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A framework for quality management of university educational information: a review study

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Abstract

Background: By addressing the challenges of managing academic information, especially in the field of education, designing a framework as an organized structure for managing the quality of academic educational information is necessary. The framework for quality management of university educational information has received little attention so far and all of its aspects have not been elaborated comprehensively. This study has reviewed related literature.

Methods: In this review paper, the databases such as Web of Science, Scopus and Irandoc were searched for valid English and Persian articles from 1995 to 2017 using keywords or a combination of keywords such as "information quality management". After reviewing the printed references, 48 relevant cases were selected. No limitations were applied in the selection of articles and sources in terms of their types. There are no in-press or personal communication sources. The review was conducted at all of the three steps of information management.

Results: Four aspects of data quality (DQ) were identified: intrinsic, contextual, representational and accessibility. Information quality is the main process of information management. The framework for quality management of university educational information was recognized in five main categories: the information quality and its necessity, the features of information quality, comparative study on the models of data quality management (DQM), improving information quality and university policies about DQ.

Conclusion: Quality management of university educational information is an effective step toward continuous improvement of DQ and can pave the way for information and academic managers while facing the current changing environment in the future issues.

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Introduction

Information is a critical investment for universities.[1] The constant challenge for any organization that generates statistical information is to ensure that their information quality is appropriate for their intended applications.[2] Data quality (DQ) is an essential element, "in spite of their expenditures on information technology, many organizations still do not have the accurate, timely, and useful data they require for effective operations and decision-making, and the problems of DQ are increasing practically."[3] The accessibility, reliability, consistency and relevance of the data that supports information systems are essential to its use and effectiveness in university settings.[4]

Ahmadi et al determined 669 information requirements by distributing questionnaires among the managers of the Deputy of Treatment. According to their results, 56% of the information requirements had no specific sources; hence, it was recommended to first evaluate the existing information system of the medical sciences universities and then, by concentrating all of the affairs of the university's information management under one unit's supervision, it would become possible to manage and eliminate parallel works under different deputies.[5]

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Torkzadeh and Ahmadvand presented a practical model of strategic guidance for the information system of the university. They have stated that, in the current complicated and dynamic conditions of the university's environment and systems, accurate and timely information has an essential role and strategic value in the quality of decisions and actions and the success of the university in dynamic improvement and development and consequently helps ensure organizational effectiveness and health.[6]

"The framework and model for managing and controlling DQ to support health decisions" is a paper for proposing a model based on the current condition of DQ for supporting health decisions which defines the semi-structured revision model for health data, designs a strategy for fast access to revision rules and clarifies the method of DQ revision as well as the problematic method of data process. It is emphasized that the issues of health DQ are significant effective factors on the validity and scientific nature of health decisions.[7] "Data completeness analysis in the Malaysian Educational Management Information System (EMIS)" is a study for measuring the quality of data in EMIS regarding 3 basic dimensions of DQ: completeness; validity and accuracy; and determining the root causes of problems in EMIS DQ. According to the authors, EMIS has a major function in making good decisions. This matter requires high quality data that are accessible to relevant individuals. However, the senior managers of the ministry raised doubt about the accuracy of the collected data. Promoting the quality of data collection is of great importance.[8] Chapman, in a study entitled, "Education DQ in Nepal," which was published in the United States, evaluated the rate of errors in the national education data in Nepal, estimation of the available educational data errors by ministry-level decision-makers, and the process of reporting the errors. Results revealed that decision makers' doubts about DQ would result in these data not being used.[9]

The wide range of academic activities and the enormous size of their information have increased the challenges in information management, especially in the field of education, as the main function of the university. Therefore, designing a framework as an organized structure for managing the quality of university educational information is a necessary solution. The framework for quality management of university educational information as an interdisciplinary study has received little attention so far and all of its aspects have not been elaborated comprehensively. This study has reviewed related literature in this field.

Material and Methods

In this review study, the valid English and Persian articles from 1995 to 2017 were searched in databases such as the Web of Science (WOS), Scopus, ProQuest, Elsevier, Scientific Information Database (SID), and Irandoc using keywords singly or in combination. Search engines such as Google Scholar and printed references were also used. Forty-eight subject relevant cases were categorized. (Education OR student OR learn* OR teach*) AND ("DQ" OR "DQ management"), "DQ", "DQ management", "DQ management model", "information quality", "information quality management", and "information quality management model" were used as some of the search strategies. No limitations were applied in the selection of articles and sources in terms of their types. There are no in-press or personal communication sources and all papers were full text. The process of information quality management contains all the 3 main steps of information management: collecting, processing and presenting the data, and information. Thus, the literature review was conducted in all of these three steps by addressing all dimensions. The synthesis of findings in 5 main categories were mentioned in the results. Educational information means information about the educational function of the university as one of the 3 missions of universities for students.

Results

The process of data quality management (DQM) consists of ensuring the reliability of collected data from the inputs, which included data acquisition and authentication, data management, processing, which included data storage, aggregation, classification, updating and computation, and data output, which included data retrieval and presentation.[10] A summary of English studies are shown in Table 1.

The framework for managing the quality of university educational information was evaluated, based on the literature, in 5 main categories of information quality and its importance, characteristics of information quality,

Table 1. International studies around educational information quality

No.	Educational information quality - title	Author, publication year
1	A data quality management and control framework and model for health decision support	Dai et al,[7] 2015
2	A model for managing data assurance in higher education	Hamblin and Phoenix,[11] 2012
3	Information quality assessment and improvement of student information in the university environment	Penning and Talburt,[12] 2012
4	Data completeness analysis in the Malaysian educational management information system	Mohamed et al,[8] 2009
5	Organizational determinants quality in local education agencies	Crandall,[13] 2008
6	Education data quality in Nepal	Chapman and Dhungana,[14] 1991
7	Education data quality in the third world a five country study	Chapman,[9] 1991

a comparative study of the models of DQM, improving information quality and university policies about DQ.

Information quality and its importance

Information quality and its importance have been mentioned in different studies as follows. Information quality should be considered as a key element in information management.[15] Presenting quality information is vital for demonstrating accountability and clarity in organizations. Information is the key asset, heart and soul of every organization. Ensuring timely and sufficient information is essential for managerial activities for organizations to make decisions, improve efficiency and gain competitive advantage. Effective information governance can be ensured by effective information management because information management can provide quality information to support the goals of information governance.[16] Information systems require accurate, up-to-date information so that the decision makers can rely on information.[17]

According to a research report at the University of Australia, the management placed a high level of emphasis on the university's application systems and databases, and noted the insufficiency of some of the management information they received from these systems.[18] The accuracy, timeliness and accessibility of education data have been identified as key limitations to education data use. In many countries, poor DQ is a serious constraint for applying data at the national level of management and policy-making.[14] Poor data and information quality have a significant negative effect on the success of organizations. Consequently, organizations are implementing programs to improve DQ in order to achieve competitive advantages.[19] The problems of DQ are exacerbated by large organizational databases where data is collected from multiple sources.[20] One of the common threats to the educational DQ includes poorly designed data collection tools.[21]

Professionals in the international education community should be able to rely on the statistics they use as a basis for planning, policy making, monitoring, and evaluation. The varying quality of statistics is detrimental in that it discourages the use of evidence for decision-making, or even leads to decisions based on erroneous information.[22] Because of the need for relevant, timely, and accurate educational statistics, countries are now paying close attention to EMIS and to the quality of its data.[23] One of the measures of an efficient education management information system is the extent to which returns from school censuses and surveys are accurate, timely and up to date.[24] Quality data is the basis of EMIS.[21]

Information quality characteristics

DQ aspects. Various studies have mentioned the following aspects for DQ.

Four aspects have been recognized for DQ: intrinsic, contextual, representational and accessible. Intrinsic means the data is naturally qualified. Contextual means that DQ must be considered within the context of the task at hand. Representational means that the provided data should have a specific quality.[25] Gendron, in accord with Wang and Strong in 1996, also considered these 4 aspects with each one's characteristics noted as the basis for his framework.[26]

DQ characteristics. Regarding the characteristics of DQ, the following items were extracted.

All areas in the university rely on quality information (accuracy, reliability, and integrity) to make good decisions.[18] Efforts to optimize the quality of data and information have continued for a long time to improve the educational system and to support decision-making.[27] The features of DQ are also considered as the assessment standards of DQ.[7]

There are 5 descriptive indicators of the quality of originated data and information by the academic information system (AIS): effectiveness, confidentiality, compatibility, legibility and reliability.[28] DQ is a complex construct which includes multiple dimensions: accuracy, reliability, precision, completeness, timeliness, integrity, and confidentiality.[29]

DQM models

Among DQM models, the following models are discussed.

The American Health Information Management Association (AHIMA) model. The domains or functions of DQM which have been shown in the paper diagram include application, collection, warehousing and analysis.[30] The characteristics of DQ are shown in Table 2.

The Johns model. Johns has listed the following characteristics of DQ in his reference book: accuracy, comprehensiveness, consistency, currency, granularity, precision, relevancy, timeliness, completeness, appropriateness, accessibility and integrity. Johns believed that one of the perfect perspectives about DQ dimensions is Redman's model, which stated the following features: relevancy, being easily obtainable, legitimacy, clear definitions, comprehensiveness, granularity, precision, timeliness, currency, consistency, accuracy, presentation of data to the end-user format. Format means the signs that can be used to express the meaning of data.[31]

The DQ framework (DQF) model in Canada. The DQF was proposed to create a corporate-based meaningful method to evaluate the quality of data in all databases. This framework would standardize the information related to DQ for the users and would help them prioritize the matters and consequently would cause continuous improvement. Its first edition was conducted in 2000. DQF consists of five general dimensions: accuracy, timeliness, comparability, efficiency and relevancy. These dimensions are based on 24 features and the features are based on 86 criteria. The implementation of the framework is a part of the quality cycle.[2]

The TACOMA (Timeliness, Accuracy, Completeness, Oriented, Measurable, and Applicability) model. In the report of the National Coordinating Council for Cancer Surveillance (NCCCS) which was published by the Centers for Disease Control and Prevention (CDC) in

Table 2. The characteristics of data quality

Characteristics
Data Accuracy: The values of the data should be correct.
Data Accessibility: Data items should be easily obtainable and legal to collect.
Data Comprehensiveness: All required data items should be included. Intentional limitations in data collecting should be documented.
Data Consistency: Data should be reliable and the same across all applications.
Data Currency: Data should be up to date.
Data Definition: The clear definitions of data elements should be provided so that the current and future users of data could understand their meanings.
Data Granularity: The appropriate level of details which attributes and values of data should be defined.
Data Precision: data values should be strict to support the purpose.
Data Relevancy: data should be useful for the purposes for which they are collected.
Data Timeliness: data should be up to date and available within a useful time frame; timeliness is determined by manner and context in which the data are being used.

the United States in March 2000, DQ characteristics were represented through the TACOMA model in addition to mentioning the importance of cancer DQ. The key aspects of DQ are timeliness, accuracy, completeness, oriented, measurable, and applicability. The TACOMA model can help cancer registry professionals evaluate and develop quality assurance activities.[32]

The Martin and Powell model. Martin and Powell, in 1992, presented a list of characteristics that they argued are usually coupled with information quality: accuracy, completeness (comprehensiveness), conciseness, cost-effectiveness, presentation, relevancy, timeliness (the information appears at the appropriate time in the decision making process), and up-to-date (age/currency).[33]

The Bowley model. The Bowley model includes the following data features: complete, relevant, accurate, up-to-date, timely, adequate, accessible, sharable, appropriate and clear.[33]

The Wang and Strong model. According to Wang and Strong, poor DQ can have vital social and economic impacts. Although organizations are improving DQ with practical approaches and means, their improvement activities tend to focus narrowly on accuracy and often overlook other important characteristics and dimensions of DQ.[34] Wang and Strong proposed 20 dimensions of DQ, which then were reduced to 15 dimensions and grouped into four categories:

- Intrinsic DQ: accuracy, objectivity, believability, and reputation;
- Contextual DQ: relevancy, value-added, timeliness, completeness and amount of data;
- Representational DQ: interpretability, ease of understanding and concise and consistent representation;
- Accessibility: accessibility and security.

Other characteristics of DQ include the following: cost-effectiveness, ease of operation, flexibility, trace-ability, variety of data and data sources.[35]

The Gendron and D'Onofrio's model in healthcare. Gendron and D'Onofrio from Central Connecticut State University presented the results of assessing the dimensions of DQ by Wang and Strong in 3 health care divisions including profit, non-profit and combined. Gendron and D'Onofrio contended that the eliminated features from the model of Wang and Strong are valuable to the health care. Therefore they utilized their primary 20 features in their study. The survey population consisted of health care managers of the United States. Their results revealed that the managers not only believed the 15 features of Wang and Strong DQ to be important in the healthcare industry, but they believed that the five eliminated features were also important. Each part of the health care industry should develop a set of specific dimensions for the domain along with the supplementary of 15 general dimensions.[35]

Gendron's data quality management model. Gendron arranged the characteristics of DQ in his PhD dissertation entitled "data quality in the health care industry" in the United States, in order of importance from the viewpoint of the management levels in a table. The characteristics of DQ in order of importance from the viewpoint of strategic management levels include accuracy, access security, accessibility, believability, ease of understanding, objectivity, completeness, ease of operation, value-added, relevancy, interpretability, timeliness, traceability, reputation, conciseness, cost effectiveness, appropriate amount of data, representational consistency, flexibility, and variety of data & data sources.[26]

The Mannio model. In the first section of his book, Mannio states the features of DQ to be completeness, clarity, correctness, timeliness, reliability and stability.[36]

The health data quality control model (HDQCM). Dai et al[7] asserted that, according to the definition of DQ and in combination with the current state and characteristics of health data collection, processing and application, the level of health DQ can be assessed around the following dimensions: accuracy, integrity, validity, consistency and repeatability.

The product and service performance model for information quality (PSP/IQ). The PSP/IQ model provides a meaningful view of information quality to decision making (Table 3).

DQ assessment framework (DQAF). DQAF provides a comprehensive evaluation of educational DQ by comparing

Table 3. PSP/IQ Model[19]

PSP/IQ model	Conform to specifications	Meet or exceed consumer expectations
Product Quality	Sound Information IQ Dimensions: • Free of Error • Concise Representation • Completeness • Consistent Representation	Useful Information IQ Dimensions: • Appropriate Amount • Relevancy • Understandability • Interpretability • Objectivity
Service Quality	Dependable Information IQ Dimensions: • Timeliness • Security	Usable Information IQ Dimensions: • Believability • Accessibility • Ease of Operation • Reputation

a country's data production with current international standards. Such a comparison enables a country to assign priorities to areas in need of strengthening. Six features have been pointed out: prerequisites, integrity, method correctness, accuracy and reliability, serviceability and accessibility.[37]

Moghaddasi's systematic-biological DQ model. Moghaddasi in his study entitled "a systemic biologic model for healthcare data quality" proposed a model with two main components (content and representation format) and 7 features for DQ including accuracy, completeness, timeliness, relevancy, definition, data representation format, and logical linkage.[38]

Table 4 shows the frequency distribution of DQ features for selected models separately.

According to the findings in Table 4, the models of "Wang and Strong", "Gendron and D'Onofrio" and "Gendron" included the majority of the features (51.28%). Table 5 shows the frequency distribution of the features of educational DQ for each selected models separately.

The accuracy characteristic was the common feature in all the reviewed models and then timeliness and relevancy were the most important features in the selected models by 85.71% and 78.57%.

Table 4. Frequency distribution of the number of the data quality characteristics in the selected models (14 models)

Data quality characteristics models	Frequency distribution	
	No.	Percent
Wang and Strong	20	51.28
Gendron and D'Onofrio	20	51.28
Gendron	20	51.28
PSP/IQ	15	38.46
Johns	12	30.76
AHIMA	10	25.64
Bowley	10	25.64
Martin and Powell	9	23.07
Moghaddasi	7	17.94
TACOMA	6	15.38
DQAF	6	15.38
Mannio	6	15.38
Canada National Model	5	12.82
HDQCM	5	12.82

Information quality improvement

- The improvement programs are critical for the development and maintenance of data warehouses. Without proper DQ processes, the data warehouse will begin to accumulate inappropriate data.[19]
- The investment in metadata repositories and in DQ tools creates a better data foundation for analytics tools. It seems likely, however, that improved processes and collective action will contribute more to the improvement of DQ than technology.[39]
- The data should be cleaned every time they are collected from schools. Some data are not complete and missing values should be imputed with the default values to be used in data queries and reports. The EMIS application does not include comprehensive business rules to check on the data before they are sent. Therefore, it is vital to improve EMIS DQ. However, before any improvements, the current condition of DQ must be determined and its source of problems should be identified.[8]
- A guideline is needed for DQ measurement, assessment, and improvement processes.[8]
- It should become easier to assess how good EMIS data are when a DQAF for education statistics becomes available. This will set out standards and good practices in institutional procedures and arrangements.[40]
- The mission and function of organizational planning and research as a profession is to improve the quality of available information for strategic planning and management decision making.[41]
- In the health system, the five functional components of data management system matter based on the DQ audit tool.[29]

Data quality principles

- The integrity of data depends on appropriate database structure, reliable hardware and software, data and transition standards, storage devices and reliable

Table 5. Frequency distribution of the characteristics of educational data quality in the selected models (39 characteristics)

Data quality characteristics	No.	Percent
Accuracy	14	100
Timeliness	12	85.71
Relevancy	11	78.57
Completeness	10	71.42
Accessibility	8	57.14
Consistency	8	57.14
Reliability	6	42.85
Adequacy	5	35.71
Conciseness	5	35.71
Currency	4	28.57
Cost-effective	4	28.57
Security	4	28.57
Objectivity	4	28.57
Ease of Operation	4	28.57
Ease of Understanding	4	28.57
Comprehensiveness	3	21.42
Integrity	3	21.42
Flexibility	3	21.42
Validity	3	21.42
Trace-ability	3	21.42
Value-added	3	21.42
Variety of Data & Data Sources	3	21.42
Reputation	3	21.42
Granularity	2	14.28
Precision	2	14.28
Appropriateness	2	14.28
Meaningful	2	14.28
Interpretability	2	14.28
Definition	2	14.28
Obvious Presentation Format	2	14.28
Presentation Format	2	14.28
Efficient	1	7.14
Oriented	1	7.14
Measurable	1	7.14
Sharing ability	1	7.14
Comparable	1	7.14
Prerequisites	1	7.14
Serviceability	1	7.14
Logical linkage	1	7.14

backup processes, precision of coded data, expertise in the field of computer data request, skill in data analysis and interpretation and reporting capabilities.

- DQ should be monitored, evaluated and reported.
- Databases list registries and their reports and controls help to have timely and precision data.
- Continuous monitoring and evaluation of the quality of information management services based on professional standards should be an essential practice.[42]
- Information is a professional strategic resource in enterprise property. Data need to be managed in the enterprise environment.
- Information policy is required for effective information management in financial and human resources policies.
- The profession's focused data standards should be required.
- The data should be modelled, named and determined based on standard values and similar professional rules.
- Professional processes should be reengineered before automation.
- Manual recording should be eliminated and data should be electronically collected if possible.
- Data should be collected once and reproduced if needed.
- A person who produces or updates data is responsible for them.
- Access to the instruction of repositories or information should be provided to data producers.
- Information workers should be trained sufficiently.
- Producers should have performance criteria about DQ.
- Assessment of DQ should be used to identify and correct the flawed processes.[43]
- The produced data should have equally high quality. Mechanisms also should be developed to require the validity and reliability of data, only necessary data should be collected, and integration should be regarded considering the needs of all users when handling the data.
- The first step toward data management is recognition of the users. The goal is "to provide the appropriate information for the right person at the right time and in an appropriate manner".[44]

Quality control of the data collection systems

- The structure of data collection forms should be evaluated periodically to determine the use of the most efficient method of data collection.
- Criteria can be created to determine the necessity of each data elements.
- There should be three types of controls over data collection and recording: preventive, detective, and corrective.[45]

University policies on data quality

Data are of critical importance in our enterprise in order to support the educational and business processes of the organization. All data are owned either by services or schools, and the data owner is responsible for DQ. We seek to continuously maintain and enhance our data management systems, policies and procedures and communicate them. We ensure that our policies and procedures are consistent with legal requirements. We strive to implement and maintain the Higher Education Funding Council for England (HEFCE) good practice framework for DQ. We will ensure that the personnel are equipped with the right resources, skills and knowledge to complete their responsibilities, and the university manages

data risks appropriately. The policy and processes will be reviewed periodically. The Audit Committee has endorsed the use by the institution of data standards published by the Audit Commission in 2007 titled 'improving information to support decision making: standards for better quality data'.[11]

Discussion

These findings were collected in three areas that are mentioned in the methods section and categorized into five subsections. This paper presents a literature review about the framework for quality management of university educational information as a subject which has received little attention so far. According to the findings, this subject has not been explained comprehensively and earlier studies concentrated on various aspects of quality management of university educational information, not all assessed simultaneously (Table 1). A summary of the most important results and their discussion are outlined in this section.

Information systems require quality information so that the decision-makers can rely on that information.[17] The process of information quality management includes three main stages of information management: collection, processing, and representation of the data and information. "The features of DQ are also considered as the assessment standards of DQ."[7] Each of the selected models propounds a series of characteristics for DQ. Hence, it is necessary to develop a comprehensive model for quality management of university educational information. Accuracy is the common characteristic in all of the reviewed models. After accuracy, timeliness and relevancy were the most important characteristics. Other resources have also highlighted accuracy.[8,14,15,18,24,26,29,39] DQ improvement is vital, which was noted in previous literature.[8,19,41] "DQ should be monitored, evaluated and reported."[42] Other researchers have presented evaluation model.[7] In the recent study in 2016, a strong relationship was reported between process factors such as lack of DQ control pertaining to technical and lack of DQ protocols.[46] However, before any improvement, the status quo of DQ must be determined and the source of its problems should be identified.[8] Mohammad et al and Chapman and Dhungana determined DQ in their studies based on this method.[8,14] Information quality should be considered an important element in information management.[15] Another study declared that information management provides quality information.[16] The aim is to provide the appropriate information to the proper person at the proper time and in a proper method.[44] The most recent study recommended changing the approach of studies towards an understanding of the implications and applications of information quality to improve health services.[47] This is expected to establish a framework to improve university educational information too. Designing a model for the quality management of university education information is recommended.

Conclusion

DQ is an essential element in the management of educational services. "Information governance systems are critical for the mission of the university to produce and exchange knowledge for the benefit of the society.[1]" Access to quality data and analyzing them is essential for effective decision-making in any organization, especially universities. "Institutions require close monitoring and review of their academic standards, work that can only be undertaken if the student DQ is of a high standard."[48] All areas in the university rely on quality information to make good decisions.[18] Information quality should be considered an important element and a principal axis in information management. The framework for the quality management of educational information at the university is a very valuable subject that has been discussed inadequately. Quality management of university educational information is an effective step toward the continuous improvement of DQ in the field of the country's higher education. Moreover, it can pave the way for solving future problems of information and university managers in encountering today's changing environment. Quality management of educational information in the medical sciences universities can provide a background for education quality and training of human resources in the healthcare system to improve the quality of health information management system and eventually to improve the health level of society as a whole.

Ethical approval

All applied references were mentioned. No part of this paper was copied from other sources.

Competing of interests

Authors have no conflict of interests.

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