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USE OF SINGLE-SUBJECT RESEARCH DESIGN IN SPECIAL EDUCATION: ADVANTAGE AND DISADVANTAGE

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Abstract: in the field of special Single-subject research design (SSRD) is a type of scientific research that is becoming more popular in the area of special education and it is an alternative to group-research designs. The objective of this paper is to provide an overview of single-subject experimental design including their basic features, type of SSRD used in special education research, and advantage and disadvantage of SSRD. Internal and external validity are also described. Replication of measurements across phases, baseline and intervention phase are the three foundations of SSRD. On the other hand, meta-analytic research can help to improve the generalizability of single-subject design findings in similar situations.
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INTRODUCTION:

In the area of education and psychology there are several research design to examine the effect and it involved a large number of participants. But today there are many research problems that do not involve the huge numbers of participants. Specifically, in the fields of special education and psychology, researchers are required to answer questions that may affect only one or a few participants, such as a special educator or psychologist measure that which type of intervention programme effect the behaviour of children with Autism. A psychologist is working with children with autism to reduce their undesirable behaviour. According to Mesibov & Shea (2011), the majority of evidence-based strategies in special education focus on developing a scientifically teaching programme, instructional strategy, or intervention programmes. This type of studies, researcher find out that what type of behaviour children occurred and what type of intervention programme needed, how to implement the intervention programme. These type experimental designs are known as single-subject designs because they usually include only one or a few participants.

Practices in special education should be guided by science. However, doing scientific research in the area of special education can be difficult due to the circumstance that people with disabilities have significantly more variability than people without disabilities (Alnahdi, 2013; Odom, et al., 2005). "Person with Disabilities Act., (1995)", "RPwD Act., (2016)", "Action for Autism", and "The National Trust for the Welfare of Persons with Autism, Cerebral Palsy, Mental Retardation, and Multiple Disabilities" have developed guidelines for determining the quality and quantity of research studies that focus on practices in special education. It is difficult to compare and analyse the peer groups because of the heterogeneous characteristics of person with disabilities such as Autism with randomization sampling technique (Parker, et al., 2008).

Galassi & Gersh (1993) defined that "Single-subject design (SSD) is a scientific research methodology that is used to measure the functional relationship between dependent and independent variable". Parker, et al., 2008) stated that SSRD is a quantitative research study that provides an alternative to group design in special education research and most practical for experimental designs for person with autism or other disabilities. Single-subject design research have been described by different names such as "Single case research design", "n of 1 studies", "small-n design". Single-subject design research focuses on a small sample consisting of one to ten individuals (Jhangiani, et al., 2015).

In the area of special education, SSRD has a long history that provided useful information (Odom & Srrain, 2002; Horner, et al., 2005). Last sixty year ago, Sidman (1960) first operationalization the methodology of single-subject design in his book

"*Tactics of Scientific Research: Evaluating data in Psychology*". After that Baer, et al., (1968) elaborated the single-subject design in the context of how single-subject research design useful to measure the effect of an intervention programme with individuals.

Special education is a discipline that emphasises the single person as a unit and need for continued study in practical settings is critical; it is similarly problem-solving discipline in which the intervention programme increasing the desirable behaviour and decreasing undesirable behaviour of Children with Disabilities/ Autism (Horner et al., 2005). Purpose of this paper is to provide an overview of single-subject experimental design including their basic features, type of SSRD used in special education research, and advantage and disadvantage of single-subject-research design.

Despite the fact that several of textbooks discussing about SSRD extensively, these resources do so in a broader framework of single-subject design. Furthermore, many books do not address the use of single-subject design in the field of special education. Therefore, they do not provide concrete examples of how these SSD may be implemented in special education or inclusive school settings. The examples used to demonstrate single-subject design in this work was taken from the special education literature.

IMPORTANT FEATURES OF SINGLE-SUBJECT DESIGN

SSRDs are a quantitative research methodology, and real experiments can reveal the causal relationship between independent and dependent variables (Alqraini, 2017; Kazdin, 2011; Horner, et al., 2005). The ability of SSRD to examine the intervention programme with only one or a few participants is a distinguishing feature. The importance of results from group data is undeniable; however, researchers want to know more about the intervention effect on individual person, which group experiment studies often do not address. Therefore, Kazdin (2011) discuss that the SSRD can be used to develop an intervention if it does not work or fails to meet its objectives. The single-subject design has some important features that make it different from other research design.

According to Horner, et al. (2005) & Kazdin (2011) seven key features are: "(i) individual or single person as a unit of analysis; (ii) the operational definition of study characteristics; (iii) the use of baseline or intervention phase; (iv) experimental control; (v) the repeated measurements of dependent variable; (vi) repeated and systematic introduction of intervention programme; and finally (vii) visual analysis". These fundamental qualities are present in all SSRD sand serve as the foundation for all variations.

The essential assumption of a SSRD as a special education research method is that the intervention is effective if it improves the behaviour of children with disability such as Autism before, during and after the intervention. Repeated measurements, baseline phase and intervention phase has three basic components of SSRD and baseline and intervention phase measurements are commonly represented in graphs.

(i). Individual or single person as a unit of analysis

Individual data analysis is the first and most important feature of single-subject design. Each and every individual play his role as his or her own control. Single person is an important element of SSRD since it allows researchers to examine each participant's individual performance. Researchers regularly observe the performance of a group sample and report the average to indicate the effectiveness of the intervention in group experimental designs. However, in a single-subject design researchers present the success of an intervention using individual data analysis. Individual's performance during the intervention is compared to before and after the intervention programme (Horner, et al., 2005). Special educators can also assess the efficacy of an intervention programme for each person who is involved in study.

(ii). The operational definition of study characteristics

In single-subject research design, defining the study parameters such as participant's behaviour, demographic details, and research setting because these clear definitions allow other researchers to more accurately repeat this study in a new circumstance. For example, improvement of specific skills of Children with Autism Spectrum Disorder, the researcher defining the specific characteristics in details that should be used in study such as: area of impairment in social, and communication skills; age in which the diagnosed the disability; gender and socioeconomic status of participant; severity level of impairment, etc.

(iii)The repeated measurements of dependent variable

In single-subject research design, dependent measurement must be measured repeated between phases/conditions. Before, during and after the intervention, the researcher should be able to measure the children's performance on the desirable behaviour at regular time intervals, whether the intervals are hours, days, weeks, or months (Kazdin,

1982). In most SSRDs, determining the baseline phase is the first phase and "A" donates the baseline phase. The baseline phase is used to create beginning patterns of children behaviour against which a child's performance during and after an intervention is implemented can be compared (Kennedy, 2005). After the baseline phase, the intervention phase is generally implemented "B" donate the intervention phase. Researchers collect data (repeated measurement) across phases to prove the causal relationship between the dependent and independent variables.

(iv). Repeated and systematic introduction of intervention programme

Hersen & Barlow (1976) explain that to determine functional relationships between the dependent variable and independent variables in single-subject design, intervention programme must be introduced repeatedly and systematically across phases. However, the researcher delivers an intervention programme in group experimental designs to one group of participants sample drawn from the large population, and data is collected from both the groups (control and intervention) on a pre-post of the study (Cohen et al., 2000). After that the researcher examines the scores of both groups to see if there is a difference in their performance. But in single-subject research design, researcher introduces the intervention to individual person in phase to determine whether it is beneficial or not (Hersen& Barlow, 1976).

(v). Visual analysis

Visual analysis is used in SSRD to demonstrate the effectiveness of an intervention (Cakiroglu, 2012) and it is an important method to analysis the data. Researchers look the patterns of data while analysing a single-subject graph. Kratochwill, et al., (2010) compare the baseline and intervention phase data using visual analysis of graphic representation; and define six elements to compare the patterns of data within or between phases: (i). stability or consistency of data patterns; (ii). Change in level; (ii). Change in Trend/Slope; (iv) variability; (v) overlap; and (vi) immediacy. All these elements are used to see if an independent variable and a dependent variable have a causal relationship.

TYPE OF SINGLE-SUBJECT RESEARCH DESIGN (SSRD)

SSRD research to address challenges in special education is a complicated process that required an understanding of the research methods because all single-subject research designs did not suitable for research concerns. According to Kazdin (2011), "reversal/withdrawal design and multiple-baseline designs are most commonly used in single-subject research design". The researcher must select the one design that is most probable to show a functional relationship between the dependent variable and independent variable because each design has benefits and drawbacks.

Reversal/Withdrawal

In the area of special education reversal/withdrawal design are commonly used. According to Cakiroglu (2012) "the removal of intervention during one or more phases of a study in order to demonstrate a powerful functional relationship between the dependent and independent variables is known as withdrawal". The ABAB design of single-subject research design is a common withdrawal design, in which "A" representing the baseline phase and with 'B' representing the intervention phase. In the special education literature, there are various variations on the traditional withdrawal design such as on the bases of reversal design (A-B-A design); ABABA; ABABAB; or BABA; and so on (Alqraini, 2017; Richards et al., 1999).

According to Richards et al. (1999), "Single-subject ABAB design include the following steps; first A_1 represent the baseline phase where the children behaviour is observed; then first intervention B_1 is implemented/introduce by researcher for a specific time period and observed the children behaviour. After that researcher withdraw the intervention A_2 and again observed the behaviour of a child and revert the baseline phase. Finally, intervention is re-implemented or reintroduces (B) to confirm the change the behaviour of child". This design is appropriate for circumstances where a researcher is interested in the reversible improvement or decrease of child's behaviour.

For example Faiz, et al., (2022) conducted a study on "manding in children with autism to decrease problem behaviour" using an ABAB design and purpose of this research was to determine the efficacy of employing the Makaton approach to reduce crying behaviour in Children with Autism Spectrum Disorder. Only one student was included in this study and he received ABA therapy (speech, occupational and behavioural) from five day in a week, per two hours. The result of this study was to demonstrate that problem behaviour of children with autism was decreased while using Makaton method.

In A-B-A design, repeated measures/ observed behaviour in at least three phases where A is an first baseline phase, researcher observed the behaviour of a child before the intervention phase; B is an intervention phase where researcher introduce or

implement the intervention and finally a is return the baseline phase where intervention is withdraw or removed to observed the effect of an independent variable on dependent variable. According to Alqraini, (2017) "in B-A-B design, the independent variable is implemented in the first phase (B), then intervention is withdraw in the second phase (A), and finally intervention is implemented in the third phase (B). It is a weak design due to the inability to examine the effect of intervention on the pre-intervention level of answering. The non-treatment in phase (A) cannot confirm an estimate of the previous non-existent baseline". Hammond & Gast (2010) stated that it is similar to reversal/withdrawal design because in this design children behaviour must be reversible. It is used to compare the baseline phase or interventions with each other such as ABACBCB, ABACAC etc.

There is some behaviour where withdrawal designs cannot be used to study the non-reversible behaviours; such as dyslexia is a behaviour that cannot be reversed because if a learner able to read, he or she will never be able to return to the state in which they were before learning ability. The challenging behaviour cannot return to its baseline level and researchers are unable to demonstrate a functional relationship between the intervention and dependent variable. Furthermore, withdrawal design is ineffective where withdraw the intervention is undesirable for children. For example, if a researcher wants to observe self-injurious behaviour in children with autism, it may be risky for the subject to return to the stage before using the intervention. For example, if a researcher wants to observe the self-injurious behaviour in children with autism, going back to the stage before the intervention was used could be risky for the children and the use of withdrawal design to study assured behaviours creates ethical issues. For this other single-subject design are alternatives for better to dealing with sensitive or irreparable behaviours such as multiple baseline design is one option, according to Cakiroglu (2012).

Multiple-Baseline and Multiple Probe Design

According to Kennedy (2005) & Cooper et al. (2007) the multiple baseline design is commonly used to measure the effect of an intervention programme. In reversal/withdrawal design, every child serve as the control for intervention efficacy and the intervention must be removed to confirm the prediction in the baseline phase. However, in Multiple-baseline design researcher wants to see the impact of an independent variable on dependent variable (Children's behaviour) without removing the intervention across different or multiple settings, and children's behaviours. According to Cakiroglu (2012) Multiple-baseline design have implemented in special education research in three different ways:

(i). Multiple-baseline design across behaviour: in which researcher implement the same intervention to the individual children in the context of related to their behaviour and different.
(ii). Multiple-baseline design across settings: In which researcher implement the intervention to individual children in different setting.
(iii). Multiple-baseline design across children/subject: in which researcher implement the intervention to the specific problem of experimental subject/children.

Researchers combine a baseline phase with an intervention phase across children, behaviours, or environments/settings in a multiple baseline design. First researcher established or observed a stable baseline for children, behaviour and environment/setting then implemented/introduced the intervention until the children's behaviour changed according to researcher criteria and after that the intervention is systematically introduced. The data are collected in another setting, behaviour or children (Cakiroglu, 2012; Tankersley et al. 2008). Kennedy (2005) stated that in the special education research multiple-baseline designs have not requiring the reversal/withdrawal or repeated the phases and researcher can create two or more baselines at the same time in multiple-baseline design and then introduce/implement an intervention across the baselines. To examine the long lasting effects and ethical reasons a multiple-baseline design is suitable. Furthermore, multiple-baseline designs are preferable to withdrawal designs for evaluating specific behaviours of children such as self-injured behaviour, because this behaviour harm to their peers or him thus researcher does not withdraw the intervention (Cakiroglu, 2012).

For example Raghav (2021) conducted a study on "the effect of transforming stimulus form picture exchange communication to vocal mands on maladaptive behaviour with children with autism". Purpose of this study was to measure the effect of Stimulus Control Transfer (SCT) from PECS to vocal mands reduce the maladaptive behaviour such as hand flopping, self-injurious behaviour and screaming crying of children with autism. For this researched used multiple-baseline design across setting to measure the effect of intervention programme on their behaviour. Result of this study was demonstrated that SCT was decreased their as hand flopping, self-injurious behaviour and screaming crying, and increased vocal mands.

Multiple Probe design

It is similar to multiple baseline design, when using the multiple probe design, irregular measurements are taken at the beginning of the study and at a time children learn one of the behaviours or skills and achieved mastery, after that children learn other skills or behaviour. Data are collected until the stability in baselines phase after the intervention is introduced. It is beneficial for measuring the impact of an intervention programme on acquiring the skills or positive behaviour of children with autism. Cooper et al. (2007) stated that when it is unlikely that the children will mastery in skills later stage without intervention, the multiple probe design is useful for analysing the impact of intervention on skill sequences. Furthermore, a multiple probe strategy is beneficial in those circumstances when a long baseline may be harmful to a children or the intervention.

Internal and external validity are important to researcher conducting intervention studies (Alqraini, 2017; Cannon, et al., 2016). Kazdin (2011) stated that internal validity means that the intervention affects the dependent variable while external influences are unaffected by the intervention's outcome. The experiment is considered internally valid when the outcomes are attributed to the impact of the intervention with little or no uncertainty. One of the characteristics of single-subject research design is replication. When the effects of an intervention are repeatedly and reliably established within single subject/children or among a small number of children, this is referred to as experimental control (Breanne et al., 2012).The method by which the effects are replicated is determined by the single-subject experimental design used. Each time the intervention is administered or withdrawn after an initial intervention phase, an opportunity for effect replication is established for many designs. Internal validity for single-subject research design is based on this replication within studies.

Horner et al., (2005) explained that the external validity refers to the degree to which the intervention's outcomes can be applied to persons and situations other than those who involved in the study. Replication can help to improve external validity. Researchers can generalize the intervention effects by replicating the experimental study among different children or different types of children's behaviours and thus possibly improve external validity.

Without a doubt, one or a few children do not represent all population of the same children. The researcher may repeat the intervention programme to maintain the external validity. Kazdin (2011) stated that direct and systemic replication is the two types of replication to confirm generalisation. Direct replication involves repeating the same study with new children under exactly similar features and same settings as those in original study. This type of replication of the study helps the researcher to see if the results of the original study were unique to the children who were involved in the previous study.

Whereas, Systematic replication is when a study is repeated while one or more area of the original study. The intervention can be implemented with new heterogeneous characteristics of children, different dependent variables, different settings, etc. The variability characteristic in systematic replication allows the educator and researcher to establish how well the findings will generalize across different types of children, situations, or behaviours. Direct replications of an effect provide information on the certainty of our understanding, whereas systematic replications can enhance our knowledge, noted by Alnahdi (2013).Cakiroglu, (2012) stated that a study can be conducted in an elementary school and then replicated with high school students in the area of special education.

ADVANTAGES OF SINGLE-SUBJECT RESEARCH DESIGN

Single-subject experimental research has several advantages or strengths. Such as, this type of research study is commonly used in the field special education. For special education single-subject research design provides numerous opportunities to researcher to answer the question of 'Why single-subject research design is preferred by the researcher in the field of special education'. Although group experimental designs are beneficial to researchers, but several difficulties can be arise to implement in special education. The following are some of the most significant advantages:

- **Few participants/children involved in this study:** The ability to conduct a scientific examination with only one or few children is the most significant advantage of single-subject research design. In the special education field single-subject research design is conducted of those studies where number of participants or children is small. However, it is extremely difficult to researcher to select an adequate number of children using random sampling technique from a large population in special education area (Cakiroglu, 2012). Such as the percentage of children with autism receiving special education is 2.23 percent per one thousand children in India (Arun & Chavan, 2018), about 0.9 percent per one thousand

estimated by Raina, et al.,(2015) and prevalence rate of Autism in India approximately one in five hundred or 0.20 % people in India (Rehabilitation Council of India). Due to limited access to children with autism or other disabilities, it may be problematic to conduct group experimental designs with this category of children. So a huge number of children is not required for a single-subject research design and researcher conducted experimental study with a small number of children in special education to identified their behaviour, develop intervention programme or strategies and decreased their problematic behaviour.

- **It helps to measure the individual performance:** The researcher is sometimes more concerned with individual performance than group performance in special education. Researcher measures the group performance using average and mean in group experimental designs. Therefore, "it is impossible to demonstrate the effectiveness of the intervention on an individual basis" (Cakiroglu, 2012). There are numerous types of studies such as autism, intellectual disabilities where children labelled with their disability. Researchers can explore the unique impact of an intervention on single children using single-subject research techniques. In the field of special education researcher may be able to provide that which variables of an intervention programme influence the children performance.
- **Establishing a functional relationship:** Single-subject designs can provide a solid foundation for establishing a functional relationship. However, extrapolating this functional link to different contexts, times, and people is insufficient. Therefore, "meta-analytic studies can help to improve the generalizability of single-subject design findings in similar situations. This can be accomplished by using statistical analysis of a vast collection of results from various researches for the purpose of integrating the findings" (Alnahdi, 2013).
- **No requirement for a control and experimental group:** when researchers use single-subject designs they did not require for control of experimental group because each participant acts as his or her own control. For example, a researcher studying self-injurious behaviour in children with autism, he should divide children into two groups (Control and experimental groups) based on their behaviours, with the first group receiving intervention to reduce harmful behaviours and the second group receiving no intervention. The experimental group will be able to benefit from the intervention, while the control group may not. Researchers utilising group experimental designs can avoid these challenges by adopting crossover designs, in which children receive the intervention in order (Shadish, et al., 2002).However, several disabilities such as autism in special education have a relatively small number of children, conducting a group experimental design with these children approximately impossible. All children can be involved in the experimental group of a study and a successful intervention can help to improve their behaviour and problem (Horner et al., 2005).
- **Teacher-initiated research in school:** Single-subject research is an important step for teachers to identify and rectifying the problems of children in school because it provides an initiative for teachers to conduct research. Teachers can observe students' problems during class, gather data on their performance, calculate/examine them, and create judgments about how to design an intervention program. For example, implement single-subject research design, teacher to handle classroom social skills problems of children with autism. Teachers identify the problem related to social and communication skills such as, not making eye contact or initiate to help for this teacher observed baseline data, develop a social skills intervention programme, implemented the intervention programme, collect data after is implementation of intervention programme, then the data is analyse to determine whether the intervention programme was successful. This type of research demands to researchers because it removes the control group, makes data analysis simple, and provides data on individual person's performance.

DISADVANTAGE OF SINGLE-SUBJECT RESEARCH DESIGN

- **Not applicable for all research questions:** Single-subject research design, like any other research methodology, is not appropriate to all research issues. For

example, it does not allow the researchers to gain a comprehensive understanding of complicated and sensitive problems, nor does it always help them in drive the attitudes, beliefs, and opinions of the persons. For these topics, qualitative research methodologies provide more suitable, and in the complexity of analysis by qualitative analysis is critical in facilitating understanding of person's perspectives and attitudes about special education.

- **Baseline Issues:** In single subject research, Barlow and Herson (1984) examined a variety of baseline issues and established a steady baseline. It is difficult for the researcher to determine a consistent change in behaviour following intervention if baselines differ.
- **Irreversibility:** In some designs such as withdrawal design, once the independent variable (IV) changes, the dependent variable (DV) changes as well, and this cannot be reversed by simply removing the independent variable.
- **Researcher Bias:** When implementing an intervention programme, some biases on the side of the researcher are often visible. In most cases, the researcher waits for indications representing a change in the children's behaviour before withdrawing the intervention. The researcher's actions are not scientific.
- **Generalization of Results and Lack of External Validity:** External validity and generalizability is most controversial aspect in single-subject research than in between-groups or large-N studies. The outcomes of such an experiment are difficult to generalize to more participants because it is limited to one person.
- **Statistical Data Analysis Technique:** According to Tankersley et al., (2008) it is another issue with single-subject research because it is used to analyse the data visually. Several studies have claimed that the outcomes of a single-subject research study may not be valid because researchers interpret comparable data differently. According to Kazdin, (2011), "when analysing the data visually, equally competent researchers produce varied interpretations, including changes in mean, level, trend, variability, and the replication of effects within or across subjects". Therefore it's been advised that researchers employ statistical data analysis techniques like randomization (Franklin, et al., 1997).

CONCLUSION:

Over the last few decades, Single-Subject research Design have become one of the most widely used methodology in special education. Single-Subject research will surely contribute to the experimental literature in the field of special education by filling a gap. The key difference between Single-Subject research and other research methodology is the use of each study children who are involved in this study as his or her own control to measure intervention effect. Because children with special education students are not a homogeneous group, this aspect of Single-Subject research makes them a particularly attractive alternative for special education research. Researchers' ability to establish control or experimental groups for every person in special education is difficult because there is diversity among children with special needs so researchers should avoid dividing children into two groups.

Single-subject research designs are not answered the all questions but its researcher choice to select research method for data collection. The most appropriate methodologies and practises are determined by the nature of the research question.

Researchers and educators use single-subject research designs to measure the effectiveness of an intervention programme on a single person. Replicated measurements, baseline phase, and intervention phase are the three foundations of single-subject research designs. In the field of special education, all type of single-subject designs has several positive aspects and possible benefits however, they also have some disadvantage that should be considered.

Internal validity threats can be controlled by Repeated measures (multiple times of data collection) in single-subject research designs; the baseline is maintained until a clear pattern occurs, which usually takes at least three measurements of children's behaviour In a single-subject design the data can be analysed using a visual examination of a graphical representation of the data's consistency, level changes, trend, and non-overlapping representations of the data. Finally, direct replication and systematic replication are required for the generalisation of result in single-subject designs.

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