The Journal of Behavioral Science
2021, Vol. 16, Issue 2, 73-85

ISSN: 1906-4675 (Print), 2651-2246 (Online)

The Journal of Behavioral Science (TJBS)

Original Article

Key Steps and Characteristics for Successful Interdisciplinary Research: An Analytical Review

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Article Information

Received: *11.11.20*
Revised: *11.1.21*
Accepted: *15.1.21*

Keywords

steps of interdisciplinary research, characteristics of interdisciplinary research, importance of IDR, content analysis, definition of IDR

Abstract

There is an increasing importance of the application of interdisciplinary research (IDR) in all kinds of disciplines over the past two decades as it helps to improve a researcher's career and also enables them to compete successfully in the job market. The term "interdisciplinary" means collaboration and integration of different disciplines with aims to find or develop something new. However, IDR has many challenges, in terms of integrating different theories of different disciplines. So, it is very important to study and follow the systematic steps and characteristics of IDR for successful integration. This article has been framed through literature review from various available sources and then categorized using content analysis method. The article aims to describe 1. definition and importance of IDR; 2. steps of IDR; and 3. characteristics of IDR approach. The article defined IDR as a collaboration or synthesis of two or more disciplines to develop a better methodology for conducting complex research problem, identified the main steps of IDR as team formation, identifying the research problem, selecting collaborators, and a strong team leader for effective team management. Among the important characteristics of IDR includes clarity of objectives, sharing, adaptability, team members' willingness to cooperate, team leader and management, flexibility, improvement in communication strategies, dedication, cooperation, and clarity of objectives for successful integration or synthesis of IDR. This review is expected to be helpful to future researchers, who need to adopt IDR methodology for solving complex research problems.

There are a growing usage and importance of incorporating interdisciplinary research methodology in the curriculum of various disciplines (Bruun et al., 2005) because a researcher needs to have interdisciplinary research education if the researcher wants to achieve all-round knowledge and aspire to improve their career (Metzger & Zare, 1999), unlike the traditional way, where a researcher is trained only for a specific discipline (Tekian, 2014). "Interdisciplinary research is a synthesis of two or more disciplines with aims to discover something new or develop a better outlook, where the contributions of the various disciplines are integrated to provide holistic or systemic outcomes" (Tait & Lyall, 2007, p.1). Examples of interdisciplinary research include environmental science, gender studies, nuclear physics that synthesize two or more disciplines to enhance more understanding of a particular issue or in building a postulate or principle. Nowadays it is increasingly being used in physical science even though its domain is conventionally in the social sciences (Interdisciplinary Research, 2020). There were many researchers, whose discoveries, even though they

were the foundation of science, were interdisciplinary as their research aims to make significant contributions beyond a particular disciplinary margin (Bruhn, 2000). For instance, Sir Isaac Newton, a great scientist of the 17th Century created Calculus, even though he was a physicist and mathematician. Like-wise, Rene Descartes, a physician, surgeon, and philosopher, invented the Cartesian system. These are some of the scientists who exemplified the usage and importance of the interdisciplinary research approach (Gill et al., 2015; Klein, 1990).

Interdisciplinary research (IDR) can be distinguished from multidisciplinary research (MDR) because IDR requires interaction between various disciplines related to the stipulated identified problem of the research throughout the research process. In contrast, MDR is conducted with inputs from multiple disciplines without discussion or interaction between them. What distinguishes IDR from other research approaches is that it seeks cooperation between researchers of various disciplinary backgrounds while maintaining the core value of their particular expertise (Kapila & Moher, 1995). Huutoniemi et al. (2010) further distinguish IDR from MDR in that MDR is more accumulative rather than integrative, the elements of new findings are collected from various disciplines without the need to adapt in the process of research interaction. Integration of various disciplines is an essential characteristic of the IDR approach, based on active interaction in various stages of research, from formulating research problems to result from analysis and interpretations. So, (Lattuca, 2001) and many scientists along with the advancement of scientific discipline now have awareness of the importance to conduct interdisciplinary research as it will help to have a deeper insight for application of the gained knowledge. For example, research only on tobacco consumption for lung disease was insufficient for smoking prohibition. It requires other related research on risk factors assessment, motivation, and reasons for designing programs to reduce the rate of tobacco consumption or smoking. These factors have instigated scientific researchers to develop interdisciplinary networks to share knowledge among multiple disciplines as many subjects are interdisciplinary by nature, examples, social psychology, environmental science, biochemistry, and so on (Aboelela et al., 2007). So, the current problems of the society, for example, environmental problems or health problems, can be solved through interdisciplinary studies as IDR is conducted through collaboration and interaction of various disciplines researchers (National Academies, 2005). Consequently, scientists have emphasized the importance of interdisciplinary research collaborations along with institutional recommendations and collaborations to facilitate its results (Porter & Rafols, 2009; Carayol & Thi, 2005). This article has been framed by the state-of-the-art literature review from various available sources, including electronic and printed, and then presented by grouping into fewer categories using the method of content analysis (Cavanagh, 1997). Content analysis, as a research method, is a systematic and objective means of describing and quantifying phenomena and its growing importance can be seen in its application in other interdisciplinary research (Elo & Kyngas, 2008; Downe-Wamboldt, 1992). A search on the steps and characteristics of IDR methodology from the available literature resulted to the availability of only a few works on steps and characteristics of interdisciplinary research. So, this review made a modest attempt to fill up the gap in knowledge by providing future IDR researchers, the appropriate steps and essential characteristics for the successful operation of interdisciplinary research. It is important to have knowledge of IDR methodology because the current world is faced with lots of unpredictable crisis, causing confusion and distress to scientists of natural, physical, behavioral, and social science. It is beyond the domain of a particular discipline to solve this complex problem. It needs interdisciplinary consultation of two or more disciplines. Herein lies the significance of the present review. This review article is presented with three objectives:

1. What is interdisciplinary research (IDR), its distinction from multidisciplinary research (MDR), trans-disciplinary research (TDR), and its importance?
2. What are the key steps of interdisciplinary research?
3. What are the characteristics of interdisciplinary research?

What is Interdisciplinary Research?

The term "interdisciplinary" refers to collaboration with two or more disciplines. It is a synthesis of two or more disciplines, for establishing a new subject or resulting in knowledge integration (Klein, 1990). "Interdisciplinary research generally

refers to the appropriate combination of knowledge from many different disciplines to solve an actual problem" (Brewer, 1999). "Interdisciplinary research is a synthesis of disciplines to discover new knowledge or theory" (Griffin et al., 2006).

> Interdisciplinary research is any study or group of studies undertaken by scholars from two or more distinct scientific disciplines and is based upon a conceptual model that links or integrates theoretical frameworks from those disciplines, uses study design and methodology that is not limited to any one field, and requires the use of perspectives and skills of the involved disciplines throughout multiple phases of the research process (Aboelela et al., 2007).

In other words, IDR is generally adopted when it is difficult to solve a research problem with a single discipline (Klein & Newell, 1997). In brief, it is research conducted by collaborative participants, studying together, using combined techniques and procedures to obtain the common objectives (Gabriele et al., 2005). Examples include a combination of nuclear physics with medicine for cancer treatment, quantum physics (Choi & Pak, 2006), writing an encyclopedia, environmental science, nanotechnology, genetic engineering, gerontology and geriatrics, social psychology, etc. Multidisciplinary research (MDR) team members have the lowest level of integration since they work independently. Despite low interaction, the MDR approach is still widely used as it has an important role in the theoretical foundations or development of a perspective (Tang, 2020). Kelly et al. (2019) distinguish MDR, IDR, and TDR. In MDR, different academic disciplines collaborate and combine their disciplinary knowledge in parallel while researching a single topic without integration. For IDR, different academic disciplines work together to integrate disciplinary knowledge and methods to achieve the shared research goal through a real synthesis approach. For TDR, all disciplines, consisting of both academic and non-academic work together for achieving the research goals through integrating shared findings and shared methodology. Nicolescu (2014) also distinguishes IDR from MDR and TDR in that MDR is concerned with studying a particular topic in multidisciplinary dimensions. For example, a painting can be studied not only in the context of arts but also in terms of social history. That means MDR crosses the disciplinary boundaries even though its goal is confined in a disciplinary context (Nicolescu, 2005).

The interdisciplinary approach has a different goal than the multidisciplinary approach as it integrates independent disciplinary data, methodology, concepts, and perspectives for creating a comprehensive outlook or shared interpretation of a complicated issue, question, or problem (Bruun et al., 2005). It concerns the transfer of disciplinary techniques leading to the generation of integrated disciplines. The core principles of IDR are based on three "C's" (collaboration, cooperation, and communication) among disciplines in various stages of the research process (Klein, 1993 cited in Kapila & Moher, 1995). There are three degrees of interdisciplinary approach: (a) Application degree, such as the application of nuclear physics in medicine, to introduce new therapy for cancer treatment; (b) Epistemological degree, such as the application of formal logic in the study of general law, to help to generate some interesting relation with the epistemology of law; (c) Generation of new disciplines degree example, application of mathematics to physics, to generate mathematical physics, or application of mathematical methods in meteorology study or stock market processes, generating another perspective; application of particle physics to astrophysics, for generating quantum cosmology. Like the multidisciplinary approach, the interdisciplinary approach encroaches on the discipline boundary, but its objective target remains within the disciplinary research framework (Nicolescu, 2014). Since IDR requires the interaction of many disciplines, it usually requires teamwork, however, it can be carried out by a single researcher too. Bruun et al. (2005) also reported three types of integration for IDR as follows:

i) Empirical IDR: In this method, empirical data are collected, testing the hypothesis of the research for proving a theoretical perspective, and the data is obtained from different areas using different methods of disciplinary triangulation.
ii) Methodological IDR: Here different techniques of data collection are used, collected from various fields for testing the research hypothesis and to answering the research question.

iii) Theoretical IDR: In this method, there is integration beyond the disciplinary boundary or field in terms of the hypothesis, concepts, and theory used and ultimately leading to a synthesis of theoretical perspective or an integrative framework.

The trans-disciplinary research approach is increasingly being used in contemporary society for solving complex societal problems. It implies using research methods beyond the disciplinary boundaries, involving intensive involvement and collaboration of disciplinary experts, stakeholders, researchers, to create new perspectives, knowledge, or systems for solving a defined research problem (Choi & Pak, 2006; Lattuca et al., 2004). There is an increasing importance of IDR which can be seen in the research contexts, especially in the sustainability issue of environmental science, taking into account the close relationships between natural and social science (Horlick-Jones & Sime, 2004). Wickson et al. (2006) identified key characteristics of TDR, including problem-solving, methodology evolution, and collaboration. Examples of trans-disciplinary research include theoretical perspectives of Marxism, structuralism, phenomenology, eco-feminism, socio-environmental science, and so on. TDR approaches are related to the emergence of contemporary theoretical foundations for systematic integration of paradigms, research results for finding solutions for any societal problem or movement.

Examples include attempts of researchers, academicians, stakeholders, and policymakers to solve complex health problems, diseases such as cancer, epidemic, pandemic, climate change, and other environmental impacts (Tang, 2020). Table 1 briefly distinguishes IDR from MDR and, TDR approaches.

Table 1

Distinction of IDR from MDR and TDR

Theme	IDR	MDR	TDR
Goal	Goal is synthesized by crossing above boundaries (Choi & Pak, 2006)	Goal is not completely synthesized as it remains on its boundaries (Balsiger, 2004).	Goal is complex, shared, and multidimensional research problems, such as sustainability issue (Klein, 2004)
Teamwork	Repeated interaction with other disciplines in the research process (Bruun et al., 2005; Choi & Pak, 2006)	Work independently with minimal consultation in the research process (Nicolescu,2005; Kapila & Moher, 1995)	Integrate teamwork across disciplines to achieve the common objective (Morgan et al., 2003)
Theory	Perspectives is blended and synthesized (Klein, 2014)	Perspective is not synthesized (Nicolescu, 2005)	Shared model perspective and methods to achieve the shared research goals by transcending each disciplinary perspectives (Kelly et al., 2019(
Integration	Integrate elements by crossing traditional disciplinary lines smoothly or by challenging the disciplinary borders (Griffin et al., 2006)	Integration of various disciplines is not essential	Integrate elements of various disciplines by challenging the borders Griffin et al., 2006)
Cost	Costlier in terms of time, people & money (Kapila & Moher, 1995)	Cheaper in terms of time, people, and money (Kapila & Moher, 1995)	Costlier in terms of time, people & money (Kapila & Moher, 1995)
Development	Develop researchers by training them on IDR conceptual frameworks and methodological tools (Nash, 2008).	Accumulate different disciplinary knowledge but the conclusion of the research remains within the disciplinary boundaries (Choi & Pak, 2006).	Researchers from different departments work together on a common problem for an extended period. (Rosenfield, 1992).

Note. Interdisciplinary (IDR), Multidisciplinary research (MDR), Trans-disciplinary research (TDR)

From the review of literature, we obtained 15 summarized steps of interdisciplinary research listed in the following headlines. Each step has certain characteristics, that are described under each step.

1. Identify the research problem and formulate the common goal or objective

In the first step, it is essential to define the research question with consideration of the problem, generated issues, methodology to be used in consultation with all team members. This will help to build a systematic framework, that agrees to the common problems and to formulate the project target goals or objective (Kapila & Moher, 1995; University of Leicester, 2016).

2. Develop IDR proposal

In this step of developing IDR proposal, it is important to state the reasons for using IDR and the role of other disciplines, describe ways of integrating the other involved disciplines with a summary of the involved researchers' skills, state a clear plan for the involvement of stakeholders, state the expected benefits and roles and contribution of the stakeholders and mention the budget and additional expenditures that may be needed (University of Leicester, 2016; Vajaradul, 2016).

3. Form and develop a team

While forming a cohesive team for IDR, it is essential to select competent researchers who are willing to work together sincerely in an interdisciplinary team as team members. The selection of team members should be based on consideration of individual characteristics, their expertise, and attitude that support interdisciplinary teamwork. Some of the essential qualifications of IDR team members include: a) being an IDR researcher having IDR background, have an innovative idea, adjustable, cooperative, and willingness for collaboration and interaction with other disciplines; b) have adequate skill for IDR methodology; c) flexible, adaptable, creative, open-minded and willing to learn other disciplinary ideals; d) have effective skills for interdisciplinary communication; e) have ability to fill up the gap between theory and practice; f) have multi-skills knowledge and be a good team worker (University of Leicester, 2016). Along with these, there should also be a provision for personal reward and training for further development of team members (Nancarrow et al., 2013). In other words, the team should be composed of an appropriate skill mix, assigning the right roles to the right person, each member understanding and respecting their roles and should be trained and rewarded.

4. Review IDR proposal

The IDR proposal should be sent to review to a competent reviewer. While reviewing, the reviewer should examine the nature of the research project and how it is interdisciplinary, for example in terms of methodology that enables to address new issues or disciplines, in terms of technical or policy relevance, the strategies to be used for issues on shared research vision and identity (University of Leicester, 2016). For example, Bruce et al. (2004) identified two models of IDR: 1) Academically-oriented research that aims to integrate different academic skills and expertise through incorporating the disciplinary research methodology to address new issues, new disciplines, or sub-disciplines; 2) Problem-focused research that focuses on social, technical, or policy-relevant issues without emphasis on disciplinary-related academic outcomes.

5. Select a competent leader to select partners for collaboration

A strong team leader with the willingness and ability to coordinate and collaborate with different disciplines, regional, national, and international networks should be selected (Vajaradul, 2016). The leader should demonstrate the capacity to mobilize the team group (Kapila & Moher, 1995. IDR leader requires certain characteristics, such as senior personnel with networking skills and all-around knowledge and skills for negotiation along with the ability to recruit the right subordinate from various disciplines of various institutes for any kind of project. The leader should possess excellent interpersonal and team-building skills for dealing with all kinds of people in all kinds of situations, a dynamic approach, and the ability to interact with research partners productively. The leader should have leadership skills with IDR vision and interest in a wide range of subjects, listen to new methods and other disciplines data, ability to organize the functioning of the team as well as allocating the responsibilities appropriate to the team members with due consideration of their expertise. In other words, the leader should assign the right roles to the right person, be negotiable, welcome new ideas and provide a supportive team environment (Nancarrow et al., 2013). The leader also should have the ability

to choose an appropriate group of collaborators who can contribute equally and appropriately, including distribution and management of responsibilities within that team. While selecting partners for collaboration, the leader should have consideration of partners with IDR background, expertise in their disciplines and at the same time have appreciation and respect for other disciplines; readiness to learn from others and respect other disciplines (University of Leicester, 2016).

6. Management of IDR teams

The success of an interdisciplinary team requires effective management. Some functions of a leader for management include: a) effective communication mechanisms; b) effective relationships building, teamwork, and networking mechanisms, with the ability to negotiate with stakeholders of various disciplines and work across the disciplines boundaries and issues; and c) facilitate the development of a team identity so all the researchers work collectively in unity rather than individually even though the role of various disciplines vary (Kapila & Moher, 1995). The requisite qualification of good project management according to University of Leicester (2016) includes:

- To have a clear vision of the project target goals and knowledge as to apply in industry, public or private spheres to obtain the project outcome;
- To manage team members effectively by assigning responsibilities to get the appropriate result;
- To develop IDR team culture and strategies covering issues on i) shared research vision and identity; ii) long term research strategy to help individuals; access to resources, etc.
- To be an effective leader with the ability to manage issues on knowledge-driven goals, practical goals, or both, ways to win for all involved stakeholders, and combination of all disciplines to build new knowledge; and
- The management leader needs to have an accurate common goal and adopt multi-technique to achieve the target goal along with satisfying participant stakeholders, such as the parent organization, sponsor, funder, etc.

7. Role of IDR funders

Research funders' role in IDR include formulating IDR research question, introducing and developing a research plan and design, availability of research funds or grants; designing the organizational structure of IDR program, such as location, selecting a leader, research evaluation and accountability; integration of research results for capacity development to facilitate long term impacts; play an enterprising and dynamic role to create a congenial and inclusive IDR future academic environment; and finally guaranteeing the availability of funding to future interdisciplinary research, to facilitate sustainability of interdisciplinary research (University of Leicester, 2016).

8. Select collaborators

For collaborators selection, personality factors should be considered more than discipline, including having a broad outlook, appreciation of all languages, research methods, and cultures of different disciplines, ability to identify and analyze strategies such as availabilities of research grants for development of IDR career (Sa, 2008, Borrego & Newswander, 2008). The collaborator should be accountable to the opinion of fellow interdisciplinary researchers and participate regularly in a follow-up meeting, can adjust and adapt in teamwork, take responsibility for achieving practical results, tolerate and assimilate different disciplines, involving participants both from the private and public enterprises, have an appreciation of other disciplines along with in-depth study to have awareness and abide as per their general principles (University of Leicester, 2016). Further, it needs institutional analysis before pursuing large-scale inter-institutional research collaboration in terms of (1) the epistemic development of the disciplines involved in the collaboration or (2) the organizational structure of the collaboration (Corley et al., 2006).

9. Collect data and analyze

IDR data should be collected according to the listed objectives and it should be organized on a scheduled timetable with the inclusion of all participants from all disciplines. The collected data then should be analyzed with due consultation and discussion of the different aspects of the listed research problem since the IDR process aims at integrating the results of various disciplinary participants (Vajaradul, 2016).

10. Troubleshooting problems in IDR management

If there arises any disagreement among team members, it should be discussed openly to bring a consensus and settle it (Kapila & Moher, 1995). At

the same time, the leader needs to negotiate with collaborators by sharing the common vision to bring awareness of the objectives and target goals of the research project amongst the team members and attempt to solve any troubleshooting transparently. Also, the leader conducts an honest assessment of the skills and roles within the team to achieve and satisfy team member needs (University of Leicester, 2016).

11. Schedule a day and time for a periodic meeting, discussion, and follow-up

IDR team members should meet on a scheduled day and time at least once a week for interaction, sharing information, and to inform the project's status in terms of the progress report and tentative time for completion. The meeting will provide the opportunity for interaction, communication, and discussion for a research plan, status, progress, tentative time for completion of the research, discussion to solve any disagreement or troubleshooting, advantages and disadvantages of the existing research methodologies techniques along with application and steps for integrating data by writing and integrating participant disciplines. The meeting can be arranged in many ways, including networking events, video conferences, and social events to connect the distance team members through joint fieldwork, to provide an opportunity for interaction and discussion, and to create awareness that effective integration of a research project takes time since IDR involves the integration of many disciplines in the process (Vajaradul, 2016).

12. Evaluate IDR

Evaluation of interdisciplinary research can be done in various ways, for example, peer-reviewing, presentation of research proposals, evaluating manuscripts for publication, or end-of-research impact evaluation, etc. However, many scholars have mentioned the challenges of evaluating IDR due to its variability in goals (Carr et al., 2018; Klein, 2008; Bark et al., 2016; Lyall et al., 2011; Langfeldt, 2006; Mansilla et al., 2006). While selecting evaluators, there should be careful consideration of their IDR skills and experiences along with the availability of training program for research staff, specified goals and criteria are written in calls for proposals, with instructions for reviewers and panels, selection of expert panel members having IDR experiences, organizing panel meeting for mutual understanding and so on (University of Leicester, 2016). Also, need to develop evaluation concepts and intervention proposal for improving interdisciplinary integration, such as agreement on a conceptual model, incorporating independent review, assisting synthesizers, strengthening intra-project communication, and building-in organizational learning (Bark et al., 2016). So, massive efforts are needed in evaluating and improving the effectiveness of the IDR project (Mansilla & Duraising, 2007; Saito et al., 2012).

13. Integrate research findings, presentation, and publication

Successful integration of IDR needs to have a common language, goal, adaptability, and respect for each discipline along with the ability to interact and collaborate with researchers from other disciplines, such as learning new from other disciplines and learning the art of integrating other disciplinary knowledge. The quality of this integration is influenced by certain variables as shared IDR practices, interaction, understanding, questions, and answers, solving differences in boundaries, social learning, the intensity of communication, consultation and exchange of data, and finally the tentative result and conclusions (Carr et al., 2018). During the report writing stage of the interdisciplinary research, it is essential to integrate the result from various research components. Further, there needs integration and synthesis of different theories of both the researchers and the stakeholders. In other words, the result should not be presented as a collection of disciplinary inputs but be an integrated input from the various participating disciplines related to the research issue. For this, IDR supervisors have a great role in encouraging genuine integration and at the same time, students and supervisors are required to discuss regularly on a routine schedule for effective communication to solve common research issues, such as what methodologies or format to be used.

14. Develop Capacity

It is essential to develop IDR capacity skills in young researchers by making them understand the accurate definition of IDR along with providing work-shop based training, career guidance, improvement in supervision and mentoring (Lyall & Meagher, 2012, Sa, 2008), as these issues are important in designing and conducting IDR (Szostak, 2007). Capacity can be developed by establishing institutions that encourage interaction and linkages between various disciplines and

ultimately to build capacity for leadership in integrated research. Further, the capacity of IDR scientists can be developed through providing training of different methodological backgrounds and the application of various IDR tools (Nash, 2008). Also, a higher education curriculum should include IDR Methodology to train students in synthesizing and applying knowledge and skills of various disciplines (Ashby & Exter, 2019). There should be the availability of regular IDR training and other facilities to actively nurture mutual appreciation and awareness of different disciplines' languages, research methods, culture, and to better understand the phenomenon that is researching and interdependence between disciplines (Sa, 2008). Local and national-level capacity can be developed by inviting researchers to participate from the beginning of the research process to develop closer relationships between researcher and policymaker and finally to integrate the research findings in designing public policy (Kapila & Moher, 1995).

15. Promote and design IDR for policy and practice

IDR should be promoted to enable research collaboration with different disciplinary backgrounds (Sa, 2007). To promote further research there should be steps to adopt IDR as an institutional strategy to foster interdisciplinary activities in research universities or institutes (Feller, 2002). IDR can be promoted by providing a reward, grant, or scholarships to those who have undertaken IDR for their efforts and dedication, such as implementing funding program (Seed money/grant) for research collaboration, between departments or colleges, by improving and nurturing young IDR researchers' career or team (Sa, 2008). Also, it is promoted through publicity, advertisement, or call for IDR approaches to solve common problems of the society, aided by the availability of facilities for partnership, collaboration, and networking among institutions and researchers (Bloschl et al., 2012). At the same time, there should be a change in policies and practices of Universities, including hiring, recruitment of faculty members who have IDR background or interests (Brint, 2005).

Conclusion, Limitation, and Recommendation

On analysis of the reviewed literature, it is found that IDR is a synthesis of two or more disciplines with aims to discover something new or develop a better outlook, where the contributions of the various disciplines are integrated to provide holistic or systemic outcomes. There is a growing importance to include IDR in the research curriculum of every educational institutions as it is difficult to solve a complex research problem by a single discipline. Nowadays, human society is faced with complex problems in every fields. So, we need collaboration, discussion and sharing with other disciplinary participants, studying together, using combined techniques and procedures to obtain the common objectives. For example, while studying pollution research of the environmental science, we need to study human behavior, responsible for creating pollution and the particulate matter released in the environment due to pollution, and the impact on human health. So, such type of research problems need to adopt interdisciplinary research methodology, a collaboration of behavioral science, environmental science, chemistry and health.

IDR is different from MDR, and TDR. In MDR, different academic disciplines collaborate and combine their disciplinary knowledge in parallel while researching a single topic without integration. For IDR, different academic disciplines work together to integrate disciplinary knowledge and methods to achieve the shared research goal through a real synthesis approach. For TDR, various academic, as well as non-academic researchers, collaborate and study to achieve the shared research goals or objectives, using different research techniques including even integration and synthesis of expert knowledge and methods. So, one of the characteristics that distinguish IDR from MDR is in terms of the intensity of contact and communication between the disciplines. IDR synthesizes and integrates knowledge of various disciplines through intensive interaction and collaboration. Team members of IDR generally use integrated mixed disciplinary techniques, ideas, and theories for solving common research problems or complete common research purposes, thus providing every participating discipline a chance to discover more findings, knowledge, or result than by a single studying individually. It can be concluded at the end that key steps of the IDR approach include 1) Identifying the research problem and formulating the common goal or objective; 2) Developing IDR proposal; 3) Team formation; 4) Reviewing IDR proposal; 5) Select a competent leader; 6) Team management; 7) Searching for a funder; 8) Selecting collaborators; 9) Data collection and analysis; 10) Troubleshooting any problem that arises in the

research process; 11) Fixing a particular day and time for periodic meeting, discussion, and follow-up; 12) Evaluating the research result; 13) Capacity development; 14) Integration of the research results through presentation, and publication; 15) Capacity development; and 16) Promotion of IDR. The characteristics of the IDR approach includes sharing, cooperation, availability of training for researchers' improvement, strong leadership with effective management, improvement in communication strategies, dedication and cooperation of IDR team members, selection of skilled and adaptable team members, clarity of objectives for successful integration or synthesis and collaboration of IDR approaches. Some of the important characteristics needed by interdisciplinary researchers include adjustable and flexible personality. So, while selecting team members, there should be consideration of researchers' attitudes, their skills or specialization, their personality, whether they are flexible, adaptable, creative, and adjustable. In addition, there needs consideration of researchers who can communicate effectively with other disciplinary researchers in a multi-cultural environment and also having the eagerness to learn from others, besides possessing skills and knowledge of more than one discipline, and a good team worker.

Despite its growing importance in knowledge production, IDR has many limitations. The limitations are:

- Firstly, researchers in different disciplines may study the same phenomenon but differ in their theories, differences in methodological analysis, the concept of adequate proof, and other assumptions of different fields. Also, there are difficulties in collaboration between different disciplinary scientists, such as collaborating with botanists and social scientists (Lele & Norgaard, 2005).
- Secondly, difficulties may arise when there is insufficient data to identify the contribution of the IDR team and formulating an outcome without the sufficient contribution of interdisciplinary team members or partners in the IDR process (Nancarrow et al., 2013)
- Thirdly, since most researches mainly aim to achieve the objectives or goal, there is inadequacy on the definition of IDR team, and also no clear guidelines on the recruitment qualification of good interdisciplinary team practice. Also, there are capacity-building barriers, including knowledge barriers, cultural barriers, methodological barriers, psychological barriers, reception barriers, etc. (Bruun et al., 2005).

There are many challenges for doing IDR, including diverse disciplinary 'languages', research time limitation, and guidance on how to achieve success in IDR practice. The following are the recommendations to overcome these barriers or limitations:

- Firstly, learn new languages, be open-minded, have patience, accept complexity, collaborate widely, foster IDR culture, increase the ability to engage in IDR, and reward IDR researchers (Kelly et al., 2019).
- Secondly, improve the IDR institutional team building through the promotion of IDR capacities (Lele & Norgaard, 2005).
- Thirdly, the capacity building of IDR needs to overcome several barriers, including knowledge barriers, cultural barriers, methodological barriers, psychological barriers, reception barriers…, etc. (Bruun et al., 2005).
- Fourthly, the IDR approach in social and behavioral science needs more research and attention on its definition and how to conduct or achieve the goal of the research (Guerreiro, 2016, May).
- Fifthly, as there is no adequate framework for interdisciplinary research approaches in behavioral science, the following points need consideration for further analysis: a) Reasons of using IDR approach; b) If IDR helps in integration, the type of proposed integration and the outcome; c) Appropriate approaches and method for successful integration; d) How to integrate successfully with consideration of both intellectual and organizational consideration; Feasibility of integration in terms of scope as well as human resources and material (Bruun et al., 2005)
- Sixthly, need to target the long-term impacts of IDR projects in terms of organizational and individual research users along with interventions to solve any shortcoming in the IDR process and its outcomes to achieve the target goal with better management and integration (Knight et al., 2013).
- Seventhly, as many researchers may still be reluctant to join the IDR approach or projects, it needs innovative organizational structure, learning, and cultural adaptation, which may

help to achieve successful integration (Bark et al., 2016).

- Eighthly, there should be an integration of interdisciplinary approaches into the higher education curriculum by adopting the best strategies (Ashby & Exter, 2018).
- Lastly, should develop a new clear conceptual model for IDR conceptualizations in the behavioral science that helps to connect all involved participants (Pennington, 2016).

The IDR methodology should be inculcated in the school, college and university curriculum of all disciplinary studies, including the behavioral science, as it is beyond the domain of a single discipline to solve complex human problem. It needs interdisciplinary consultation and collaboration of two or more disciplines. So, this review made a modest attempt to fill up the gap in knowledge in the research methodology literature by providing future IDR researchers, the appropriate steps and essential characteristics for the successful operation of interdisciplinary research.

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