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Operationalization of the concepts of interdisciplinarity: An implication elicitation exercises based on the framework synthesis methodology

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Abstract:

BACKGROUND: Over the last few centuries, the overspecialization of various sciences under the pretext of benefiting from pure disciplinary knowledge led to alienation among and competition between different fields of science. Such competition has deviated knowledge from its main objective which is to understand and explain the phenomena. The remedy to this dilemma is to address a new approach, introduced to higher education in the late 1950s as "interdisciplinarity." Accordingly, the main purpose of this article is to propose the strategic instances of operationalizing interdisciplinarity as the key requirements to provide a guideline for designing interdisciplinarity activities.

MATERIALS AND METHODS: The present survey was carried out through the framework synthesis method. To codify the instances of operationalizing interdisciplinarity, the main elements and structures of the model were set as the basis of the query for each element and structure; an independent query was carried out in the literature of the study. The correspondence of the discovered instances was once more compared with the conceptual boxes of the primary theoretical model. Ultimately, the taxonomy was concluded through the operational instances based on the primary framework.

RESULTS: A total of 152 strategies were identified as implications of operationalization of 13 layers and 38 sublayers of the multilayer interdisciplinary model.

CONCLUSION: The development of interdisciplinarity in the national higher education system requires several measures to be taken at different levels of a discipline or scientific field of study. Relying on this, which is the main basis of entering into interdisciplinarity activities, the present study suggests and presents strategic instances of interdisciplinarity operationalization.

Keywords:

Framework, implication, interdisciplinarity, operation, unification of science

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Introduction

Today, the interdisciplinarity approach is considered as one of the important fields of study in the world. This is such that the intellectuals have hopes of presenting comprehensive and efficient solutions in the light of this perspective, so that they would solve the peripheral complicated and multidimensional issues. However, the point to pay attention to is how this interaction and merger as requirements of interdisciplinarity approach should be established? In line with this, Frodeman and Gabriele Bammer assert that: "one of the most important challenges of accomplishing interdisciplinarity activities is the lack of an accepted method among the interdisciplinary activists." Or Gabriele Bammer believes that there is no standard process to put the disciplines next to each other and to determine how they should be merged and combined to decide about a phenomenon or solve a problem.[1,2]

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The main problem with interdisciplinary activities is how to implement and apply this approach in the process of activities related to interdisciplinarity. Researchers and lecturers – activists in general – may not be encouraged to adopt interdisciplinary activities by only pronouncing their benefits. The studied literature on the implementation of interdisciplinary activities is chaotic, the road map is unknown, and the languages of scientific disciplines are dissatisfying to other disciplines, and finally, individuals face plenty of hesitations and difficulties along their way.[3]

As commentators believe, the interdisciplinarity approach is well understood when compared with the scientific disciplines under question. A scientific discipline is a systematic subject encompassed by the context of scientific knowledge, which categorizes and specializes the work, and responds to the diversity of scientific fields. Although every discipline is within a larger scientific body, it tends to be independent due to the hypotheses, language, and techniques it establishes or exploits.[4]

Hence, to have a clear understanding of the essence of interdisciplinarity, the symbolic boundaries that lead to identity building for various disciplines and differentiation between them need to be first determined. As mentioned in our article entitled "Rethinking Inter-disciplinarity: Proposing a Multilayered Model," the breadth and multitude of semantic layers of a discipline are rooted in the following facts: the philosophical backgrounds, culture, language, focus and interest, aim, fund of knowledge, knowledge human resources, knowledge institutes, knowledge-based activities, knowledge resources, knowledge-related events, knowledge value addition, and the stewardship of the scientific discipline.[5]

Interdisciplinarity is underpinned by the fundamental rationale that actors need opportunities to comprehend the existing relationships among different disciplines and could acquire the skills and knowledge in the real world. Interdisciplinarity cannot be witnessed in practice unless an appropriate theoretical and applied understanding of interdisciplinary activities is arrived at.[6,7]

Interdisciplinarity is an approach to establish a more comprehensive understanding to encounter complicated or broad questions and problems in reality by integrating the epistemology, methodology, knowledge, theory, procedure, technique, and concepts of different disciplines through reciprocal understanding, interaction, collaboration, shared discourse, and multidimensional analysis. In terms of quantity, integration, and holism, interdisciplinarity hierarchically stands somewhere between multi-, inter-, and metadisciplinarity.[8]

The authors intended to fill this languish gap in the interdisciplinarity literature to find out what should be done to operationalize an interdisciplinary activity. To respond to this concern, the existing literature of this ground was addressed considering the theoretical framework called "multilayered interdisciplinarity" model, developed and published by the authors of the article entitled "Rethinking interdisciplinarity: Proposing a multilayered model," and out of the findings and through cognitive synthesis, the questions were answered as of how to use approaches and insights resulted from various disciplines or how to extravagate the interdisciplinary boundaries and identify the standpoints and perspectives of two or more scientific disciplines.

The present study can offer excellent literature to interdisciplinary activists and education planners of the country to make it instrumental in further expanding and utilizing the interdisciplinary approach. Accordingly, the interdisciplinarity operationalization model is hereby proposed to develop such programs.

As we proceed, a brief discussion of the theoretical "multilayered interdisciplinary" models of the researchers' interest is overviewed. In this pyramidal model, the pillars of scientific disciplines are identified and composed in 13 layers and 38 sublayers, with the basic and abstract layers on the bottom and the objective layers on the upper sublayers of the pyramid. To adhere to the brevity and a possibility of a more convenient review of the study results, the fallowing displays the pyramidal model of interdisciplinarity development, that is, the "multilayered interdisciplinarity" model by disciplinary boundaries.[9]

These 13 layers are as follows: the philosophical background of the scientific discipline, the culture of the discipline, the language of the discipline, the focus and interest of the scientific discipline, the aims of the scientific discipline, the discipline's fund of knowledge, the knowledge-based human resources of the discipline, the knowledge institutes of the discipline, the knowledge activities of the discipline, the discipline's knowledge resources, the knowledge-related events of the discipline, the knowledge-based value addition of the discipline, and the stewardship of the discipline. The sublayers associated with each layer are as follows:

1. The philosophical background of the scientific discipline: The ontological assumptions of the discipline, the epistemological assumptions of the discipline, the methodological principles of the discipline, the semantic assumptions of the discipline, the values/axiological and moral assumptions of the discipline
2. The culture of the discipline: The customs and social behavior of the discipline's scientific community, the

norms of the discipline's scientific community
3. The language of the discipline: The ontology of the discipline and the standard terminology system of the discipline
4. The focus and interest of the scientific discipline: The domain of discourse of the discipline, the problematics of the discipline, and the discipline's priorities
5. The aims of the scientific discipline: The cognitive goals of the discipline, the practical goals of the discipline, and the moral goals of the discipline
6. The discipline's fund of knowledge: The theories, the propositional knowledge, the prescriptive knowledge, and the normative knowledge
7. The knowledge-based human resources of the discipline: The discipline's knowledge knowers and the discipline's knowledge seekers
8. The knowledge institutes of the discipline: Scientific organizations and institutes, scientific networks, and scientific teams
9. The knowledge activities of the discipline: Knowledge research/production, knowledge management and translation, knowledge education/transfer, knowledge dissemination, and knowledge application
10. The discipline's knowledge resources: The scientific journals of the discipline, the textbooks of the discipline, and the databases of the discipline
11. The knowledge-related events of the discipline: The scientific seminars of the discipline and the scientific conferences of the discipline
12. The knowledge-based value addition of the discipline: The economic value addition of the knowledge and the noneconomic value addition of the knowledge
13. The stewardship of the discipline: Setting the standards and enforcing the standards.

Materials and Methods

Study design and setting

This study is a qualitative study conducted in 2020 using framework synthesis methods to achieve taxonomy of the operationalizing inter-disciplinarity as the key requirements to provide a guideline for designing inter-disciplinarity activities. Framework synthesis methods is a process of combining or aggregating related evidence extracted from numerous similar studies, aiming to obtain sufficient results with high generalization capability against what could possibly be achieved by findings of an individual study. [10]

The researchers who define the classifications of techniques have determined framework synthesis as follows:

1) Freestyle Subsequent Categorization: The operational methods are probed and classified by subject in the absence of a preliminary theoretical framework. In this method, inductive analysis is utilized following the subject
2) Best Fit Framework Synthesis: In this method, we simultaneously look for the theoretical frameworks and operationalization methods. The theoretical framework and operational implications that best fit with the examples are selected through constant comparison, and they are postulated as the basis for classifying the implications. In this technique, both deductive and inductive analyses are integrated
3) Sequential Framework Synthesis: by this approach, the resources are first searched to detect a framework. Then the implications are searched and assigned to the components of the selected framework through deductive analysis
4) Predetermined Framework Synthesis: In this method, the researcher has already developed a theoretical framework to be utilized as a basis underpinning the search for the implications and operations. The operational implications are then elicited and attributed to the components of the framework through deductive analysis.

Data collection tool and technique

To collect the Data using the framework synthesis, an exhaustive review of literature by the theoretical model has been done and each of the keywords related to the contents of the interdisciplinary multilayer model is searched in databases like google scholar, Eric, PubMed, web of science in English. As a result, little evidence has been found; therefore, authors elaborate implication elicitation method of interdisciplinary strategies.

Predetermined framework synthesis:

To achieve taxonomy of the operationalization methods in interdisciplinary development strategies, this study uses predetermined framework synthesis technique, the fourth category of the above classification of the framework synthesis. This technique encompasses five steps as follows:

1. The main components and structures of the model or the theoretical framework are determined
2. The research literature is independently probed to find operational implications for each of these components and structures
3. The correspondence between the discovered implications and the conceptual boxes of the preliminary theoretical model is re-examined
4. The redundant instances are eliminated and the vague instances are clarified and explained
5. The taxonomy of operational examples is presented based on the preliminary framework.

Ethical considerations

This study is part of a PhD dissertation of medical education discipline in Medical Sciences University

Shahid Beheshti with the code of ethics) (IR. SBMU. SME. REC.1397.002.

Research findings

According to the objectives of the study, a total of 152 strategies were organized and proposed in 13 layers and 38 sublayers in Tables 1-13, considering the cross-, multi-, inter-, and metadisciplinary techniques to develop interdisciplinarity in the higher education system. The four terms "cross-disciplinary, multidisciplinary, interdisciplinary, and metadisciplinary" are used to refer to different forms of interdisciplinary interaction and integration between scientific disciplines. Cross-disciplinarity includes per-case activities providing a discipline with the benefits of other ones. The term "multidisciplinary" is referred to those activities performed in teamwork or to those activities consisting of individuals and members of different disciplines while fully preserving the identity of the discipline. Interdisciplinarity encompasses activities focusing on an issue or phenomenon to use the existing capacities of different disciplines. Questioning the disciplinary boundaries, transdisciplinarity includes activities seeking to reach a single fact and to provide a single solution to the issues and problems, fully considering the uniqueness of the phenomena regardless of any disciplinary boundaries.[5]

The "ontological assumptions" layer of the discipline

Nowadays, what researchers and scientists of various fields perform is the fruit of a belief system formed gradually over the centuries by the thinkers of these fields. Such a belief system is indeed a philosophical framework instructing the researchers to develop and apply the scientific method.[11] In this layer, the interdisciplinary activists should consider and headline the strategies proposed in Table 1 to achieve a common philosophical belief.[12-15]

The discipline's layer of culture

Disciplinary culture involves the norms, customs, and social behavior of a scientific community and the values extracted from the behaviors of scientific activists in an abstract discipline. The interdisciplinarity approach seeks to understand, access, and transmit cultural values and norms and culturally assimilate different disciplines. The strategies propounded in Table 3 can help interdisciplinarity activists address the interactions between the involved disciplines as more clearly and with higher quality as possible.[16]

The language layer of a scientific discipline

One of the layers associated with the discipline is its language. The terminology used to establish scientific communication between the scientific experts is placed in the scope of a discipline, and the semantic system governing a discipline varies for different disciplines.[17,18] The following strategies and implications provide the possibility for the experts to overcome the challenges of linguistic communication and dialog establishment among the disciplines.[19-21]

The focus of a scientific discipline

The focus of each scientific discipline in a scientific discourse determines the basic issues the scientific community of the concerned discipline encounters and specifies the research priorities of the discipline.[22,23] The practical strategies and implications of Table 5 provide the discourse context for interactions and crossing the boundaries of two or more disciplines.[23-25]

The aims of a scientific discipline

The overall goals and aims of a discipline may be classified into three groups of cognitive goals, moral goals, and practical goals.[22] The final objective of efforts made by the scientific body of every discipline is to reach these aims, considering the following implications.[26-30]

The discipline's fund of knowledge

Every discipline's fund of knowledge is formed by a

Table 1: The strategies and implications of operationalization of interdisciplinarity development elicited from the "ontological assumption of discipline" layer

The primary layer of the discipline	The secondary layer of the discipline	Integration layers			
		Cross-disciplinary	Multidisciplinary	Interdisciplinary	Transdisciplinary
The ontological assumptions of the discipline	Ontology	Pragmatic ontological borrowing	Shared ontological assumptions	Critical transcendental ontology	Metaphysical/ ontological unity
	Epistemology	Epistemological explication	Epistemological pluralism	Aggregated epistemology	Epistemological unity
	Methodology	Methodological cross-fertilizations	Shared components approach	Method-interdisciplinarity/ cross-cutting organizing principles	Unified scientific methodology
	Semantics	Concept discovery and semantic embedding	Reciprocal translation and overarching concepts	Concept-interdisciplinarity	Semantic integration
	Values/axiology	Cross-boundary value awareness	Values pluralism	Integral value constellations/shared reference value framework	Global values system

Table 2: The strategies and implications of interdisciplinarity development operationalization elicited in the "culture of discipline" layer

The main layer	The subsidiary layers	Integration levels			
		Cross-disciplinary	Multidisciplinary	Interdisciplinary	Transdisciplinary
Culture	The norms, customs, and social behavior of the scientific community	Cultural awareness/ cultural competencies	Shared communities of practice	Shared acculturation	Grand culture of scientific communities
	The norms of the scientific community	Cross-disciplinary norm diffusion	Multitaskholder normalization	Shared platform of clarified norms and values	Global norms of scientific community

Table 3: The strategies and implications of interdisciplinarity development operationalization elicited from the "language of discipline" layer

The main layer	The subsidiary layer	Integration layers			
		Cross-disciplinary	Multidisciplinary	Interdisciplinary	Trans disciplinary
The language of the discipline	Ontology	Pluralistic dialog	Multidisciplinary dialect	Interdisciplinary articulation	Metalanguage
	The standard terminology system	Cross-linking ontologies	Shared ontology	Methodical terminology management	Unified ontology of scientific terms

Table 4: The strategies and implications of interdisciplinarity development operationalization elicited from the "focus and interest of the scientific discipline" layer

The main layer	The subsidiary layer	Integration layers			
		Cross-disciplinary	Multidisciplinary	Interdisciplinary	Trans disciplinary
The focus and interest of the scientific discipline	The discourse domain	Cross-disciplinary discourse awareness	Pluralistic discourse/ multistakeholder discourse	Problem-focused open discourse	Transdisciplinary discourse
	The problematics	Cross-disciplinary problematic enrichment	Pragmatic shared problematic	Interdisciplinary problematics	Unified problematic
	The priorities	Exchanging priorities	Participatory priority setting	Shared priority setting	Shared goals for priority setting

Table 5: The strategies and implications of interdisciplinarity development operationalization elicited from the "aims of the scientific discipline" layer

Main layer	Subsidiary layer	Integration layers			
		Cross-disciplinary	Multidisciplinary	Interdisciplinary	Trans disciplinary
The aims of the scientific discipline	Cognitive goals	Disciplinary discovery agenda with a glimpse of cross-disciplinary issues	Shared multidisciplinary discovery agenda of mutually interested phenomena	Phenomena specific discovery agenda	Transdisciplinary discovery agenda of united ontologies
	Practical goals	Cross-boundary awareness of "practical orientations"	Multidisciplinary shared "what to do"	Interventional interdisciplinarity	Unified scientific taskforce
	Moral goals	Cross-boundary goal consideration	Multilateral target determination	Interdisciplinary aggregated goal platform	Unified phenomenological utopia

Table 6: The strategies and implications of interdisciplinarity development operationalization elicited from the "the discipline's fund of knowledge" layer

Main layer multidisciplinary	Subsidiary layer interdisciplinary	Integration layers			
		Cross-disciplinary	Multidisciplinary	Interdisciplinary	Trans disciplinary
Fund of knowledge	Theories	Theory borrowing	Transtheoretical approach	Metatheory development	Unifying theories
	Propositional knowledge	Disciplinary knowledge of phenomena with some cross-disciplinary themes	Multiperspective knowledge of phenomena	Bridged interperspective knowledge of phenomena	Universal knowledge of phenomena
	Prescriptive knowledge	Disciplinary knowledge of practice with cross-disciplinary implications	Multidisciplinary package of practice knowledge	Integrated knowledge of practice	Universal knowledge of practice
	Normative knowledge	Disciplinary perspective of ideal states with cross-disciplinary awareness	Negotiated multidisciplinary approach to ideal states	Interdisciplinary vector approach to ideal states	Universal knowledge of ideal states

Table 7: The strategies and implications of interdisciplinarity development operationalization elicited from the "knowledge-based human resources" layer

Main layer multidisciplinary	Subsidiary layer interdisciplinary	Integration levels			
		Cross-disciplinary	Multidisciplinary	Interdisciplinary	Trans disciplinary
Knowledge-based human resources	Knowledge knowers	Disciplinary faculty members with cross-disciplinary activities	Faculty members with multidisciplinary capacity enhancement	Faculty members with interdisciplinary career development	Pluripotent academic scientist/faculty member
	Knowledge seekers	Disciplinary students with cross-disciplinary activities	Students with multidisciplinary/ modular coursework	Students with interdisciplinary project-based education	Transdisciplinary capable knowledgeable student

Table 8: The strategies and implications of interdisciplinarity development operationalization elicited from the "knowledge institutes" layer

Main layer multidisciplinary	Subsidiary layer interdisciplinary	Integration levels			
		Cross-disciplinary	Multidisciplinary	Interdisciplinary	Trans disciplinary
Knowledge institutes	Scientific organizations and institutes	Organizations with interdisciplinary placements	Multidisciplinary departments	Interdisciplinary centers	Organizations formed around real-world problems
	Scientific networks	Disciplinary networks with occasional cross-links	Interconnected multidisciplinary networks	Integrated interdisciplinary networks	Global science network
	Scientific teams	Disciplinary teamwork with occasional cross-participation	Reactive multidisciplinary teamwork/shared interdisciplinarity teamwork	Proactive interdisciplinary teamwork	Multitask project-based teamwork

Table 9: The strategies and implications of interdisciplinarity development operationalization elicited from the "knowledge activities" layer

Main layer multidisciplinary	Subsidiary layer interdisciplinary	Integration levels			
		Cross-disciplinary	Multidisciplinary	Interdisciplinary	Trans disciplinary
Knowledge activities	Knowledge production/ research	Disciplinary research with methodological borrowing	Multidisciplinary joint research	Boundary spanning translational research	Transdisciplinary inquiry
	Knowledge management and translation	Intradisciplinary synthesis of boundary problems	Metanarrative	Critical interpretative synthesis	Transdisciplinary transparadigmic knowledge synthesis
	Knowledge transfer/education	Multidisciplinary teaching	Interdisciplinary (modular) curriculum	Interdisciplinary (problem based) curriculum	Transdisciplinary curriculum
	Knowledge dissemination	Discipline-specific knowledge portal with cross-disciplinary users	Joint multidisciplinary knowledge portal	Phenomena/ problem-focused interdisciplinary knowledge portal	Universal science portal
	Knowledge application	Cross-boundary works	Multidisciplinary practice, multidisciplinary projects	Interdisciplinary projects/services/ practices	Real-world knowledge-based problem solving

Table 10: The strategies and implications of interdisciplinarity development operationalization elicited from the "knowledge resources" layer

Main layer multidisciplinary	Subsidiary layer interdisciplinary	Integration levels			
		Cross-disciplinary	Multidisciplinary	Interdisciplinary	Trans disciplinary
Knowledge resources	Scientific journals	Disciplinary journal with cross-disciplinary guest editor	Journal with multidisciplinary editorial board	Problem/issue-based interdisciplinary journals	Unified/general science journals
	Textbooks	Cross-disciplinary boxes in disciplinary textbooks	Multiauthorial multidisciplinary textbook	Multiauthorial interdisciplinary textbook	Integrated science textbook
	Databases	Disciplinary database with occasional records from other disciplines	Cross-linked multidisciplinary database	Integrated interdisciplinary database	Unified database of science

Table 11: The strategies and implications of interdisciplinarity development operationalization elicited from the "knowledge-based events" layer

Main layer multidisciplinary	Subsidiary layer interdisciplinary	Integration levels			
		Cross-disciplinary	Multidisciplinary	Interdisciplinary	Trans disciplinary
Knowledge-related events	Scientific seminars	Seminar with cross-disciplinary invited speaker.	Multidisciplinary joint seminar	Phenomena or issue-based interdisciplinary seminars	"Science as perspective" instead of "perspectives in science" seminars
	Scientific conferences	Conference with invited speaker from another discipline	Multidisciplinary joint conference	Problem-based interdisciplinary conferences	Science as enlightenment" instead of "science as flashlight" conferences

Table 12: The strategies and implications of interdisciplinarity development operationalization elicited from the "knowledge-based value addition" layer

Main layer multidisciplinary	Subsidiary layer interdisciplinary	Integration levels			
		Cross-disciplinary	Multidisciplinary	Interdisciplinary	Trans disciplinary
Knowledge-based value addition	Economic knowledge-based value addition	Commercialization of disciplinary knowledge with "as-needed" use of cross-disciplinary knowledge	Joint firms based on multidisciplinary collaboration	Service/product-focused interdisciplinary knowledge commercialization	Boundary-less knowledge as wealth ideology
	Noneconomic knowledge-based value addition	Valorization of disciplinary knowledge with "as-needed" use of cross-disciplinary knowledge	Joint noncommercial activity based on multidisciplinary collaboration	Problem/development focused interdisciplinary knowledge valorization	Boundary-less knowledge as salvation ideology

Table 13: The strategies and implications of interdisciplinarity development operationalization elicited from "stewardship"

Main layer multidisciplinary	Subsidiary layer interdisciplinary	Integration levels			
		Cross-disciplinary	Multidisciplinary	Interdisciplinary	Trans disciplinary
Stewardship	Setting the standards	Disciplinary governing body with cross-disciplinary representatives	Joint multidisciplinary body of governance	Problem-focused interdisciplinary governance body	Transboundary governance of scientific bodies
	Enforcing the standards	Disciplinary standards with occasional cross-disciplinary considerations	Collaborative multidisciplinary standard setting	Goal-oriented interdisciplinary standards	All-inclusive standards of scientific activities

set of theories, propositional knowledge regarding the behavior of the phenomena in the real world, and its prescriptive knowledge to intervene and change the behavior of the phenomenon in a discipline.[14,22] The following strategies and implications are selected for interaction and setting the boundaries between two or more disciplines.[31-33]

Knowledge-oriented human resources

A scientific discipline may educate the most outstanding scientists, researchers, and theoreticians, as well as talented and knowledge-seeking students of that discipline.[22,34] The scientific relations and interactions in the scientific and academic community of both national and international levels take place between two or more disciplines considering the following implications.[35-39]

Knowledge institutes

Think tanks, advanced laboratories, research centers, universities, educational hospitals, and knowledge management and interpretation centers are considered among the knowledge institutes of every discipline.[14,22] The practical strategies of Table 8 should be kept in mind when intending to undergo activities among the organizations, networks, and scientific teams.[38,40-44]

Knowledge activities

A scientific discipline in a knowledge domain requires research (knowledge production), education (knowledge transfer), knowledge management and translation, and provision of knowledge service (knowledge application) at the highest level of quality possible.[14] The knowledge activities relate to familiarity with the proposed strategies and implications as follows.[36,45-52]

Knowledge resources

A scientific discipline has scientific journals, scientific textbooks, and databases of scientific articles. The knowledge sources seek to draw the horizons ahead and to record and distribute the interdisciplinarity scientific findings through the following strategies and implications.[43]

Knowledge-related events

In a scientific discipline, international gatherings or

scientific seminars or conferences are held at the top scientific level with the participation of the international outstanding scientists and researchers. The role of knowledge-based events is applied in scientific and entrepreneurship developments and identifying the challenges, obstacles, and solutions with the following strategies.[53]

Knowledge-based value addition

The knowledge-based value added is the formation of a technology-specific innovational system, the development of a knowledge-oriented economy, and the establishment of knowledge-based centers to produce economic and noneconomic value addition in a discipline. The interdisciplinary activities with general favorability in producing knowledge and policy-making, economy, and social values may become practical through the strategies at this level, provided in Table 12.[54-56]

Stewardship

Stewardship is a scientific discipline including institutes active at an international level in policy-making, legislation, setting the standards, validation, and accreditation. Forming a stewardship among 2 or more disiplines is required for interdisciplinarity activities.[57,58]

Discussion

The main purpose of this study is to present a taxonomy of operationalization strategies of developing interdisciplinarity for higher education. For the first time, this taxonomy of operationalization strategies seems to answer the questions of how to implement interdisciplinarity, or on what basis or model should we establish interaction and association.

According to the findings of this study, 152 instances of the operationalization strategies for the development of interdisciplinarity based on a multilayered model of scientific disciplines with 13 layers and 38 sublayers are compiled and presented. This strategic model implies four levels of integration (namely cross-, multi-, inter-, and metadisciplinarity).

This operational model casts a comprehensive glance into the development of the interdisciplinarity approach. It introduces the operational strategies to the interdisciplinarity actors by considering integration between the contents of the lowest level that is the philosophical fundamentals of two or more scientific disciplines to the shallowest realm in between, which is stewardship.

As the first step, the interdisciplinarity actors ought to prioritize the acquisition of knowledge and awareness about the assumptions of the philosophical foundations of the scientific disciplines over the rest of the discipline layers. These philosophical foundations are ontology, epistemology, methodology, semantics, and values/axiology that ought to be managed and directed by the interdisciplinarity actors. This finding is in line with the results of the researches conducted by Jan Schmidt, Bhaskar, (2014), Pourkarim *et al*., Nicolini *et al*., Graham *et al*. (2013), and Little (2003). It indicates that interdisciplinarity activities are in connection with critical realism, epistemological pluralism, value pluralism, and semantic integration.[15,59-63]

The strategies proposed for the advancement of interdisciplinarity work at the cultural sublayer are after the recognition, penetrability, transfer of cultural values and norms, and cultural assimilation between the different disciplines. This is in line with the results of the study carried out by Balsamo and Mitcham arguing on observing the indicators of ethical and cultural practices among the disciplines, including intellectual generosity, intellectual confidence, intellectual humility, intellectual flexibility, and intellectual integrity.[16]

One of the layers associated with the disciplines is their language. Often, terms used to establish a scientific relationship between the activists of a scientific discipline, as well as the semantic system governing the scientific terminology in a discipline, differ by discipline. The operational strategies proposed at this level are supported by the studies of Schnieder and Wegener (2010), Noy, and Little who have emphasized providing a comprehensive and compatible ontology, management of scientific terms, and attainment of a common ontology in interdisciplinarity activities.[19-64]

According to the results of this study, one of the important pillars in every scientific discipline is the focus and interest layer of the discipline. Participation in the scientific discourse among the disciplines, determination and enrichment of the basic issues the scientific community encounters, and determining the research priorities among two or more scientific disciplines should be paid attention to by the policy-makers, planners, and administrators of the interdisciplinarity approach because it is the best solution for detecting the issues ahead of the interdisciplinary activities. Studies by McCallin, Gruskin and Daniels, and Fuchsman and Henry have entirely approved the approaches of pluralistic dialog, integration of the subjects, and rational responsibility.[18,23,24]

Another scientific discipline layer constitutes the objectives of the scientific discipline. Efforts made by the scientific body of every discipline would ultimately achieve the three objectives namely cognitive, moral, and practical goals. The work order of recognizing the phenomena is practical, interventional orientations,

recognizing and considering the favorable conditions of a phenomenon among other strategic implications of this sublayer. Through these solutions, it is readily possible to understand the different dimensions and aspects of the phenomena and to identify them. The findings of this sublayer are in line with the studies of Stein, Prager *et al*., Mansilla, and Szostak who emphasize the development-orientation studies, platform-orientation-emotional-interactive studies, and problem-based interdisciplinarity models of educational and research interventions.[29,30,65]

Every special knowledge discipline may encompass an endless number of theories, propositional knowledge, prescriptive knowledge, and normative knowledge. The operationalization strategies of necessity have suggested the use of the existing theories' capacity, integration of the propositional knowledge, and aggregation and integration of prescriptive and normative knowledge for the expansion and development of determining the aims of scientific disciplines. The findings of the studies carried out by Overton and Muller, Sawa, and Max-Neef have underpinned the metatheories, organization of knowledge acquisition, and interventions toward the desired aim.[31-33]

To have the most outstanding knowledge, human resources is one of the pillars of a scientific discipline. Scientific participation, communications, and interactions in interdisciplinary activities lead to the development and improvement of the interdisciplinary attitude of the professors of scientific groups, as well as their support for the individual development and building credo for designing and implementing the tasks and activities. The suggestion is that the faculty members and students participate in educational associations with interdisciplinary approach in order to recognize and understand the accomplishments of interdisciplinarity activities. The study carried out by Stevenson *et al*., Golding, and Crebert *et al*. conform to that suggestion.[31-33,66]

Knowledge institute is another domain of the scientific discipline. Building reciprocal relationships and collaborations, integrating two or more scientific networks, teamwork, and establishing international networks are among strategic implications of interdisciplinary development in building relations between departments, faculties, etc., They create and settle the required mechanisms, grounds, and structures for interdisciplinary activities and disciplines. The subjects of universities without departments, college networking, and interorganizational networking are pointed out in the studies of Bililign *et al*., Palmer *et al*., and Haythornthwaite *et al*., and they conform to the present study.[38,40,41]

A subject associated with discipline is their scientific activities. The most significant strategies of the required operationalization to remove the obstacles and constraints of the field are research, knowledge management and translation, knowledge dissemination, and providing knowledge-based services in a participatory manner or as two or more integrated disciplines to assist the researchers in eliciting the interdisciplinarity problems. Investigations by Desmarais *et al*., vom Brocke and Lippe, Ivanitskaya *et al*., Modo and Kinchin, and Harden, have entirely supported the impact of interdisciplinarity curriculum, using Harden's education eleven-fold integration phases, interdisciplinarity and critical pedagogy, and outcome-oriented curriculum.[37,45-49,52]

Knowledge resources are other scientific discipline criteria. Journals, textbooks and databases which are formed by editorial board, team of authors and linked records respectively, can be looked at as some of the implications of interdisciplinarity development strategies.

Klein's study focuses on traditional and electronic searching methods.[43]

Scientific gatherings are regarded as scientific events in a scientific discipline. The role of the knowledge-related events in the scientific development and identification of the challenges and hindrances and cross-border solutions to the real-world problems would be handled through holding joint seminars and conferences between two or more disciplines. Accordingly, Chrysanthou and Nottingham stated that conferences are effective as a tool in learning the interdisciplinary activities and to get aware of them.[53,67]

The knowledge-based value addition points out the economic and noneconomic added values in every discipline. The development of the required infrastructures for commercialization of the findings of the university surveys through establishment and formation of the technology-specific innovation system, knowledge-oriented economic development, and launching knowledge-based centers, technology towns and parks, and growth centers, building trust in the universities and academics for the industries to create and expand interdisciplinary relationships are among the most important practical manifestations of rendering the interdisciplinary activities as targeted ones. Adapting these activities to fit the needs of the educational and research community in line with our findings, Blackwell *et al*. and Linde emphasize the fund of the interdisciplinarity knowledge of commercially exploiting new ideas, technologies, and processes to create, develop, implement, and sell the products and services.[55,56]

The scientific discipline stewardship is the last domain of a scientific discipline, identified by this study. Formation of a common governance unit between two or more disciplines aiming to legislate the rules, preparing the standards, evaluations, and accreditation of governance decision-making are among practical interdisciplinarity implications. The operational strategies recommended on this sublayer are aligned with the studies of Gray and Holley that emphasize senior management backup, collaborative leadership, adaptable prospect, development of faculty members and the personnel, and perceivable action.[57,58]

By reviewing the study literature, it can be concluded that on the one hand, the researchers of this field hold a one-dimensional position toward the question of interdisciplinary performance, neglecting the point that some degrees of integration should take place in all elements of scientific discipline in the interdisciplinary activities. On the other hand, the proposed recommendations are not based on a theoretical framework.

We believe that this taxonomy is among the operationalization strategies of interdisciplinarity development, responsive to the separation of theoretical and practical domains in interdisciplinary activities. The interdisciplinary organizations, actors, and beneficiaries of higher education could enjoy the merits of a transparent executive structure with the possibility of conversion into a common language, as well as simultaneous management and control of the costs and time in the interdisciplinary projects, by adopting this strategic model in their activities. Like every other system invented by the human mind, this model never claims good interdisciplinarity executive management. However, there is no doubt in total that this model of operational strategies introduces a strong conceptual framework for the actors of this field.

Limitations and innovations

The only limitation was the lack of theoretical and implicational framework models available in the literature of this study. This study suggests the mentioned model for the development of interdisciplinary studies for the first time.

Conclusion

For real-world problems, a comprehensive development of the nationwide universities requires identification and intervention and effective strategies for interdisciplinary development. Therefore, considering this matter, the present study has proposed and presented strategic implications of interdisciplinarity operationalization, relying on different dimensions of the scientific discipline which is the main basis of entering into interdisciplinarity activities.

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Conflicts of interest

There are no conflicts of interest.

References

1. Frodeman R. Sustainable Knowledge: A Theory of Interdisciplinarity. Palgrave Macmillan: Springer; 2013.
2. Bammer G. Disciplining Interdisciplinarity: Integration and Implementation Sciences for Researching Complex Real-World Problems. Published by ANU E Press The Australian National University Canberra ACT 0200, Australia: ANU Press; 2013.
3. Razzaq J, Townsend T, Pisapia J. Towards an understanding of interdisciplinarity: The case of a British University. Issues Interdiscip Stud 2013;31:149-73.
4. Morin E. Sur l'interdisciplinarité. Bulletin interactif du Centre international de recherches et études transdisciplinaires. 1994;2.
5. Yazdani S, Hajiahmadi M, Shakerian S. Rethinking interdisciplinarity: Proposing a multilayered model. Medical Journal of the Islamic Republic of Iran. 2020;34:118.
6. Klein JT. Interdisciplinarity: History, Theory, and Practice. Detroit, MI: Wayne State University Press; 1990.
7. Klein JT. Creating Interdisciplinary Campus Cultures: A Model for Strength and Sustainability. 1807, New York, New York, United States John Wiley & Sons; 2009.
8. Yazdani S, Hajiahmadi M, Shakerian S. Interdisciplinarity; Out of Semantic Confusion in Iran. Journal of Medical Education. 2019;18:1-5.
9. Yazdani S, Hajiahmadi M, Shakerian S. Rethinking interdisciplinarity: Proposing a multilayered model. Med J Islamic Repub Iran 2020;34:802-10.
10. Booth A, Carroll C. How to build up the actionable knowledge base: The role of 'best fit'framework synthesis for studies of improvement in healthcare. BMJ Qual Saf 2015;24:700-8.
11. Kuhn TS. The Structure of Scientific Revolutions. 1427 E. 60th Street Chicago, IL 60637 USA University of Chicago Press; 2012.
12. Garcia, A., 2019. *Transdisciplinarity from Marginal Spaces: Unsettling Epistemic Erasure of Critical and Decolonial Scholars* (Doctoral dissertation, University of Colorado Boulder).
13. Rosenberger RS. An Integrative Hierarchical Framework for Environmental Valuation: Value Pluralism, Thresholds, and Deliberation. Regional Research Institute and Division of Resource Management West Virginia University Research Paper; 2001. p. 14.
14. Rousseau D, Wilby J, Billingham J, Blachfellner S. A typology for the systems field. Systema Connecting Matter Life , culture, and technology 2016;4:15-47.
15. Schmidt JC. Towards a philosophy of interdisciplinarity. Poiesis Prax 2008;5:53-69.
16. Balsamo A, Mitcham C. Interdisciplinarity in Ethics and the Ethics of Interdisciplinarity. The Oxford Handbook of Interdisciplinarity.

Oxford, United Kingdom: Oxford University Press; 2010. p. 259-72.
17. Dressel PL, Marcus D. On Teaching and Learning in College. Reemphasizing the Roles of Learners and the Disciplines. The Jossey-Base Series in Higher Education. *Jossey-Bass Inc., 433 California St., San Francisco, CA 94104* ERIC; 1982.
18. Krishnan A. What Are Academic Disciplines? Some Observations on the Disciplinarity vs. Interdisciplinarity Debate; 2009. ESRC National Centre for Research Methods NCRM Working Paper Series.
19. Little E, editor. A Proposed Methodology for the Development of Application-Based Formal Ontologies. KI Workshop on Reference Ontologies and Application Ontologies; 2003.
20. Schnieder L, Wegener M. Transgression of semantic boundaries by methodical terminology management. InLeicester: International Symposium on Spatial Accuracy Assessment 2010 (Vol. 9).
21. Vosskamp W, Miller RC, Klein JT. From scientific specialization to the dialogue between the disciplines. Issues Interdiscip Stud 1986.
22. Gabbay DM, Thagard P, Woods J, Kuipers TA. General Philosophy of Science: Focal Issues. North-Holland Elsevier; 2007.
23. Fuchsman, K. "Rethinking integration in interdisciplinary studies." Issues in Integrative Studies 2009;27:70-85.
24. Gruskin S, Daniels N. Process is the point: Justice and human rights: Priority setting and fair deliberative process. Am J Public Health 2008;98:1573-7.
25. McCallin AM. Pluralistic dialogue: A grounded theory of interdisciplinary practice. Aust J Rehabil Couns 1999;5:78-85.
26. Lynch J. It's Not Easy Being Interdisciplinary. 1586, Oxford, United Kingdom Oxford University Press; 2006.
27. Miller ML. 2005. Integrative concepts and interdisciplinary work: A study of faculty thinking in four college and university programs (Doctoral dissertation, Harvard Graduate School of Education).
28. Prager K, Morris S, Currie M, Macleod K. Exploring Interdisciplinarity: Summary Report of the 'Developing an Interdisciplinary Culture of Excellence (DICE)' Project at the James Hutton Institute. Scotland, UK: The James Hutton Institute; 2015.
29. Stein Z. Modeling the demands of interdisciplinarity: Toward a framework for evaluating interdisciplinary endeavors. Integr Rev 2007;4:91-107.
30. Szostak R. Extensional Definition of Interdisciplinarity. Issues in Interdisciplinary Studies. 2015;33:94-116.
31. Max-Neef MA. Foundations of transdisciplinarity. Ecol Economic 2005;53:5-16.
32. Overton WF, Müller U. Metatheories, theories, and concepts in the study of development. In: Handbook of Psychology. 2nd ed. 1807, New York, New York, United States John Wiley & Sons 2012. p. 6.
33. Sawa RJ. Foundations of interdisciplinarity: A lonergan perspective. Med Health Care Philos 2005;8:53-61.
34. Whitley R. Umbrella and polytheistic scientific disciplines and their elites. Soc Stud Sci 1976;6:471-97.
35. Carp R. Relying on the kindness of strangers: CEDD's report on hiring, tenure, promotion in IDS. Assoc Integr Stud Newslett 2008;30:1-7.
36. Golding C. Integrating the Disciplines: Successful Interdisciplinary. Centre for the Study of Higher Education. The University of Melbourne; 2009.
37. vom Brocke J, Lippe S. Managing collaborative research projects: A synthesis of project management literature and directives for future research. Int J Project Manag 2015;33:1022-39.
38. Palmer MA, Kramer JG, Boyd J, Hawthorne D. Practices for facilitating interdisciplinary synthetic research: The National Socio-Environmental Synthesis Center (SESYNC). Curr Opin Environ Sustain 2016;19:111-22.
39. Stevenson CB, Duran RL, Barrett KA, Colarulli GC. Fostering faculty collaboration in learning communities: A developmental approach. Innov Higher Educ 2005;30:23-36.
40. Haythornthwaite C, Lunsford KJ, Bowker GC, Bruce BC. Challenges for Research and Practice in Distributed, Interdisciplinary Collaboration. New Infrastructures for Knowledge Production: Understanding E-Science. Pennsylvania, United States IGI Global; 2006. p. 143-66.
41. Bililign S, Schimmel K, Roop JP, Meyerson G. A university without departments and colleges-A new structure to strengthen disciplinary and interdisciplinary education and research. Int J Innov Educ Res 2015;3.
42. Bingham NE, Doty WG, Klein JT. Integrating Interdisciplinary Organizations: A Preliminary Directory For Networking. Issues in Interdisciplinary Studies; 1990.
43. Klein JT. Finding interdisciplinary knowledge and information. New Directions for Teaching and Learning 1994;58:7-33.
44. Mazaheri E, Geraei E, Zare-Farashbandi F, Papi A. The condition of interdisciplinary communication among various Educational and Research Departments of Isfahan University of Medical Sciences. J Educ Health Promot 2017;6:46.
45. Desmarais L, Parent R, Leclerc L, Raymond L, MacKinnon S, Vézina N. Knowledge transfer between two geographically distant action research teams. J Workplace Learn 2009;21:219-39.
46. Etzkowitz H, Leydesdorff L. The dynamics of innovation: From National Systems and "Mode 2" to a Triple Helix of university–industry–government relations. Res Policy 2000;29:109-23.
47. Harden R. AMEE guide No. 12: Multiprofessional education: Part 1-effective multiprofessional education: A three-dimensional perspective. Med Teacher 1998;20:402-8.
48. Hyun E. Transdisciplinary higher education curriculum: A complicated cultural artifact. Res Higher Educ J 2011;11:1.
49. Ivanitskaya L, Clark D, Montgomery G, Primeau R. Interdisciplinary learning: Process and outcomes. Innov High Educ 2002;27:95-111.
50. Johnson AG. "Deep Interdisciplinarity" as Critical Pedagogy: Teaching at the intersections of urban communication and public place and space. Int J Crit Pedagogy 2014;5:p5-23. 19p.
51. Klein JT. Integrative learning and interdisciplinary studies. Peer Rev 2005;7:8-10.
52. Modo M, Kinchin I. A conceptual framework for interdisciplinary curriculum design: A case study in neuroscience. J Undergrad Neurosci Educ 2011;10:A71.
53. Chrysanthou A, Nottingham E. Conferences as a Tool for Interdisciplinary (Postgraduate) Learning in Bioethics. Jahr: Europski časopis za bioetiku. 2018;9:234-46.
54. Barry A, Born G, Weszkalnys G. Logics of interdisciplinarity. Econ Soc 2008;37:20-49.
55. Blackwell A, Wilson L, Boulton C, Knell J. Creating value across boundaries. Nesta Rep 2010. NESTA Research Report CVAB/48.
56. Linde C. Narrative and social tacit knowledge. J Knowl Manage 2001;5:160-71.
57. Gray B. Enhancing transdisciplinary research through collaborative leadership. Am J Prevent Med 2008;35:S124-32.
58. Holley KA. Understanding Interdisciplinary Challenges and Opportunities in Higher Education. Jossey-Bass; 2009 San Francisco, California, United States.
59. Bhaskar R. The Possibility of Naturalism: A Philosophical Critique of the Contemporary Human Sciences. Routledge; 2014. Milton Park, Abingdon-on-Thames, Oxford shire, England, UK.
60. Pourkarim M, Ghamsari AS, Noeparast KB, Mehrmohammadi M. The explanation of the bhaskar's critical realism ontological assumptions and their applications on interdisciplinary research. Interdiscip Stud Humanit 2014;6:131-7.

61. Nicolini D, Mengis J, Swan J. Understanding the role of objects in cross-disciplinary collaboration. Organ Sci 2012;23:612-29.
62. Graham J, Haidt J, Koleva S, Motyl M, Iyer R, Wojcik SP, Ditto PH. Moral foundations theory: The pragmatic validity of moral pluralism. InAdvances in experimental social psychology 2013 Jan 1 (Vol. 47, pp. 55-130). Academic Press.
63. Little D. Beyond positivism: Toward a methodological pluralism for the social sciences. www-personal. umd. umich. edu/~ delittle/BEYPOSIT. PDF. 2004;10.
64. Noy NF. Semantic integration: A survey of ontology-based approaches. ACM Sigmod Record 2004;33:65-70.
65. Mansilla VB. Interdisciplinary Learning: A Cognitive-Epistemological Foundation. Oxford, UK: Oxford Handbook for Interdisciplinary; 2016.
66. Crebert G, Patrick CJ, Cragnolini V, Smith C, Worsfold K, Webb F. Griffith graduate attributes teamwork skills toolkit. Griffith Graduate Attributes Teamwork Skills Toolkit. 2011.
67. Chrysanthou A, Nottingham E. Conferences as a Tool for Interdisciplinary (Postgraduate) Learning in Bioethics. Jahr: Europski časopis za bioetiku. 2018 Dec 19;9(2):234-46.