2 classes, hence there are 2 sub-groups per year. If in Year 1, the year group's population is 30 then the boys' group can include 20 boys, while the girl's group can take 10.

Having identified the sub-groups, SRS is used to choose the sample from the 12 sub-groups.

Figure 3 illustrates an exemplar related to this sampling technique.

If instead of a school level investigation, the Ministry for Education (MFED) needs to carry out a national exercise investigating the adherence to the homework (HW) policy, then a cluster sampling (CS) would be more appropriate as the different regions can form the cluster cohort. CS is frequently used when determining the number of individuals proves to be difficult. In Malta, this might not be that relevant due to its size, however, due to the spread of the students, it would make more sense to consider clusters. The underlying difference between CS and STS is the population spread over a large geographical area (Karwa, 2019). A further distinguishing feature is the ensemble of the group as a homogenous cohort on the basis of their location and here, it is the entire sub-group that is selected and not the elements within the sub-group (Alvi, 2016). For instance, Malta, albeit being a small country, if a national exercise across schools needs to be carried out, due to their spread, three clusters can be formed for each sector. Similarly, if an investigation needs to be carried out within the state sector only, then the Northern, Central and Southern cluster of colleges can be considered. These exemplars show that the cluster groups need not, and most likely would not, have equal members in each (Statistics and Theory, 2020). The main advantages of CS are the travelling time saved, the cost-effectiveness due to low or no commuting expenses and implementation is easy. On the flip side, Taherdoost (2016) cautions us that analysis are difficult because the findings can be biased according to the group's views (Sharma, 2017). CS adopts the following procedure in which a list of the population is not needed –

i. Decide the population
ii. Form the clusters – a crucial step in ensuring the validity of the study because careful analysis that in each, and across, the groups the elements represent the whole population (Thomas, 2020)
iii. Random selection of the clusters.

An exemplar of CS can consist in the investigation of the performance in English Benchmark exam writing component. The Benchmark Exam is a compulsory exam at the end of the primary sector aiming at gathering a snapshot of the Year 6 students attending the state sector. Non-state schools participate on a voluntary basis, and there are some private candidates from non-participant schools.

Population: All Year 6 students who sat for the BM exam.
Clusters: Yr 6 State North Cluster, Yr 6 State Central Cluster, Yr 6 State Southern Cluster, Yr 6 independent sector cluster and Yr 6 Church Schools cluster.

Random Selection: Year 6 State Southern Cluster, Year 6 independent sector and Year 6 Church School sector.

The southern cluster has been chosen because most of the non-state sector schools are found in the central and northern parts of the island which sector includes students coming from rural villages in the south too.

Figure 3: Exemplar of Cluster Sampling

The random selection in Figure 4 can be done through a double-staged sampling, also referred to as multistage sampling which is needed when the population is heterogenous but widely spread. Multistage sampling acts like a funnel where a broad population sample is narrowed down until it becomes the final unit for the investigation (Alvi, 2016; Taherdoost, 2016). A minimum of two stages are required where a sample is worked out on an already sampled group to overcome the heterogeneity of the group because the clusters must be a mini-representation of the population otherwise generalisation is not possible. Exemplar of a multistage sampling could be as illustrated in Figure 5 below.

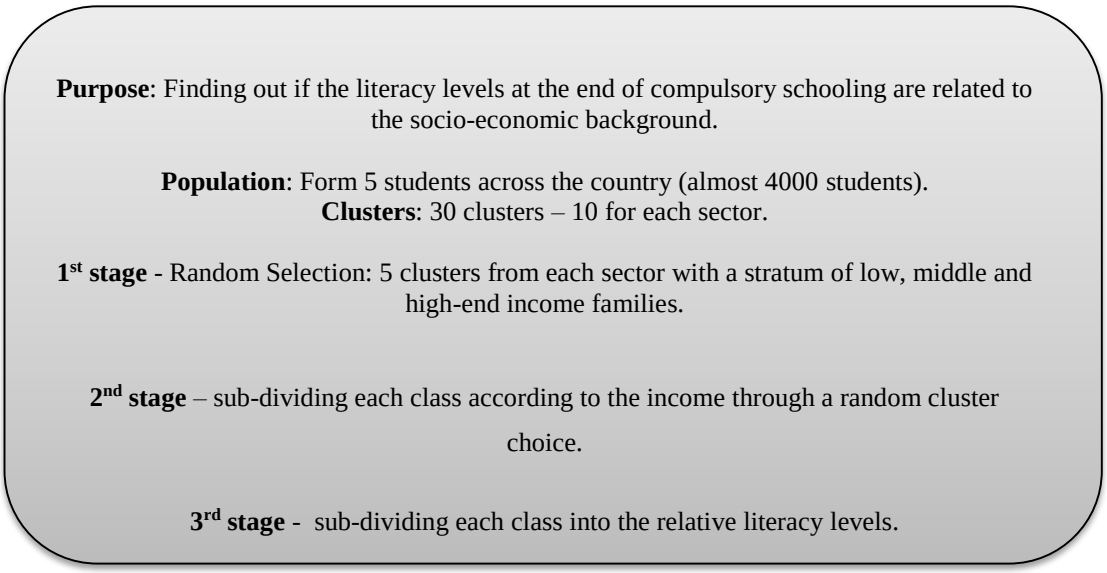

Figure 4: Exemplar of Multistage sampling

Having amply discussed the random type sampling, I now turn to non-random sampling where the choice of being chosen are unknown to the participants (Brown, 2007). Such method is used within qualitative or exploratory research because the research aims at exploring an idea in its richness and depth (Creswell, 2013).

Exploratory Research

Choosing the population depends mostly on the researcher's interests on the basis of "information about cases that are relevant to the study" (Henry, 2009, p. 3). In being driven by a personal interest, this sampling method is very much criticised for its high subjectivity (Etikan et al., 2016), and consequently, for the bias in the absence of sampling estimation and errors leading to a lack of generalisation (Cutajar, 2019; Vehovar et al., 2016). Nonetheless, the leap to a wider context occurs through the depth and trustworthiness of the research (Wilson, 2016). In fact, qualitative researchers are very careful with the terminology they use, *possible indicators* rather than strict fixed estimates of hard facts. Counteracting these negative effects is possible by keeping an accurate audit trail highlighting the steps taken by the researcher to contain the bias and to acknowledge one's positionality (Carcary, 2009). Situatedness in the field context is important if an ethnography study is being carried out. If phenomena are of interest,

then phenomenology is the most appropriate and for these studies the research would need to use non-representative sampling methods like those stated in Table 1.

Convenience sampling uses the closest and most convenient people to you which suits young researchers like teachers who cannot move freely from their school (Statistics and Theory, 2020). However, this comfort zone can turn into a professional conflict as these young researchers would now have a dual role - professional and that of an inside researcher which can cause some stir (Sikes & Potts, 2008). In turn, this might question the credibility of the study and the external validity due to its under representation (Sedgwick, 2013). Such technique is most useful when the population is very general and can be anywhere (Alvi, 2016). Furthermore, the cost-effectiveness in terms of time and money are also two major benefits of this approach (Taherdoost, 2016).

Two sampling methods which build on the convenience sampling are quota and snowball samplings. The similarity of the former lies in the fact that participants can be recruited if the selection parameters are met, (Taherdoost, 2016), whilst the latter shares the characteristic of the first selection being made by the researcher (Etikan et al., 2016). In quota sampling, the ceiling is set by the researcher on the basis of the percentage reflection of the population (Vehovar et al., 2016). For instance, if quota sampling is used for the Maltese student population, then the sample must have 60% of the participants from the state sector, 30% from the church and 10% from the independent. The non-random selection is the distinguishing factor between quota and stratified sampling (Alvi, 2016). High bias and the non-calculation of the sampling error are amongst the downsides of quota sampling (Sharma, 2017). Given its association of use in exploratory methods, the sample size needed would be small as fewer elements are involved (Daniel, 2012). A special case of quota sampling, this author explains, is dimensional sampling. Cora (2018) clarifies that such technique is used when taking different characteristics into account like gender, income, residence and education where each sub-group must have a representative of each. The sub-groups can either be proportional or non-proportional in that the first contains a similar structure to the population but in the second, other criterion can be involved where such widespread allows for further inclusion of the representatives.

With the aforementioned knowledge about probability and non-probability techniques, the next section discusses how a combination of techniques were used in a recent research by Said Pace (2020).

Research Project – a further exemplar

Triggered by the COVID-19 lockdown, this project explored the use of formative assessment (FA), if any, in online teaching and learning. The research questions guiding the study were:

- *What are the teachers' perceptions of FA in the online teaching and learning within compulsory education during the COVID-19 school closure?*

- *In what ways, if any, did the teachers embed FA practices in online teaching and learning within compulsory education during the COVID-19 school closure?*

The fine details required by these questions where collected through a web-based questionnaire comprising closed and open-ended questions. Dissemination was done through an email shot by the Ministry for Education's Information Management Unit, the Director General at the Secretariat for Catholic Education, the respective Heads of School within the independent sector and on social media. This type of dissemination targeted the intended audience and hence voluntary sampling was used. However, the professional and social media connections have helped to invite educators through convenience and voluntary sampling who were then encouraged to share the questionnaire with colleagues, so snowball sampling was used too. Such combination was appropriate as the data needed was about the experience of teachers across the sectors in using FA in the online modality. The greatest limitation was the lack of human interaction with the participants, (Reja et al., 2003), sampling errors could not be calculated due to the qualitative nature of the study, and the self-selection could include non-teaching educators making the data invalid (MeanThat, 2016). No specific numerical sample size value was set upfront except that I wanted a good representation from each sector, so I kept sharing until a good sample was reached, the aim being of at least 100 educators. This has been surpassed as 385 educators voluntarily participated meaning that from a quantitative lens, such return is a good sample size from around 4000 educators. Also, the number of responses per sector fulfil the quota criteria as the state had 234, the church 109 and the independent 42 representations, figures which reflect the national percentage of the population. A similar study by Busuttil and Farrugia (2020) has attracted a very close number of participants, 407, indicating that my sample provides a good snapshot of the situation.

The findings revealed numerical figures of the usage of FA strategies by the Maltese educators in the first lockdown of March 2020 whilst the open-ended questions enriched and substantiated further the qualitative data. Details of these findings can be found in Said Pace (2020) and in another paper currently in press (Said Pace, in press).

Significance of this Paper

The reflection on, and the subsequent, action by the author following a taught module in a synchronous format as part of an undergraduate course within the field of education to support higher education students to engage in the academic debate of research methods is the main contribution of this paper. The author is humbly stating and presenting this work as an entry point to the world of research methods for undergraduate students because the simple exemplars within the educational field can be easily related to. Furthermore, this paper can support school administrators who are not researchers but need to carry out in-school small research by making the strange familiar.

Future research into higher education students' perceptions, feelings and the related contributing factors about research should be an important study to carry out, at least,

in the Maltese context as this would help us lecturers to understand better our students for a more individualised learning approach.

CONCLUSION

In the attempt to make the complex simple for beginning researchers, exemplars for each sampling techniques were used to facilitate the student's understanding of each. Furthermore, in not limiting each technique to the what it consists in, as it has included the how, the when and the why, it is hoped that a better-informed decision can be made on the sample most suited for a particular study. The debate on the benefits and limitations of the probability and non-probability sampling techniques emphasised the point that both methods are equally valid if they fit the purpose for which they are being used. In accepting such parity of esteem, researchers can increase the robustness of their studies when making the best use of both worlds.

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