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Bridging research and practice in health professions education: Single case designs

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I. INTRODUCTION

Single case designs (SCDs) comprise repeated measurements (time series) of the same variables of interest (Van de Schoot & Miocevic, 2020) to understand changes in knowledge, skill, attitude or other constructs in a defined time period that includes one or more events or developments that may affect that change. Possible units of analysis include individuals (e.g., individual skill development), teams (e.g., team dynamics), or settings (e.g., situational-contextual change). Whether the outcome variables are quantitative (e.g., time-on-task), qualitative (e.g., changes in habits or preferences), or some combination of the two (e.g., test scores and transitions in practice strategy), a range of parametric and nonparametric statistical models are available for analysis at the level of $N = 1$, and the outcomes of multiple $N = 1$ analyses can be combined using multilevel and meta-analytic models (for reviews and examples, see: Leppink, 2020; Van de Schoot & Miocevic, 2020). This makes SCDs useful for any sample size and, contrary to traditional randomised controlled experiments and other group comparison studies, can help health professions education (HPE) researchers and practitioners to (1) Respect the dynamic nature of learning, (2) Use no more resources than needed, (3) Bridge the research-practice gap, and (4) Appreciate diversity and approach challenges in the sector accordingly. Each of these advantages is explained in the following.

II. RESPECT THE DYNAMIC NATURE OF LEARNING

Although learning by definition involves *time*, the vast majority of traditional randomised controlled experiments and other group comparison studies focus on performance at a single occasion or at best at two occasions. SCDs can incorporate quantitative and qualitative information to understand the *longitudinal* and *non-linear* nature of learning, effects of interventions or events, and possibly the temporal order of changes. For example, in a five-year medicine program in which we assess knowledge, skill and attitude every 3-4 months in each year of the program, we can monitor change in each of these variables and study possible temporal orders in changes at the level of the individual student as well as – through multilevel and meta-analytic models that combine individual outcomes – at the level of a larger group (e.g., changes in attitude tending to precede changes in knowledge, or the other way around). Although a commonly perceived limitation of SCDs is a lack of generalisability to larger populations, generalisability is not always of interest in our field (e.g., 'what is the level of competence of *this* resident at *this* point?', or 'does this simulation session contribute to more effective communication in *this* team in *this* hospital?'), and where it is of interest (e.g., under which conditions can the use of virtual reality games help to improve communication skills?), it can be increased through replication studies from different settings the findings of which are combined in multilevel and meta-analytic models.

III. USE NO MORE RESOURCES THAN NEEDED

While traditional randomised controlled experiments and other group comparison studies with a limited number of measurements (usually one or two) often require more than 100 participants, SCDs – through their use of series of repeated measurements – allow researchers and practitioners to investigate educationally interesting phenomena with any number of individuals, teams or situations including *one* (i.e., $N = 1$). This is great for example for institutions that do not have large numbers of students or residents (e.g., eleven students or six residents) and do not pretend that the outcomes of their study can be generalised to all of the rest of the world, and is one of the reasons why in some clinical areas (Van de Schoot & Miocevic, 2020) and some areas in education (Leppink, 2020) SCDs have already been used successfully for a while. In addition, not using more resources than needed is always important and even more so in times of enormous pressure on healthcare systems across the world. To use an example from assessment practice, decisions about the progression of individuals or teams usually require longer exams when performance is *borderline* (i.e., almost at the expected level with minor lapses that would not cause concerns for patient outcomes) compared to where performance is good or poor. In this context, SCDs can help us determine when we have sufficient information about the knowledge (how many questions?), techniques (how many tasks?), skills (how many stations?) or attitudes (how many portfolio reflections?) of a specific individual or team being assessed in order to make informed and confident decisions.

IV. BRIDGE THE RESEARCH-PRACTICE GAP

Most group comparison studies include the unethical and often practically nonsensical action of withholding an educational intervention from some participants (control group), whereas in SCDs the question is not *if* but *when* that intervention takes place. Just like in a study on skydiving one would never include a 'control' condition in which participants are not allowed to open their parachute (the question should be *when* not *if* one should open that parachute), in an educational context in which the use of for instance virtual reality technology which allows students or residents to practice with complex anatomy structures in 3D is an inherent part of an anatomy training programme, including a condition in which no virtual reality technology is offered does not make sense. A more appropriate question in this context is *when* to use the virtual reality technology. On a related note, in complex domains such as medicine, we tend to move from simple to complex because more complex tasks require one to be able to complete a series of simpler tasks. Sticking with simple tasks only or moving from complex to simple does not make sense in this practice, and it is therefore pointless to design experiments which incorporate such conditions (i.e., a no-complex-tasks control group or a group in which we start with complex and end with simple). SCDs which introduce (more) complexity at different points in time for different participants or teams make more sense, and if that starting point is randomised for different participants, we speak of a *single case experimental design* (SCED; Van de Schoot & Miocevic, 2020); *experimental* because like in traditional experiments we have both *manipulation* (here: simple vs. more complex) and *randomisation*. SCEDs can facilitate causal inference, although where effects of several interventions are considered the complexity of the design as well as the number (generally a higher demand) and timing of measurements (sufficient measurements in each of several stages of the study) will require very careful thought. Finally, HPE is ultimately about contributing to the best possible healthcare, hence research questions on possible effects of training on future healthcare performance (e.g., are we delivering good doctors?) are key (Nickson et al., 2021; Prideaux, 2019), and the longitudinal character of SCDs allows us to study these questions.

V. APPRECIATE DIVERSITY AND ACT ACCORDINGLY

As eloquently formulated by Prideaux (2019), medical schools must "*direct their activities to local priorities and to serving local health systems*" (p. 25) and at the same time healthcare systems across the world share many challenges and can all benefit from solid theory on what works in which circumstances. SCD (or in experimental form called SCED) findings from different institutions or settings can be combined into meta-analyses (Van de Schoot & Miocevic, 2020) and systematic reviews, helping us to understand commonalities and diversity across institutions, to develop existing and new theory, and to approach sector challenges accordingly. Although where generalisability is of interest smaller samples tend to provide substantially less information than larger samples, many carefully performed smaller sample studies combined in meta-analyses and systematic reviews can make a more powerful and, in our field, much more useful end result than small numbers of larger sample studies. Besides, although the number of measurements needed depends on what we are measuring and not all models require large numbers of measurements (e.g., 10 measurements of the same individual for relatively simple conclusions about that individual), larger numbers of measurements – where that it is possible and makes sense in the context at hand – generally provide more information and allow for a study of more complex relations than smaller numbers of measurements.

VI. CONCLUSION

Nearly 17 years ago, Johnson and Onwuegbuzie (2004) published their immensely popular article "*Mixed methods research: A research paradigm whose time has come*". SCDs allow researchers to adopt that mixed methods lens by integrating qualitative and quantitative information on complex phenomena such as learning and other types of development, to address the needs of educational and healthcare practice while using no more resources than what is needed (no more statistical power calculations for group experiments of more than 100 participants that include conditions that would never occur in educational practice), and to appreciate diversity (rather than to average where things should not be averaged). SCDs constitute a wonderful tool for research and practice in specific institutions as well as for multi-institution studies that are part of national or international collaborative projects. Recent years have resulted in parametric and nonparametric models for different types of data, which make SCDs useful regardless of the type of data we are considering. These questions and developments in combination make that the time for SCDs in HPE has come. Institutions and centres should be encouraged to use SCDs to answer local questions and serve local needs, and to document and publish findings arising from such SCDs so others can learn from these findings and design similar studies in their local contexts. Additionally, institutions and centres should consider the use of SCDs in multi-institution or multi-centre collaborations. Both ways can facilitate generalisability through meta-analysis and systematic review.

Note on Contributor

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Declaration of Interest

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